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Official Publication of the National Athletic Trainers' Association, Inc Volume 53, Number 6, Supplement, 2018

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Dear NATA Members and Friends:

We are pleased to present the annual *Supplement* to the *Journal of Athletic Training*. This Supplement contains abstracts presented at the 2018 NATA Clinical Symposia & AT Expo in New Orleans, LA as part of the NATA Foundation Free Communications Program.

The Free Communications Program provides certified athletic trainers, students and other healthcare providers an opportunity to present and learn about the latest in athletic training research. Research is presented in oral and poster formats and includes general research, NATA Foundation-funded research, clinical case reports and our Student Exchange program posters. Abstracts of the research are printed here in the order of presentation at the NATA Convention in New Orleans for your convenience. Free Communications presentations represent a wide range of research and clinical interests. In addition, the Clinical Case Reports sessions allow you to test your clinical assessment skills. We encourage you to attend these presentations.

We also urge you to attend the sessions featuring research funded by the NATA Foundation. The NATA Foundation funds research and a variety of educational programs, including summits on issues critical to athletic training, as well as annual scholarships to undergraduate and graduate students of athletic training.

Support from NATA members, corporations, and other affiliated groups make this supplement and all of our programs possible. Please note projects funded by the NATA Foundation and by the generous contributions of our donors are specified in this Supplement. To make an investment in the future of the profession, please contact us today at 800-TRY-NATA, extension 150.

NATA and the NATA Foundation are pleased to offer this supplement as a service to NATA members. We hope that it provides theoretical and practical information you can use to improve your effectiveness as a certified athletic trainer. Thank you for your support!

Sincerely,

Brian Conway, LAT, ATC President, NATA Research & Education Foundation

Scott Sailor, EdD, ATC President, NATA

Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Sub-Committee, we would like to thank all the authors who submitted abstracts to the Free Communications Program. We are happy to report a record number of submissions again this year with the total exceeding 500 Peer Reviewed and Student Exchange Track submissions, combined. We are excited about this year's Free Communications Program, as we believe it contains an exciting mix of both high caliber research reports and clinical case studies. Please keep in mind that we consider oral and poster presentations to be equal in terms of caliber and encourage clinicians and researchers to attend both oral and posters sessions.

We would also like to take this opportunity to extend a special thanks to the all of the NATA Foundation staff and especially Velma Meza, whose attention to detail and dedication makes the Free Communications Program possible. Additionally, many individuals have worked very hard to review submissions, schedule presentations, and produce this Supplement to the *Journal of Athletic Training*. Therefore, we would like to thank and recognize the efforts of the Free Communications Committee for their long hours of abstract reviews and creativity in developing this year's Free Communications program. The Free Communications subcommittee members are

Michelle Boling, PhD, AIC;	Kellie Huxel-Bliven, PhD, AIC;
Steven Broglio, PhD, ATC;	Blaine Long, PhD, AT, ATC;
Cathleen Brown Crowell, PhD, ATC	Stephanie Mazerolle, PhD, ATC;
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Jeff Driban, PhD, ATC, CSCS;	Sakiko Oyama, PhD, ATC
Jennifer Earl-Boehm, PhD, ATC;	Erik Wikstrom, PhD, ATC, LAT

We also acknowledge the unwavering support and guidance from Brian Conway, LAT, ATC, and the rest of the Foundation staff. I also specifically recognize Velma Meza, who works tirelessly behind the scenes to assure a successful program each year. Lastly, we wish to thank Leslie Neistadt and the staff at the editorial office of the *Journal of Athletic Training* for making the Supplement possible.

As we move forward, we continually try to improve and make the review process more transparent. Our goal is to be as inclusive as possible while maintaining the high level of scholarship that readers expect of the *Journal of Athletic Training*. To further improve the process, we appreciate the feedback we have received from authors, and suggestions are always welcomed and discussed in committee meetings.

We look forward to seeing you in New Orleans. Please take the opportunity to attend the Free Communications Best Practices Forums, peer reviewed oral and poster sessions, and the student exchange poster presentations. Please note that projects funded by the NATA Research & Education Foundation are specified in this Supplement. Finally, if you have the opportunity, please offer your thanks to those recognized above.

Sincerely,

Jor How PhD ATC

Joseph M. Hart, III, PhD, ATC Vice Chair for Free Communications NATA Research & Education Foundation Research Committee

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Official Publication of the National Athletic Trainers' Association, Inc Volume 53, Number 6, Supplement, 2018

Table of ContentsPage

Ernest N. Morial Convention Center

Free Communications: Room 206–207

Wednesday, June 27, 2018

	010		
7:30AM-9:15AM	Is Shoulder Mobility Good or Bad?	Elizabeth Hibberd, PhI	D, LAT, ATCS-15
9:30AM-10:45AM	. Risk Factors for Ankle Injury	Matthew Hoch, PhD, A	TCS-21
11:00AM-12:00PM	Perceptions of Injury Prevention		
	. Programs	Jessica Martinez, PhD,	ATC, CSCSS-25

Thursday, June 28, 2018

7:00AM-:8:00AM	. Rapid Fire Oral Presentations:	
	. Concussion Management and	
	. Recovery	Tamerah Hunt, PhD, AT, FACSMS-28
8:15AM-9:30AM	. Patient Beliefs and Activity After	
	. Anterior Cruciate Ligament	
	. Reconstruction	Jennifer Howard, PhD, LAT, ATCS-34
9:45AM-11:15AM	. Neuromotor Consequences of	
	. Concussion	Robert Lynall, PhD, ATCS-38
5:15PM-6:45PM	. Just Breathe: Mind and Body in	
	Athletic Training Settings	Susan Falsone, MS, PT, ATC
Friday, June 29, 2018		
7:00AM-7:45AM	. Examining Costs of Care in Athletic	
	. Training Practice	Mark Hoffman, PhD, ATCS-46
8:00AM-9:00AM	. Soccer From Head to Toe	Sandra Shultz, PhD, ATC, FNATAS-48
10:45AM-12:00PM	. Developing Clinical Reasoning in	
	. Athletic Training Students	Paul Geisler, EdD, ATC
12:15PM-1:30PM	. Epidemiology of Sports Injury	Jennifer Hootman, PhDS-55
1:45PM-3:00PM	. Patient-Reported Outcomes and	
	. Function Following Ankle Injury	Jay Hertel, PhD, ATC, FNATAS-60
3:15PM-4:45PM	Rapid Fire Oral Presentations:	
	Taking Care of Youth and	
	Adolescent Athletes	Anh-Dung "Yum" Nguyen, PhD, ATC

Free Communications: Room 208–210 Wednesday, June 27, 2018

weather and the start of the st	, 2010		
8:00AM-9:00AM	Miscellaneous Best Practices Forum:		
	Does Prediction Lead to Prevention?		
	Discussing and Translating the State		
	of Evidence for Injury Risk		
	Screening	Jay Hertel, PhD, ATC, FNATA	S-70
9:15AM-10:45AM	Prevention, Recognition, and		
	Follow-Up for Heat Illness	Mike Ferrara, PhD, ATC, FNATA	S-71
11:00AM-12:30PM	Lower Extremity Movement		
	Assessment and Injury	John Goetschius, PhD, ATC	S-75
	5 .		

Thursday, June 28, 2018

7:00AM-8:00AM	Pediatric Wellness	Jennifer Medina McKeon, PhD, ATC, CSCS	S-79
8:15AM-9:15AM	Ankle Best Practices Forum:		
	The Role of Muscle Function in		
	Ankle Sprains and Instability	Kathryn Webster, PhD, ATC	S-81
9:30AM-11:15AM	Gait and Postural Constraints in		
	Chronic Ankle Instability	Phillip Gribble, PhD, ATC, FNATA	S-82
5:15PM-6:45PM	Laser, Light, and Electrical		
	Stimulation	Noelle Selkow, PhD, ATC	S-87

Friday, June 29, 2018

7:00AM-7:45AM	Concussion Reporting	Zachary Kerr, PhD, MPH	S-92
8:00AM-9:00AM	Head Best Practices Forum: Inside	-	
	the Athlete Brain: Why Do Athletes		
	Delay or Fail to Report Their		
	Concussions and How Can We		
	Fix It?	Michelle Weber, MS, ATC	S-94
10:45AM-11:45AM	Health and Well Being of Athletic		
	Trainers	Janet Simon, PhD, AT	S-95
12:00PM-1:15PM	Central Nervous System in Lower		
	Extremity Function	Alan Needle, PhD, ATC, CSCS	S-98
1:30PM-2:45PM	Changing Rules and Injury Risk	Erik Swartz, PhD, ATC, FNATA	S-101
3:00PM-4:00PM	Injury Epidemiology in High School		
	Athletes	Kenneth Lam, ScD, ATC	S-105

Free Communications: Room 217–219

Wednesday, June 27, 2018

8:00AM-9:00AM	. Master's Oral Awards	Alison Snyder Valier, PhD, ATC, FNATA	S-108
9:15AM-10:15AM	. Doctoral Oral Awards	Eric Sauers, PhD, ATC, FNATA	S-111
10:30AM-11:30AM	. Education Best Practices Forum:		
	. Creating a Student-Centered		
	. Environment: Strategies for Faculty		
	. and Preceptors	Angela Beisner, MA, BS	S-114
11:45AM-12:30PM	. Rapid Fire Oral Presentations:	-	
	. Preceptors: Perspectives on Athletic		
	. Training Education	Jessica Edler, PhD, ATC	S-115

Thursday, June 28, 2018

	-		
7:00AM-8:00AM	. Effects of Dual Task and Cognitive		
	Demand on Movement Mechanics	Dustin Grooms, PhD, ATC, CSCS S-1	19
8:15AM-9:15AM	. Rapid Fire Oral Presentations: What's	S	
	in Your Past? Influence of Injury		
	History on Neuromuscular and		
	Functional Measurements	. Thomas Kaminski, PhD, ATC, FNATA S-1.	22
9:30AM-10:15AM	Transition to Clinical Practice	. Jessica Barrett, PhD, ATC S-12	7
10:30AM-11:15AM	. Considerations for Junior Faculty		
	Development	. Kimberly Peer, EdD, ATC, FNATA S-12	9
5:15PM-6:30PM	Rapid Fire Oral Presentations: Injury		
	Risk Factor Identification and		
	Prediction	Marc Norcross, PhD, ATC S-13	1

Friday, June 29, 2018

7:00AM-7:45AM	Rapid Fire Oral Presentations:		
	Delivery of Health Care in the		
	Collegiate Setting	. Brant Berkstresser, MS, ATC, LAT S-1	37
8:00AM-9:00AM	Rapid Fire Oral Presentations:		
	Clinical Tips for Improving Outcomes		
	Following Anterior Cruciate Ligament		
	Reconstruction	. Christopher Kuenze, PhD, ATC S-1	41
10:45AM-12:15PM	Keeping Runners Healthy:	-	
	Environmental and Overuse Injuries	. Neal Glaviano, PhD, ATC	47
12:30PM-1:45PM	Alternative Therapies	. Mark Merrick, PhD, ATC, FNATA S-1	52
2:00PM-3:15PM	Rapid Fire Oral Presentations:		
	Anterior Cruciate Ligament		
	Reconstruction Comparisons and		
	Interventions	. Grant Norte, PhD, AT, ATC S-1	56

Free Communications: Room 220–222

Wednesday, June 27, 2018

8:00AM-9:00AM	Heat/Hydration Best Practices Forum:		
	Unique Perspectives: A Comprehensive	e	
	Debate Relative to Minimizing Legal		
	Risk in Athletic Training	. Gretchen Schlabach, PhD, ATC	S-163
9:15AM-10:15AM	Rapid Fire Oral Presentations:		
	Tactical Athletes	. Timothy Mauntel, PhD, ATC	S-164
10:30AM-11:30AM	Rapid Fire Oral Presentations:		
	Performing Arts	. Michelle Pye, PhD, ATC	S-169
11:45AM-12:30PM	Rapid Fire Oral Presentations:		
	Curricular Concerns in Professional		
	Education	. Lindsey Eberman, PhD, ATC	S-175

Thursday, June 28, 2018

7:00AM-8:00AM	. Rapid Fire Oral Presentations:	Charles Thignen PhD ATC PT ATI	5 180
8·15AM-9·15AM	Shoulder Best Practices Forum	Charles Thigpen, Flid, ATC, F1, ATT	5-100
	. Return to Sport for Upper Extremity		
	Athletes: Are There Any Good		
	. Procedures Out There?	Timothy Uhl, PhD, PT, ATC	5-187
9:30AM-10:45AM	. Rapid Fire Oral Presentations: Quad		
	. Function Following Anterior		
	. Cruciate Ligament Injury and		
	. Reconstruction	Christopher Ingersoll, PhD, ATC	5-188
5:15PM-6:30PM	. Rapid Fire Oral Presentations:		
	. Quality of Life in Intercollegiate and		
	. Interscholastic Athletes	Tamara Valovich McLeod, PhD,	
		ATC, FNATA	5-194

Friday, June 29, 2018

7:00AM-7:45AM Characteristics of Cartilage Follow	ing	
Anterior Cruciate Ligament		
Reconstruction	Randy Schmitz, PhD, ATC, FNATA	S-200

8:00AM-9:00AM	Rapid Fire Oral Presentations: Testing	
	and Clinical Application for Hydration Susan Yeargin, PhD, ATC	S-203
10:45AM-11:45AM	Knee Best Practices Forum:	
	The Evolution of Return to Sport	
	Criteria After Anterior Cruciate	
	Ligament Reconstruction: A	
	Progression Toward a	
	Multidimensional Approach David Bell, PhD, ATC	S-209
12:00PM-1:00PM	Rapid Fire Oral Presentations:	
	Organizational and Professional Issues	
	in the Secondary School Setting Kelly Pagnotta, PhD, ATC, PES	S-210
1:15PM-2:15PM	Rapid Fire Oral Presentations:	
	Emerging Concussion Areas David Howell, PhD, ATC	S-217
2:30PM-3:30PM	Rapid Fire Oral Presentations: Caring	
	for the Football Athlete: Case Reports Rod Walters, DA, ATC	S-221
3:45PM-4:45PM	Rapid Fire Oral Presentations: Caring	
	for the Baseball Athlete: Case Reports Rod Harter, PhD, ATC, FNATA	S-225

Free Communications, Poster Presentations: Ernest N. Morial Convention Center, Hall XXX

Ankle Taping for Chronic Ankle Instability	
Athletic Training Practice, Education, & Administration	
Balance Outcomes	
College Football Case Studies	
Diagnostic Imaging	
Energy Needs and Disordered Eating	
Factors Affecting Concussion Management	
Factors Influencing Baseline Concussion Assessments	
Foot and Ankle Cases	
General Medical Conditions: Case Studies	
Head Impact Biomechanics	
Head, Neck, and Spine	
High School Football Case Studies.	
Hip Cases	
Infectious Disease and Allergy	
Knee and Hip	
Knee Cases.	
Lower Extremity Cases	S-344
Outcomes in Chronic Ankle Instability	
Running Injuries	
The Hip Bone Is Connected to the Back Bone	
Therapeutic Modality Uses	
Treatment for Chronic Ankle Instability	

Awards

The New Investigator Award	S-9
Freddie H. Fu, MD.	S-11
The Doctoral Dissertation Award	S-12
David H. Perrin, PhD, ATC, FNATA, FACSM	S-14

Index

Author Index

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The New Investigator Award Presented in Honor of Freddie H. Fu, MD

Johna K. Register-Mihalik, PhD, LAT, ATC University of North Carolina at Chapel Hill

Johna Register-Mihalik's interest in athletic training began during her days as a student-athlete. Several injuries required her to interact with an outreach athletic trainer; she respected and admired the work he did, which inspired further research into the profession she had never heard of previously. As a junior in high school, she visited the University of Alabama, where she met Deidre Leaver-Dunn, PhD, ATC, and learned about the prevention and recovery aspects of athletic training, a career choice that bridged her 2 long-time passions: medicine and athletics.

Register-Mihalik took this passion to the University of Alabama for her bachelor's degree in athletic training and then to the University of North Carolina at Chapel Hill (UNCCH), where she received her master's and doctoral degrees, focusing on concussion prevention and management. During her clinical career, she enjoyed treating athletes, particularly the women's lacrosse team, who helped her to embrace a new environment and learn the culture of the sport. She appreciated the opportunity to treat athletes throughout the entire injury and rehabilitation process and grew fond of supporting them both on and off the field.

As she saw athletes suffering from the consequences of brain injury during her undergraduate years, traumatic brain injury became a particular interest of Register-Mihalik's. She spent time with Kevin M. Guskiewicz, PhD, ATC, FNATA, FACSM, at UNCCH, which prompted her decision to pursue a research career with the goal of answering some of the difficult questions surrounding concussion.

Register-Mihalik is now an educator, researcher, and mentor at UNCCH, where she enjoys providing students with the necessary skills and various opportunities to facilitate their own learning. She finds educating particularly rewarding in students whose development and understanding in the classroom translates to clinical application, which sparks their interest in different aspects of athletic training. As she said, "watching that light come on in a student's eyes" is always gratifying.

When asked about advice for future athletic trainers, Register-Mihalik recommended staying true to your goals, even though they may change throughout your career; the path may be more crooked than straight, but allowing clinical experiences to spark questions and new interests is paramount to finding a successful niche in athletic training. Good communication with all those involved in the athlete's health

care and planning time off with friends and family allows athletic trainers to remain successful while maintaining the passion and drive necessary for providing exceptional health care.

In her personal life, Register-Mihalik enjoys spending time with her husband and fellow researcher, Jason Mihalik, PhD, CAT(C), ATC, and their 2 children, as well as hiking, yard work, and playing the piano. Register-Mihalik thanks her parents, Johnny and Janet Register; sister, Jenna; and husband, Jason, as well as her many mentors, colleagues, peers, staff, and students at UNCCH and the Matthew Gfeller Sport-Related Traumatic Brain Injury Research Center. Deidre Leaver-Dunn introduced her to athletic training and opened many doors for her. Kevin Guskiewicz invested time and energy in her development as an undergraduate student intern, graduate student, and faculty member. Bill Prentice, PhD, ATC, provided the graduate foundation to continue to advance her thought and opportunities. Stephen W. Marshall, PhD, and Laura A. Linnan, ScD, of UNCCH, launched her in the study of the intersection between sports medicine and public health. Mike McCrea, PhD, ABPP-CN, and Erik Swartz, PhD, ATC, FNATA, provided mentorship in her career and research development, And Tamara C. Valovich Mc-Leod, PhD, ATC, FNATA, of A.T. Still University, taught her how to be a strong, compassionate leader in athletic training while balancing career and family.





Freddie H. Fu, MD

Dr. Freddie H. Fu, a longtime advocate of certified athletic trainers, is a well-respected physician whose work in sports medicine has earned repeated honors.

The 1996 winner of the NATA President's Challenge Award, Dr. Fu is the David Silver Professor of Orthopaedic Surgery and Chairman of the Department of Orthopaedic Surgery at the University of Pittsburgh School of Medicine and the UPMC Health System.

He has been the head team physician for the University of Pittsburgh Department of Athletics since 1986. He also was instrumental in establishing the Sports and Preventive Medicine Institute in 1985. Under his leadership, the facility—now called the UPMC Health System Center for Sports Medicine—has grown into the region's largest, most comprehensive sports medicine center and is regarded as among the best in the country.

Dr. Fu holds secondary appointments as Professor of Physical Therapy and Health, Physical and Recreational Education. He was awarded an honorary doctorate of science degree from Point Park College and an honorary doctorate of public service from Chatham College.

Known worldwide for his pioneering surgical techniques to treat sport-related injuries to the knee and shoulder and his extensive research in the biomechanics of such injuries, Dr. Fu performs surgery at UPMC Health System and sees patients at the Center for Sports Medicine. He also directs the University of Pittsburgh's Sports Medicine Fellows Society.

Dr. Fu is the editor of 12 major orthopaedic textbooks and author of 60 book chapters on managing sports injuries. He has contributed to more than 150 international research publications and has given more than 400 national presentations. Former President of the Pennsylvania Orthopaedic Society, he is a member of 40 other professional and academic medical organizations.

Dr. Fu has served as Chairman of the Board and Executive Medical Director of the City of Pittsburgh Marathon Inc; Company Physician and Board Member for the Pittsburgh Ballet Theatre; and Team Physician for Mt. Lebanon High School. Additionally, he is past President and Chairman of the Children's Festival Chorus and has served the Parental Stress Center, the Pittsburgh Employment Alliance, and the Organization of Chinese Americans.



The Doctoral Dissertation Award Presented in Honor of David H. Perrin, PhD, ATC, FNATA, FACSM Sponsored by Friends of Dr. Perrin

Mark Feger, PhD, ATC Virginia Commonwealth University

Mark Feger, PhD, ATC, owes his interest in the profession to Robert Moss, PhD, ATC, at Albion College, who noticed on an intake form that he had selected athletic training as an area of interest. Although admittedly, Feger knew very little of the profession at the time, his involvement with the Albion College athletic training faculty, sideline interactions with athletes, and the hands-on approach to medicine spurred and maintained his passion for athletic training.

Feger's bachelor's degree in athletic training from Albion College prepared him for his master's and doctoral work at the University of Virginia. He is currently in his third year at the Virginia Commonwealth University School of Medicine and plans on becoming an orthopaedic surgeon. He hopes to merge his research experience from the University of Virginia with his medical school training to continue his study of appropriate interventions for patients with orthopaedic injuries.

Throughout his clinical experience, Feger most enjoyed his first position as an athletic trainer working with men's soccer at Virginia Military Institute, where he loved the increase in responsibility and the ability to work with soccer, which he played as an undergraduate. There he gained an appreciation for the role of lifelong learning in medicine and the benefit of humility in recognizing the need for collaboration to effectively manage an athlete's condition. Being humble enough to ask for help and inquisitive of mentors about their rationales for the clinical decisions they make are traits he considers pivotal to his success as an athletic trainer.

Feger's passion for research in the assessment and treatment of joint injury began as a master's student when he was exposed to the work of Jay Hertel, PhD, ATC, FNATA, FACSM, on ankle instability. Feger hopes to advance the current knowledge on functional outcomes and determine appropriate interventions to restore normal biomechanics after injury. Just because a patient has an ankle, knee, or other injury does not automatically mean that he or she will require a specific intervention. Feger believes that clinicians should always strive to assess limitations and to treat the specific impairment only in those patients who will benefit. In collaboration with Luke Donovan, PhD, ATC, Feger has worked to develop a screening tool for excessive ankle inversion during functional tasks and is now looking at how to recognize and target only those patients with excessive inversion and a history of ankle sprains who may be predisposed to subsequent sprains and may benefit from targeted rehabilitation.

When asked to give advice to future athletic trainers seeking a career in academia, Feger encouraged the pursuit of education in all aspects of athletic training, in the classroom, the clinic, and on the sideline. Feger finds it rewarding to teach students with a desire to learn. He hopes that future educators will chal-

lenge students to learn not just the answers to specific questions but the material in greater depth in order to manipulate and apply it to provide exceptional health care in the future.

Outside of athletic training, Feger still enjoys playing soccer, both indoors and outdoors. He also likes to stay active by hunting and fishing and exploring the wide variety of food, beer, and wine available in Richmond, Virginia, with his wife, Hailey. Feger thanks Bob and Carol Moss, who introduced him to and sparked his passion for athletic training; Jay Hertel, who has been instrumental in his academic career and an exceptional mentor over the last 8 years; his dissertation committee—Joseph M. Hart, PhD, ATC, FNATA, FACSM; Susan A. Saliba, PhD, PT, ATC, FNATA; and Mark F. Abel, MD—for their hard work and guidance; and Hailey, his supportive spouse, for her unwavering love and encouragement.





David H. Perrin, PhD, ATC, FNATA, FACSM

David H. Perrin, PhD, ATC, FNATA, FACSM, is a respected researcher, educator, mentor and friend of athletic training. This 2003 NATA Hall of Fame inductee is a noted pioneer of terminal degrees in sports medicine, and his dedication to athletic training is making an impact on the profession's development even today.

Serving as editor-in-chief of the *Journal of Athletic Training* and founding editor of the *Journal of Sport Rehabilitation* are only two of Dr. Perrin's significant achievements. Others include being awarded NATA's Sayers "Bud" Miller Distinguished Educator Award in 1996, Most Distinguished Athletic Trainer Award in 1998, and All-University Outstanding Teaching Awards from the University of Virginia in 1997 and 1998.

Dr. Perrin has built research education programs at the undergraduate, master's, and doctoral levels and has fully dedicated himself to mentoring and developing future scholars. Dr. Perrin makes every effort to maximize his students' potential by offering sound advice and helping them make the most of their educational programs. Many of his students have gone on to bright careers in the profession, as researchers, program directors, clinical supervisors, and award-winning scholars.

Dr. Perrin is dean of the College of Health and professor of Exercise and Sport Science at the University of Utah.

The NATA Foundation Doctoral Dissertation Award, presented in honor of David H. Perrin, recognizes outstanding doctoral student research and is a fitting tribute to a man who has dedicated the duration of his career to mentoring and developing future scholars.

Free Communications, Oral Presentations: Is Shoulder Mobility Good or Bad?

Wednesday, June 27, 2018, 7:30AM-9:15AM, Room 206–207; Moderator: Elizabeth Hibberd, PhD, LAT, ATC

Shoulder External, Internal and Total Range of Motion Relationship to Injury Incidence in Professional Baseball Players Michener LA, Plummer HA, Abeles B, Waldman E, Kindstrand N, Hostetter G, Li B: University of Southern California, Los Angeles, CA; Andrews Research & Education Foundation, Gulf Breeze, FL; Los Angeles Angels, Anaheim, CA

Context: Prior studies in youth and high-school baseball players have found that pre-season deficits in shoulder internal rotation (IR) range of motion (ROM) predict an increased incidence of shoulder and elbow injuries. In professional baseball players, prior studies indicate a loss in external rotation (ER) predicts shoulder injuries, but contradictory evidence of IR deficits to predict injury. **Objective:** Determine the relationship between pre-season ROM and upper extremity injuries in professional baseball players. It was hypothesized there would be greater deficits in shoulder ROM in those who sustained a shoulder or elbow injury during the season compared to non-injured, and pre-season ROM deficits would predict injuries. Design: Prospective cohort. Setting: Athletic Training Room Patients or Other Participants: Minor League baseball players (n = 65; 21.7 \pm 2.6 years) in 2018-7 season. Players not cleared to participate or rehabilitating an upper extremity injury at testing were excluded. Interventions: Pre-season shoulder IR and ER ROM was measured at 90° of shoulder abduction in supine with an inclinometer. Shoulder and elbow injuries were tracked throughout the competitive season. An injury was defined as any shoulder or elbow injury occurring during any baseball related activity; contact injuries were excluded from analysis. A one-way ANOVA was performed to compare ROM measures between the injured and non-injured groups. Binary logistic regression analysis was used to determine the ability of ROM measures to predict incidence of injury. Analyses were performed, alpha = 0.05. Main Outcome Measures: Shoulder IR and ER ROM of throwing shoulder, and absolute difference in IR and ER between shoulders (throwing-non-throwing shoulder) labeled glenohumeral IR deficit (GIRD) and ER-deficit. **Results:** There were n = 19injured (INJ) $(20.9 \pm 2.2; 186.9 \pm 5.8)$ cm; 89.3 ± 9.6 kg), and n = 46 noninjured (Non-INJ) $(22.2 \pm 2.7 \text{ years})$ 184.9 ± 6.4 cm; 90.1 ± 10.6 kg) players. There were no differences between INJ and Non-INJ groups in throwing shoulder IR ROM (mean difference $= 4.4^{\circ}; 95\%$ CI:-12.4, 3.5; p = 0.269), ER ROM (mean difference = 2.8° ; 95% CI:-8.9, 3.4; p = 0.375), or differences between shoulders for GIRD (mean difference = -2.1° ; 95% CI:-8.6, 4.5; p =0.530) or ER-deficit (mean difference $= 0.25^{\circ}; 95\%$ CI:-6.2, 6.7; p = 0.973. Logistic regression analysis was not significant for any shoulder ROM measures, indicating no predictive ability for the development of upper extremity injury. Conclusions: Identifying factors that contribute to injury risk will enable knowledge to develop prevention programs. Pre-season shoulder ROM deficits could not identify or predict players who sustained a shoulder or elbow injury during the season. Our results contradict prior literature that found IR deficits predicted injuries in youth and high school, and ER and IR ROM deficits predicted injury in professional players. The lack of a relationship of ROM with injuries in this study may be due to the current common standards of stringent monitoring of ROM in professional baseball players over the season.

Glenohumeral Joint Laxity and Stiffness in Collegiate Pitchers With and Without Total Range of Motion Deficit

Leddon CE, Harter RA: Sports Medicine Laboratory, Oregon State University, Corvallis, OR; Cincinnati Reds Major League Baseball Club, Goodyear, AZ; Biomechanics/Sports Medicine Laboratory, Texas State University, San Marcos, TX

Context: Rotational range of motion deficit in the thrower's shoulder has been theorized to be caused by a restriction or thickening of the posterior glenohumeral (GH) joint capsule, or a tightening of the posterior rotator cuff musculature. This loss of motion has been associated with an array of shoulder injuries common among throwing athletes. **Objective:** To determine whether a total range of motion deficit (TRMD) in the throwing shoulder, compared to the non-throwing shoulder, affects GH joint laxity and stiffness. Design: Cross-sectional cohort. Setting: Research laboratory setting. Patients or Other Participants: 47 intercollegiate baseball pitchers (age, 19.7 + 1.2 yrs; hgt, 183.9 + 5.5 cm; mass, 85.9 + 10.2 kg; years pitched, 9.9 + 2.8 yrs). Interventions: Glenohumeral internal and external rotation range of motion was measured bilaterally with a digital inclinometer in 47 intercollegiate pitchers. Pitchers with greater than a 10° deficit of rotational motion in their dominant shoulder were classified in the TRMD group (n = 24), while the Non-TRMD group (n = 23) had less than a 10° ROM deficit. Participants then had their anterior and posterior GH joint laxity and mechanical stiffness measured with a multijoint arthrometer. Main Outcome Measures: Anterior and posterior GH joint laxity (mm) under 150N loads applied at a rate of 15 N/s; anterior and posterior GH joint stiffness (N/mm). Glenohumeral joint

laxity and stiffness measures were normalized within participants by calculating difference measures of the dominant arm minus the non-dominant arm. The normalized laxity and stiffness values were then compared using a Group (2) x Direction (2) ANOVA. Results: Anterior GH laxity in throwing shoulders was 8.6 + 1.4 mm compared to 8.3 + 1.7 mm in the non-throwing shoulders (p > 0.05). Similarly, mean posterior GH laxity was 8.0 + 2.1 mm in the dominant limbs compared to 7.7 + 2.0 mm in the non-dominant limbs (p > 0.05). After normalization procedures, we found a significant Group x Direction interaction (p = 0.023) for GH laxity, which we attributed to differences in posterior laxity measures between the TRMD and Non-TRMD groups (Cohen's d = 0.65). Prior to normalization procedures, we observed significantly greater posterior GH stiffness (28.72 ± 7.18 N/mm) compared to anterior GH stiffness (22.64 \pm 5.02 N/mm) (p < 0.001). <u>Conclusions:</u> The increased posterior GH stiffness values found in the dominant arms of pitchers with a total range of motion deficit were likely due to what other researchers have described as thickening of the posterior capsule as a result of repeated distraction forces imparted during the follow-though phase of pitching. This study should be replicated with the addition of diagnostic ultrasound or MRI to quantify the physical dimensions of the GH soft tissues being tested.

Humeral Retroversion and Participation Age Differ Based on Geographical Region in Professional Baseball Pitchers Thomas SJ, Sheridan S: Department of Kinesiology, Temple University, Philadelphia, PA; Philadelphia Phillies, Philadelphia, PA

Context: Sports specialization in the US is a common concern in youth sports. It has been demonstrated that specializing in one sport at a young age can lead to significant overuse injuries due to repetitive stress. This has been observed in baseball, however the stress of throwing has also been thought to create positive tissue adaptations like humeral retroversion (HR). Therefore, it is thought that throwing should be initiated at a young age to capitalize on this adaptation. Interestingly, each geographic region of the world often institutes organized baseball at different ages. However, HR and the starting age of baseball has never been examined based on geographic region. **Objective:** The primary objective of this study was to determine if HR and the starting age of baseball differ between professional baseball pitchers from Latin America compared to pitches from North America. Design: Crosssectional design. Setting: Clinical setting. Patients or Other Participants: Thirty professional pitchers (Latin America n = 11 and North America n =19) with no current injury or surgery in the past six months participated (Latin America: age = 22.2 ± 3.1 years, mass $= 96.6 \pm 9.8$ kg, height $= 189.1 \pm 2.9$ cm; North America: age = 22.7 ± 3.8 years, mass = 95.7 ± 8.4 kg, height = $191.7 \pm$ 5.7 cm). Interventions: Geographic region (Latin America vs North America) was the independent variable. HR (dominant and non-dominant arm) was assessed with diagnostic ultrasound (Sonosite Titan, Sonosite Inc., Bothell, WA). Starting age of baseball was self-reported using a questionnaire. Independent sample t-tests were performed to compare HR and the starting age of baseball between Latin America and North American baseball pitchers. Main Outcome Measures: HR was measured supine with the arm abducted to 90° and elbow flexed to 90° using standard procedures that have demonstrated both validity and reliability. **Results:** The Latin America group had significantly more dominant arm HR (8.7°, p=0.034) yet started playing baseball at a later age (3.7 years, p=0.021) compared to the North America group. There were no group differences for non-dominant arm HR (6.5°, p=0.058), however it can be considered a trend. Conclusions: HR on the dominant arm was found to be significantly greater in Latin American compared to North American players. Currently this bony adaptation is considered to be beneficial as it allows more glenohumeral external rotation during the cocking phase of the pitching motion without soft tissue stretching. Latin American players also started playing baseball at an older age. This is interesting as it is often thought that this adaptation will be more pronounced if baseball is initiated at a young age, however these results conflict with that hypotheses. This demonstrates that more research is required to better understand the normal development of HR.

Ultrasound Comparisons of Bilateral Asymmetries Among Youth and Collegiate Overhead Athletes of Different Sports

Struminger AH, Atanda A Jr, Buckley TA, Richards JG, Swanik CB: Eastern Michigan University, Ypsilanti, MI; Nemours/Afred I. Dupont Hospital for Children, Wilmington, DE; University of Delaware, Newark, DE

Context: Dissipating loads from dynamic upper extremity activity can lead to bilateral asymmetries that precipitate injuries in youth and adult overhead athletes in multiple sports. It is unclear how developmental and biomechanical differences among these athletes may impact bilateral variations in shoulder and elbow anatomy. Objective: To determine whether athletes of different ages and sports exhibit distinctive tissue characteristics when compared bilaterally. Design: Cross-sectional Setting: Research laboratory Patients or Other Participants: Baseball (n = 54), softball (n = 46), and tennis (n = 32) players having competed competitively for at least two consecutive seasons participated. Youth athletes (31 male, 25 female, Age = 13.1 ± 1.2 years, Weight = 54.3 ± 14.1 kg, Height = 163.0 ± 10.6 cm) ranged from ages 11-14. College athletes (38 male, 38 female, Age = 19.7 \pm 1.4 years, Weight = 76.9 \pm 13.8 kg, Height = 175.4 ± 10.3 cm) ranged from ages 18-23. Participants who had undergone surgery within the last year were excluded. Interventions: Participants were stratified into groups based on age and sport, which were the independent variables. Investigators used musculoskeletal ultrasound to examine upper extremity tissue characteristics and a digital inclinometer to measure range of motion (ROM). Main Outcome Measures: Dependent variables were glenohumeral internal rotation (IR), glenohumeral external rotation (ER), posterior capsular (PC) thickness, humeral retrotorsion (HR), and ulnar collateral ligament (UCL) thickness. For all dependent variables, the mean of two measures on the non-dominant arm was subtracted from the mean of two measures on the dominant arm. Pearson correlations determined that the potential covariates of pubertal development and age of sport initiation were not significantly related to any dependent variables. Therefore, data were analyzed using 2-way between subjects ANOVAs and Tukey HSD post-hoc testing as appropriate. Results: No significant interaction effects arose for any of the ultrasound measures. However, significant main effects existed for PC thickness, indicating that it was significantly greater in baseball players (0.15 \pm 0.12 mm) compared to softball athletes $(0.10 \pm 0.10 \text{ mm})$. Collegiate athletes also exhibited more PC thickness $(P < .001; 0.16 \pm 0.12 \text{ mm})$ and UCL thickness (P = .024; 0.42 \pm 0.61 mm) than youth athletes (PC thickness = 0.07 ± 0.08 mm; UCL thickness = 0.16 \pm 0.39 mm). An interaction effect for IR occurred (P = .045) where collegiate softball athletes (-9.9 \pm 6.4°) were 3° more asymmetric than youth softball players (-6.9 \pm 5.2°). Conversely, collegiate tennis athletes $(-6.7 \pm 6.6^{\circ})$ were 4° more symmetric than their youth counterparts (-10.3 \pm 3.8°). No main effects for age were present for HR, ER, or IR. Conclusions: These data indicate that bony and range of motion changes in 11-14-year-old overhead athletes are similar to those observed in a collegiate population. However, soft tissue bilateral asymmetries only appeared at the collegiate level. Excessive tissue proliferation in the dominant arms of baseball players may indicate that baseball was the most stressful sport on the shoulder examined in this investigation. Tissue characteristic variations across groups indicate the need for sport and age specific prevention and rehabilitation programs, especially in youth athletes, that address underlying anatomical differences associated with each population.

Relationship Between Range of Motion, Strength, Upper Quarter Y-Balance Test and a History of Shoulder Injury Among NCAA Division I Overhead Athletes Kim Y, Wellsandt E, Lee JM, Rosen AB: Utah State University, Logan, UT; University of Nebraska Medical Center, Omaha, NE; University of Nebraska, Omaha, NE

Context: The shoulder is subjected to high levels of force during dynamic movement in overhead athletes making it a common site for injury. Several risk factors have been identified as contributors to the development of shoulder injuries, including glenohumeral internal rotation deficit, rotator cuff weakness, and shoulder instability. Previous investigations assessing the physical characteristics among overhead athletes with a history of a shoulder injury have been inconclusive and require further investigation to identify lasting deficits that may exist in this population. **Objective:** To compare shoulder range of motion (ROM), strength, and upper quarter dynamic balance between collegiate overhead athletes with and without a history of a shoulder injury. Design: Case-control. Setting: Athletic training clinic. Patients or Other Participants: 58 overhead athletes were distributed into a history of shoulder injury (n =25, age: 20.0 ± 1.2 years, mass: 78.6 \pm 12.3 kg, upper limb length: 92.1 ± 5.5 cm) and healthy group (n = 33, age: 20.1 ± 1.1 years, mass: 79.0 ± 12.0 kg, upper limb length: 91.7 ± 4.1 cm). Participants were recruited if they were fully participating in NCAA division I baseball, softball, volleyball, or tennis and free of any current signs or symptoms of shoulder injuries. Participants in the history of shoulder injury group had a previously resolved shoulder injury that was diagnosed by an athletic trainer or physician and required treatment. Interventions: A reliable rater (ICC's = 0.81-0.97) measured active ROM for internal rotation (IR), external rotation (ER), and horizontal adduction (HAD) of the dominant shoulder using a digital inclinometer. Isometric strength for dominant shoulder IR and ER at 90° of abduction was standardized and measured using a hand-held dynamometer. The upper quarter dynamic balance was assessed via the Upper Quarter Y Balance Test (UQYBT). Main Outcome Measures: One-way analyses of variance (ANOVA, $p \le 0.05$) and Cohen's d effect sizes were calculated to compare differences in ROM, strength, and UQYBT between the injury and healthy groups. Results: The injury group demonstrated a lower UQYBT mean score in the superolateral direction (p = 0.033, d = 0.56). However, there were no statistically significant intergroup differences in shoulder IR ROM (p = 0.541, d = 0.16), ER ROM (p = 0.921, d = 0.03), HAD ROM (p =0.946, d = 0.02), IR strength (p = 0.280, d = 0.29), ER strength (p = 0.238, d =0.32), ER/IR strength ratio (p = 0.377, d = 0.24), medial direction of UQYBT (p = 0.716, d = 0.10), and inferolateral direction of UQYBT (p = 0.493, d =0.18). Conclusions: The results of this study showed that while there were no differences in ROM or strength, those with a previous history of shoulder injury had poorer UQYBT in the superolateral direction despite a lack of ongoing symptoms or deficits in function. The diagonal pattern of the superolateral direction in UQYBT is related to overhead motions, such as throwing, serving, and spiking. Therefore, this study suggested that clinicians should examine the diagonal pattern and provide overhead athletes with proper upper quarter dynamic balance and stabilization training to potentially prevent recurrence of the shoulder injury.

Posture and Cervical Mobility are Associated With Shoulder and Elbow Pain and Disability in College Baseball Players Devaney LL, Bodurtha R, Chin A, Koudelka J, Mulligan R, Marrone W, Francisco J: University of Connecticut, Storrs, CT

Context: Upper extremity injuries in baseball players have been on the rise for three decades at all levels of play resulting in significant disability. Cervicothoracic impairments have not been explored as risk factors for throwing-related shoulder and elbow pain and disability. **Objective:** To investigate the relationship between spinal impairments (kyphosis and cervical mobility) and throwing-related shoulder and elbow pain and disability in college baseball pitchers. Hypothesis: Increased kyphosis and decreased cervical mobility are associated with reported pain and disability across a season. Design: Prospective cohort study Setting: Division I University Patients or Other Participants: Thirty-eight currently healthy college baseball players age 18-23 years old were enrolled during preseason. Four players left the team and one player was excluded due to incomplete data. Thirty-three players were included in the final analysis with a mean age of 20.09 ± 1.18 years, height $71.95 \pm$ 1.92 inches, and weight 203.73 ± 22.82 pounds. Interventions: Injury history, hand dominance, and years experience were recorded, and posture (Inclinometric Kyphosis Measure- IKM) and cervical mobility (Cervical Flexion Rotation Test-CFRT) were measured during preseason (Figure 1). Both the IKM (ICC = 0.98(95% CI 0.94-0.99), SEM = 1.28°, MDC = 3.55°) and CFRT (ICC = 0.95 (95% CI 0.90-0.98), SEM = 3° , MDC = 7°) have excellent reliability. Main Outcome Measures: Pain and disability were reported at baseline and weekly during the season using the Disabilities of the Arm, Shoulder, and Hand Sports Module (DASH-SM). Spearman's rho and a linear regression model analyzed the relationship between physical measures and average DASH-SM scores. ROC curves and risk ratios assessed the utility of the physical measures as risk factors **Results:** Mean scores were $143.6^{\circ} \pm$ 7.22 for IKM, $36.05^{\circ} \pm 10.32$ and 38.36° \pm 12.70 for dominant and non-dominant CFRT, and $3.53 \pm .91$ for the DASH-SM.

Twenty-seven percent of players reported an average DASH-SM >5. Dominant CFRT and Total CFRT (dominant plus non-dominant) were negatively correlated with the average DASH-SM (r = -.447, p = .010; r = -.444, p = .011). The IKM trended toward a significant inverse correlation (r = -.303, p = .092) and was included in the regression. Total CFRT and IKM measures accounted for 19.9% (p = .011) and 12.4% (p = .029) of the variance in DASH-SM score, respectively. ROC curves identified optimal cut points of 143.5° for the IKM (AUC .805 [95% CI .656-.954] p = .010, Sn 1.00, Sp .64) and 38.5° for dominant CFRT (AUC .753 [95% CI .532-.973], p = .034, Sn.88, Sp .64), but lack of precision of the risk estimates limits conclusions regarding the utility of these measures as risk factors (CFRT RR = 15.53 [95% CI .80-555.32]; IKM RR = 7.44, [95% CI .78-117.93]). Conclusions: Increased kyphosis and decreased upper cervical mobility were associated with shoulder and elbow pain and disability in college baseball players across a season. These measures should be further explored as potential modifiable risk factors and targets for intervention to reduce injury.



Inclinometric Kyphosis Measure (IKM) of dorsal kyphosis.

Cervical Flexion Rotation Test (CFRT) of upper cervical rotation mobility.

The Effects of a Shoulder Stretching and Strengthening Intervention on Shoulder Benchmarks in Collegiate Softball Players

Kimura B, Montalvo AM: Wake Forest University, Winston-Salem, NC; Florida International University, Miami, FL

Context: Overhead athletes must have a balance between shoulder strength, shoulder internal rotation (IR), and shoulder external rotation (ER) to reduce risk of injury. In most cases, an increase in shoulder strength can lead to a decrease in shoulder IR by 20 ° or more in the throwing arm compared to the non-throwing arm. Existing research has only examined the effects of strengthening or flexibility programs independently, but not both combined. **Objective:** The objective of this study was to investigate the effects of a shoulder strengthening and stretching program on shoulder IR and ER range of motion, throwing speed, and disability in collegiate softball players. Design: Prospective cohort study. Setting: Softball field. Patients or Other Participants: A team of eighteen Division I softball players (age = $19.5 \pm$ 1.3 yrs, height = 65.3 ± 2.6 in, weight = 148.4 ± 20.8 lbs) participated in the research. Interventions: Participants completed a four week arm care intervention two to three days per week before practice during the preseason. The intervention consisted of two sets of eight repetitions of five resistance band exercises (shoulder horizontal abduction, shoulder scaption-flexion, shoulder extension, and shoulder IR and ER in abduction) and three sets of a 30 second shoulder IR stretch (sleeper stretch). Bilateral shoulder IR and ER range of motion were measured by cell phone inclinometer app, throwing speed was measured by radar gun, and shoulder disability was measured by the Disability of Arm, Shoulder, and Hand form. All outcomes were measured at pretest and posttest. Main Outcome Measures: Bilateral shoulder IR and ER range of motion, throwing speed, and disability were the dependent variables. Paired t-tests were used to compare athletes at pretest and posttest and significance was established at $p \le 0.05$. **Results:** The mean overall compliance rate was $95.3\% \pm 12.4$. The maximum compliance rate was 100% (n = 14). The minimum compliance rate was 50% (n = 1). Dominant shoulder IR increased significantly $(54.7 \pm 13.6^{\circ} \text{ vs } 60.7 \pm$ 12.3° , p = 0.011) and throwing speed decreased significantly $(53.4 \pm 4.4 \text{ mph})$ vs 51.8 ± 4.3 mph, p = 0.005) from pretest to posttest. There were no changes in non-dominant shoulder IR (67.6 $\pm 12.8^{\circ}$ vs 74.9 $\pm 15.1^{\circ}$, p = 0.052), dominant shoulder ER (90.9 \pm 14.8° vs $86.9 \pm 16.2^{\circ}$, p = 0.481), non-dominant shoulder ER (83.9 \pm 12.7° vs 86.1 \pm 11.6° , p = 0.413), or shoulder disability $(9.1 \pm 5.7 \text{ vs } 12.7 \pm 10.4, \text{ p} = 0.871)$ from pretest to posttest. Conclusions: The sleeper stretch increased shoulder IR without changing shoulder ER. Four weeks' time may have been insufficient to increase strength in the newly acquired shoulder range of motion, which may have resulted in a decrease in throwing speed. Disability did not change following the intervention, though disability may have been low at the start of the preseason.

Free Communications, Oral Presentations: Risk Factors for Ankle Injury

Wednesday, June 27, 2018, 9:30AM-10:45AM, Room 206-207; Moderator: Matthew Hoch, PhD, ATC

Biomechanical and Clinical Risk Factors for Recurrent Ankle Sprains in Chronic Ankle Instability: A 6-month Follow-up Son SJ, Bruening DA, Feland JB, Seeley MK, Hopkins JT: Cha University, Seongnam, Korea; Brigham Young University, Provo, UT

Context: Patients with chronic ankle instability (CAI) have demonstrated altered movement patterns during landing and cutting, which are common mechanisms of ankle sprains. However, it is difficult to examine a casual effect between altered movement patterns and risk of ankle sprains in a retrospective study. **Objective:** To compare landing/ cutting biomechanics and clinical measures in CAI patients with recurrent sprains and without recurrent sprains at a 6-month follow-up. Design: Cohort. Setting: Laboratory. Patients or Other Participants: 91 of 100 CAI patients completed a 6-month follow-up survey after initial data collection. 13 CAI patients (7 M, 6 F, 22 ± 2 yrs, 174 ± 11 cm, 75 ± 15 kg, $84 \pm 5\%$ FAAM-ADL, $65 \pm 12\%$ FAAM-Sports) reported recurrent sprains within 6 months, and 78 CAI patients (39 M, 39 F, 22 \pm 2 yrs, 174 \pm 11 cm, 74 \pm 14 kg, 85 \pm 6% FAAM-ADL, 69 \pm 10% FAAM-Sports) did not have recurrent injury. Interventions: Subjects performed 10 jumps consisting of a maximal vertical forward jump-landing plus cutting at 90 deg, while lower extremity joint kinetic and kinematic data were collected. Functional linear models and t-test were used to detect between-group differences. If 95% confidence intervals did not overlap zero, differences were significant. Main Outcome Measures: 3D GRFs (body weight; BW), sagittal lower extremity joint power (W/kg) and stiffness (Nm/kg/deg) during landing/cutting, and numerous descriptive clinical measures. Results: Figure 1 shows that CAI patients with recurrent sprains within 6 months demonstrated increased vertical (0.2 BW) and medial (0.03 BW) GRF, and increased eccentric ankle power (1.3 W/kg, greater energy absorption) during initial landing. CAI patients with recurrent sprains demonstrated decreases in ankle (0.039 \pm 0.012 vs. 0.043 \pm 0.012; p = 0.04, Cohen's d: 0.29) and hip joint stiffness $(0.08 \pm 0.046 \text{ vs.} 0.11 \pm 0.093; \text{ p})$ = 0.001, Cohen's d: 0.35) during landing compared to CAI patients with no recurrent sprains, while no knee joint stiffness differed between groups (0.043 \pm 0.021 vs. 0.046 \pm 0.021; p = 0.24). CAI patients with recurrent sprains had a greater number of previous sprains (5.8 ± 2) and "giving way" episodes (5.6 ± 3) than those who did not have recurrent sprains $(3.3 \pm 2 \text{ sprains}, 2.5 \pm$ 3 "giving way" episodes; p < 0.05) at a 6-month follow-up. No differences were identified in clinical measures (p > 0.05): dorsiflexion ROM (44 ± 6 vs. 45 ± 7 deg), star excursion balance testanterior direction $(49 \pm 6 \text{ vs. } 49 \pm 9\%)$ of leg length), arch height index (0.37) \pm 0.02 vs. 0.35 \pm 0.02), Biodex static single-leg overall stability index (0.92 \pm 0.2 vs. 0.78 \pm 0.02), figure 8 hop for time $(11.8 \pm 3.7 \text{ vs. } 11.6 \pm 2.1 \text{ sec})$, triple cross-over hop for distance (4.9 \pm 1.5 vs. 4.9 ± 1.1 m), physical activity exposure $(5.3 \pm 3 \text{ vs. } 6.1 \pm 3 \text{ hours})$ week), and BMI (25.1 ± 5 vs. 24.3 ± 4). Conclusions: CAI patients who had recurrent injury within 6 months demonstrated altered kinetic movement strategies, an inability to modulate ground impact during initial landing. Reduced ankle joint stiffness along with greater impact (vertical GRF and eccentric power) during initial landing may predispose this patient population to recurrent ankle sprains within 6 months.

The Risk of Ankle Sprains Based on Arthrometer Measurements: A Longitudinal Study

Perry M, Liu K, McConnell W, Gustavsen G, Kaminski TW: University of Evansville, Evansville, IN; University of Delaware, Newark, DE

Context: Ankle sprains are one of the most common injuries found in in the collegiate athletic setting. It is essential for athletic trainers to be knowledgeable about the injury risk to better incorporate treatment plans and prevention programs. **Objective:** To take baseline measurements of ankle joint laxity and document ankle sprains over the course of the athlete's collegiate career. Design: Longitudinal prospective study. Setting: Athletic Training Laboratory. Patients or Other Participants: 41 NCAA Division I male football players athletes (age = 18.6 ± 1.2 years, height = 186.4 ± 7.3 cm, weight = 103.2 ± 20.3 kg) were recruited for this study. Interventions: Ankle joint laxities in the anterior, inversion, and eversion directions were measured using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL). Each athlete's preseason measurements were recorded and the sports medicine staff documented each ankle sprain that occurred thereafter. Main Outcome Measures: The primary outcome of interest was incidence of ankle sprain at the end of a collegiate career, treated dichotomously. The primary independent variables were baseline measurements of ankle laxities in the three directions, divided into quartile ranges. Logistic regressions were used to estimate the odds of an ankle sprain, controlling for BMI, based on quartile ranges of laxity in three directions. Average marginal effects were also calculated to estimate the probability of an ankle sprain for the quartiles of ankle laxity. Results: 11 participants sustained an ankle sprain over the course of

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this study with 7 participants sustaining unilateral sprains and 4 spraining both ankles. Laxities in the anterior and eversion directions were not associated with injury risk. However, those in the second quartile of laxity in the inversion direction had increased odds of 14.96 (95% CI 1.27-175.24, P = 0.031) for an ankle sprain in the same ankle with an increased probability of 37% compared to those in the first quartile. Further, laxity in the inversion direction in the third and fourth quartiles had increased odds of 15.89 (95% CI 1.11-225.74, P = 0.041) and 21.62 (95% CI 1.06-438.39, P = 0.045) and 37% and 42% increased probability, respectively, compared to those in the first quartile for a contralateral ankle injury. Those in the third and fourth quartiles of laxity of inversion in the ankle had increased odds of 24.63 (95% CI 1.66-365.32, P = 0.020) and 72.77 (95% CI 3.04-1741.21, P = 0.008)with 45% and 64% increased probability, respectively, for all ankle sprains. **Conclusions:** Not only does an increase in laxity increase the odds of sustaining an ankle sprain in the same ankle, it also increases the odds of a contralateral ankle sprain. Although longitudinal injury risk studies are a large time commitment, they can help to better identify true risk factors. After ascertaining the risk factors, interventions can then be determined to decrease the overall incidence of injuries.

Prediction Capability of the Star Excursion Balance Test for Recurrent Ankle Sprains in High School and College Student Athletes

Terada M, Kosik KB, McCann RS, Gribble PA: Ritsumeikan University, Kusatsu, Shiga-ken, Japan; University of Kentucky, Lexington, KY; Old Dominion University, Norfolk, VA

Context: Mounting evidence on sport injuries has shown a high recurrence rate of lateral ankle sprain (LAS). Decreased dynamic postural control has been retrospectively identified in athletic patients with recurrent ankle sprain (RAS), as well as considered as a potential risk factor for RAS. Previously, the SEBT has been utilized in prediction of acute LAS by assessing athletes' dynamic postural control performance, but the ability of the SEBT to predict RAS in high school and college student athletes has not been investigated. Establishing models of prediction for RAS using the SEBT could lead to more efficient preventative strategies to reduce RAS. **Objective:** Determine the ability of the SEBT to predict RAS in high school and college student athletes. **Design:** Prospective cohort study. Setting: Athletic training facilities. Patients or Other Participants: Three hundred five high school and collegiate athletes (basketball, football, soccer, and volleyball) with a previous history of an acute LAS volunteered (F: 111, M: 194; 18.46 ± 2.95 yrs; 176.69 ± $10.21 \text{ cm}; 78.42 \pm 19.60 \text{ kg}$). All athletes were cleared for full participation at the time of the study. Interventions: Prior to the beginning of the competitive season, athletes with a history of LAS bilaterally completed the SEBT in the anterior (SEBT-A), posteriormedial (SEBT-PM), and posteriorlateral (SEBT-PL) directions. The Athletic Trainer with each team recorded RAS incidences over a competitive season. Main Outcome Measures: Three trials of each SEBT direction were averaged and normalized as a percentage of stance leg length (%). Additionally, the mean of the three directions created a composite score (SEBT-Comp). The re-injured side of the RAS group was used for group comparison. The mean of both sides from the non-RAS players were used. Independent t-tests were utilized to compare SEBT scores between groups. Receiver operator characteristic curves were performed to examine prediction capability of the SEBT scores for RAS using the area under the curve (AUC). Significance was set a priori at P < 0.05. <u>Results:</u> One hundred twenty-two participants with a history of LAS experienced a RAS during a competitive season, while 183 those with a history of LAS were placed in the non-RAS group. Participants with RAS had lower SEBT scores compared to those without RAS (SEBT-A: RAS = 65.26%, Non-RAS = 68.39%, P < 0.001, SEBT-PM: RAS = 81.17%, Non-RAS = 85.17%, P = 0.001, SEBT-PL: RAS = 72.43%, Non-RAS = 75.43%, P = 0.04, SEBT-Comp: RAS = 72.91%, Non-RAS = 76.73%, P < 0.001). Deficits in dynamic postural control on the SEBT provided potential predictive values for RAS (SEBT-A: AUC = 0.64, P < 0.001, SEBT-PM: AUC = 0.61 P = 0.002, SEBT-Comp: AUC = 0.62, P < 0.001). Conclusions: High school and collegiate student athletes that sustained a RAS during a competitive season had lower SEBT scores before the season began. Data from this current study indicate that a specific measure of dynamic postural control may provide insight on identification of increased risk of RAS. This may lead to prevention strategies to reduce the likelihood of sustaining a RAS during sports participation.

The Risk of Ankle Sprains Based on Dynamic Stability Measurements: A Longitudinal Study

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Context: Although a seemingly innocuous injury, ankle sprains are the most common injury in collegiate athletics. Deficits in dynamic stability have been associated in those with a previous history of ankle sprains. However, it is not known whether deficits in dynamic stability increase the risk of a sustaining an ankle sprain. Objective: To take baseline stabilization measurements and follow athletes over the course of their collegiate career for any subsequent ankle sprain. Design: Longitudinal prospective study. Setting: Athletic Training Laboratory. Patients or Other Participants: 79 NCAA Division I collegiate athletes (gender = 67 M, 12 F, age = 18.8 ± 1.6 years, height = $187.7 \pm$ 8.5 cm, weight = 97.3 ± 19.3 kg) were recruited for this study. Interventions: Dynamic stability was quantified as a time-to-stabilization (TTS) of the vertical ground reaction force to fall within 5% of the participant's body weight after landing from a jump from the medial (M), lateral (L), forward (F), and backward (B) jump-landing directions onto a force platform. TTS measurements were taken during preseason and any ankle sprain documented by the sports medicine team during their athletic career was recorded. Main Outcome Measures: The primary outcome of interest was incidence of ankle sprain at the end of a collegiate career, treated dichotomously. The primary independent variables were baseline measurements of TTS in the four directions, divided into quartile ranges. Logistic regressions were used to estimate the odds of an ankle sprain, controlling for BMI, based on quartile ranges of TTS. Average marginal effects were also calculated to estimate the probability

of ankle sprain for quartiles of TTS. Results: Of the 158 total ankles, 23% (N = 37) of them sustained at least a single ankle sprain during the course of their career. Means and standard deviations of TTS for the non-injured ankles were: 1.06 ± 0.63 s (M), 1.11 ± 0.65 s (L), 1.20 ± 0.65 s (F), 1.03 ± 0.56 s (B). Means and standard deviations of TTS for the injured ankles were: 1.36 \pm 0.75 s (M), 1.49 \pm 0.88 s (L), 1.16 \pm 0.68 s (F), $1.27 \pm 0.73 \text{ s}$ (B). Dynamic stability in the lateral, forward, or backward jump-landing directions were not associated with injury risk. However, those in the second quartile of stability measurements in the medial jump-landing direction had increased odds of 4.8 (95% CI 1.51-15.23, P = 0.008) for an ankle sprain with an increased probability of 28% compared to those in the first quartile. Conclusions: With only one quartile range of one jump-landing direction presenting with a statistically significant increased odds ratio, it does not seem that dynamic stability measurements reflect a potential risk for an ankle sprain. Based on the lack of increased odds ratios, it seems that high-level collegiate athletes can generate compensatory mechanisms in dynamic stability.

Prediction of Chronic Ankle Instability Following Return-to-Play From a Lateral Ankle Sprain McCann RS, Kosik KB, Terada M, Gribble PA: Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY; Ritsumeikan University, Kusatsu, Shiga-ken, Japan

Context: Patients with a lateral ankle sprain (LAS) commonly return-to-play (RTP) before structural alterations and functional impairments have resolved. However, patients with a LAS also commonly develop chronic ankle instability (CAI). Others have assessed clinical outcomes in patients following an acute LAS in order to predict CAI development, but no previous study has considered the predictive value of clinical outcomes in athletic patients. Additionally, no previous study has examined the predictive value of clinical outcomes collected at RTP. Objective: Determine the ability of clinical outcomes assessed at RTP to predict CAI in athletes 1 year following an acute LAS. Design: Prospective cohort study. Setting: High school and collegiate athletic training facilities. Patients or Other Participants: Twenty-three high school and collegiate athletes with an acute LAS (F: 8, M: 15; 17.7 ± 4.5 yrs; 179.5 ± 12.6 cm; 87.0 ± 28.4 kg). Interventions: At the time of RTP, each participant underwent an evaluation conducted by one member of the research team. One year following the acute LAS, each participant completed the Identification of Functional Ankle Instability (IdFAI) questionnaire. Participants with IdFAI scores >10 and "giving way" episodes that occurred at least monthly were considered to have CAI, and those with scores >11 and "giving way" episodes that occurred yearly or never were considered LAS copers. Main Outcome Measures: Predictor variables assessed during the RTP evaluation consisted of involved limb pain (100mm visual analogue scale), limbto-limb differences in swelling (figure-of-eight girth measurement [cm]),

limb-to-limb differences in dorsiflexion ROM (weight-bearing lunge test [cm]), ligamentous laxity (anterior drawer and talar tilt tests [4-point scale]), limbto-limb differences in Star Excursion Balance Test anterior reach scores normalized as a percentage of leg length (SEBT-ANT [% LL]), and involved limb Foot and Ankle Ability Measure activity of daily living (FAAM-ADL) and sport (FAAM-S) scores. We compared outcomes between groups with independent t-tests. The predictive value of outcomes that differed between groups was analyzed with area under the receiver operating characteristic curve (AUROC) and a diagnostic odds ratio (DOR). Results: At the 1-year follow-up, 18 participants presented as having CAI and 5 presented as LAS copers. Participants with CAI had significantly greater limb-to-limb SEBT-ANT deficits $(-5.3 \pm 4.9 \%)$ compared to LAS copers $(-0.4 \pm 3.8 \%)$ at RTP (P = 0.05), as well as significantly lower FAAM-ADL scores ($86.4 \pm 8.8 \%$) compared to LAS copers (92.1 \pm 3.5 %) at RTP (P = 0.04). Limb-to-limb SEBT-ANT deficits possessed predictive value for CAI development 1 year following an acute LAS (AUROC = 0.83, DOR = 5.0). No other outcome differed between groups or demonstrated predictive value for CAI development. Conclusions: Participants with involved limb SEBT-ANT normalized scores at least 1.5% lower than the uninvolved limb at RTP had 5 times greater odds of presenting with CAI 1 year post-injury. Athletes that resolve limb-to-limb SEBT-ANT deficits before RTP may be less likely to develop CAI within 1 year of sustaining an acute LAS.

Free Communications, Oral Presentations: Perceptions of Injury Prevention Programs Wednesday, June 27, 2018, 11:00AM-12:00PM, Room 206–207; Moderator: Jessica Martinez, PhD,

ATC, CSCS

Health Belief Model Scale and Theory of Planned Behavior Scale to Assess Attitudes and Perceptions Towards Injury Prevention Programs: An Exploratory Factor Analysis Hartley EM, Cramer RJ, Hoch MC: Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY

Context: The Health Belief Model Scale (HBMS) and Theory of Planned Behavior Scale (TPBS) assess the attitudes and perceptions of users towards exercise-related injury prevention program (ERIPP) participation. However, the psychometric properties of these scales and their association with intention to participate (ITP) in an ERIPP require further evaluation. **Objective:** To examine the psychometric properties of the HBMS and TPBS and their association with ITP in an ERIPP within physically active adults. Design: Cross-sectional Setting: Paper survey at a large public university. Patients or Other Participants: Two hundred and eightyfour (F = 150; Age = 21.17 ± 2.78 years; Height = 172.37 ± 18.98 cm; Mass = 75.00 ± 14.99 kg) physically active adults volunteered. Participants were recruited from intercollegiate athletics, university club sports, and the physically active general campus population. Interventions: Participants completed paper versions of the HBMS and TPBS on one occasion. The HBMS consisted of 39 items which assessed perceptions of ERIPP participation using the six constructs of the Health Belief Model. The TPBS consisted of 22 items which assessed the three constructs of the Theory of Planned Behavior as well as ITP in an ERIPP. Both scales measured responses along a 7-point Likert scale from strongly agree (3) to strongly disagree (-3). Main Outcome Measures: Exploratory factor analysis evaluated the loading factors of the HBMS and TPBS. A factor loading cutoff score of 0.40 was used to retain items. Internal consistency of each subscale was determined using Cronbach's alpha. Total scores were calculated for each subscale and used for analyses. Linear regression determined if the HBMS and TPBS subscales were predictors of ITP in an ERIPP. Effect size (ES) was calculated to determine the strength of the association for significant variables using partial-eta squared. Results: Nine factors were identified within the HBMS (susceptibility, benefits, general health cues, barriers, consequences, fear of injury, community self-efficacy, individual self-efficacy, and external health cues) that explained 70.12% of the variance (Kaiser-Meyer-Olkin Sampling Adequacy = 0.83, Cronbach's alpha = 0.80-0.95). Five factors were identified within the TPBS (benefits, barriers, social norms, social influence, ITP) that explained 63.89% of the variance (Kaiser-Meyer-Olkin Sampling Adequacy = 0.88, Cronbach's alpha = 0.77-0.87). The HBMS and TPBS subscales were significantly related to ITP in an ERIPP $(R^2(16,265) = 0.56, p < 0.001)$. Benefits (B = 0.74, ES = .03, p = 0.003), social norms (B = 0.89, ES = .05, p = 0.001), and social influence (B = 1.15, ES = .10, p < 0.001) from the TPBS were positively associated with ITP. Benefits (B = 0.51, ES = .02, p =0.04), individual self-efficacy (B = 0.73, ES = .04, p = 0.001), and general health cues (B = 0.46, ES = .02, p = 0.03) from the HBMS were positively associated with ITP while barriers (B = -0.52, ES = .02, p = 0.02) had a negative association. Conclusions: The HBMS and TPBS demonstrated strong psychometric properties to assess the behavioral determinants of ERIPP participation within physically active adults. The social influence, social norm, and individual self-efficacy subscales were the best predictors of ITP followed by benefits, general health cues, and barriers.

Gender Related Differences in Behavioral Determinants of Exercise Related Injury Prevention Programs Are Present

Moran AD, D'Onofrio AM, Hartley EH, Hoch MC: Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY

Context: Previous research has indicated that females perceive a higher risk of injury, participate in more preventative health behaviors, and have a higher rate of lower extremity injury than males. Therefore, there is potential that behavioral determinants of exercise-related injury prevention program (ERIPP) participation differ between males and females. If differences exist, implementation strategies to improve participation in ERIPPs may need to be customized for each gender. **Objective:** To identify differences in the behavioral determinants of ERIPP participation between genders. Design: Cross-sectional. Setting: Paper survey at a large public university. Patients or **Other Participants:** Physically active college students including 174 females $(age = 20.52 \pm 2.40 \text{ years}, height = 165.60)$ \pm 20.95 cm, mass = 67.27 \pm 13.68 kg) and 177 males (age = 21.08 ± 2.93 years, height = 179.17 ± 9.06 cm, mass = 80.80 \pm 11.91 kg.) volunteered to participate in this study. Interventions: Participants completed paper versions of the Health Belief Model Scale (HBMS) on one occasion. The HBMS utilized the 6 constructs of the Health Belief Model to assess behavioral determinants of ERIPP participation. The HBMS consisted of 9 subscales (susceptibility, consequences, fear of injury, benefits, barriers, community self-efficacy, individual self-efficacy, general health cues, external health cues) and 37 items. Response options ranged along a 7-point Likert scale from strongly agree (3) to strongly disagree (-3). Acceptable internal consistency of the subscales within the HBMS has previously been reported (0.80-0.95). Positive scores on

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all of the subscales except barriers were associated with an increased likelihood of participation in ERIPPs. The independent variable was gender. Main Outcome Measures: The dependent variables were the subscales of the HBMS. Total scores and associated medians and interquartile ranges were calculated for each HBMS subscale and used for analysis. Mann-Whitney U tests and corresponding non-parametric effect sizes (ES) were used to compare scores on each subscale between genders. Alpha was set at P <0.05 for all analyses. Results: Females perceived more consequences of injury (Females = -3.00 (10.00), (Males = 0.00(10.00), P = 0.002, ES = -0.16), less benefits to participating in ERIPPs (Females = 8.00 (6.10), Males = 9.00 (7.00), P = 0.05, ES = -0.11), less barriers to participating in ERIPPs (Females = -3.00(8.00), Males = -1.00 (9.30), P < 0.001, ES = -0.20), less individual self-efficacy (Females = 0.00 (6.00), Males = 1.00 (7.00), P = 0.02, ES = -0.12), and less external health cues (Females = 0.00 (5.00), Males = 1.00 (4.00), P = 0.02, ES = -0.12) when compared to males. There were no other significant differences in behavioral determinants (susceptibility, fear of injury, community self-efficacy, general health cues) between genders (P > 0.05). Conclusions: Females perceive more consequences to injury and less barriers to implementation of ERIPPs than males. However, males perceive more benefits to participating in ERIPPs, more individual self-efficacy in participating, and more external health cues to remind them to participate in ERIPPs. Based on these findings, it cannot be determined whether males or females would be more likely to participate in an ERIPP. However, the differences in the attitudes and perceptions towards ERIPPs suggest that intervention strategies to improve ERIPP participation may need to be gender specific.

Comparison of Behavioral Determinants of ERIPP Participation Between Collegiate and Club Sport Athletes

D'Onofrio AM, Moran AD, Hartley EM, Hoch MC: Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY

Context: Previous research has indicated that the behavioral determinants of exercise-related injury prevention program (ERIPP) participation may differ between individuals who participate in different levels of sport. Professional athletes indicated the most important behavioral determinants of ERIPP participation were perceived susceptibility and severity while high school athletes perceived the benefits of the ERIPP to be most important. It is unclear whether differences in behavioral determinants exist between collegiate varsity athletes and club sport athletes. If differences do exist, specialized implementation strategies for those who participate in different levels of sport may be needed. **Objective:** To compare behavioral determinants of ERIPP participation in collegiate varsity and club sport athletes. Design: Cross-sectional. Setting: Paper survey at a large public university. Patients or Other Participants: Physically active individuals including 124 collegiate athletes (M/F: 51/72; age $= 19.81 \pm 1.50$ years; height = 171.07 \pm 17.30 cm; mass = 71.90 \pm 13.24 kg) and 122 club sport athletes (M/F: 68/53; age = 20.11 ± 1.80 years; height $= 174.84 \pm 22.24$ cm; mass $= 75.03 \pm$ 115.35 kg) volunteered to participate. Interventions: Participants completed a paper version of the Health Belief Model Scale (HBMS) on one occasion. The HBMS was designed to assess the behavioral determinants of ERIPP participation based on the six constructs of the Health Belief Model. The HBMS consisted of 9 subscales (susceptibility, consequences, fear of injury, benefits, barriers, community self-efficacy, individual self-efficacy, general health cues, external health cues) and 37

items. Responses were measured along a 7-point Likert scale ranging from strongly agree (3) to strongly disagree (-3). The internal consistency of the HBMS subscales has been previously reported as acceptable (0.80-0.95). Positive scores on all subscales except barriers are interpreted as an increased likelihood of ERIPP participation. The independent variable was group (varsity/club sport). Main Outcome Measures: The dependent variables were the subscales of the HBMS. Total scores and associated medians and interquartile ranges were calculated for each subscale and used for analyses. Mann-Whitney U tests and corresponding non-parametric effect sizes (ES) were calculated to examine group differences. Alpha was set at $p \le 0.05$ for all analyses. Results: Varsity athletes (1.00 (7.75)) perceived more fear of injury than club sport athletes (0.00 (6.50), p = 0.02, ES = -0.15). Varsity athletes (-2.00 (9.00)) perceived less barriers to implementing an ERIPP than club sport athletes (-0.70 (7.25), p = 0.01, ES = -0.16). Varsity athletes (2.50 (5.00)) perceived more external health cues than club sport athletes (0.00 (4.00), p = 0.02, ES = -0.15).No other significant differences were detected between groups (p > 0.05). Conclusions: Collegiate athletes reported a higher fear of injury, perceived less barriers to implementing an ERIPP, and perceived more external health cues to remind them to participate in ERIPPs compared to club sport athletes. These factors indicate collegiate varsity athletes are more likely to participate in an ERIPP than club sport athletes. Additionally, these results indicate that implementation strategies may need to be customized for individuals who participate in different levels of sport.

A Pilot In-Depth Analysis of Youth Sport Coaches' Perceptions of Sport Culture, Safety and Injury Prevention Ingram BM, Kay MC, Vander

Vegt CB, Register-Mihalik JK: The University of Alabama, Tuscaloosa, AL; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Coaches are key stakeholders in the youth sport community. As key stakeholders, they are influential to the "culture of sport" and how it pertains to sport safety and injury. However, limited coach specific data exists to inform safety interventions in youth sport. There is a critical need to understand the perceptions and norms that contribute to youth sport culture and coaches' perceptions of this culture in order to improve overall sports safety and injury prevention. **Objective:** To develop an understanding of youth sport coaches' attitudes, perceptions and norms regarding sport culture and injury. **Design:** Qualitative focus group study; Consensual Qualitative Research methodology. Setting: Focus groups were conducted at an educational institution. Patients or Other Participants: Focus groups were conducted with 26 youth sports coaches (n = 24 male, age = 46 \pm 12.1 yrs; yrs coached = 12.1 \pm 10.6) representing ten different sports including collision, contact, and non-contact sports. Data saturation guided the total number of participants selected for this study. Data Collection and Analysis: Five semi-structured focus groups were conducted with approximately five coaches per group. Focus group recordings were transcribed verbatim and independently analyzed by three research team members, utilizing a consensual qualitative research tradition. Research team members utilized an open coding method based on the key concepts identified through the language used by participants. After categorizing key concepts into groups, the research team created a consensus codebook, reanalyzed each focus group, and came to a final agreement on findings. An auditor controlled for any bias. Results: Overall, participants highlighted three key areas that encompass their perceptions of sport culture, safety and injury prevention including: 1) education and development, 2) organizational and community influence, and 3) sport safety. Education and development referred to the coach's role in the overall health, physical, interpersonal, and intrapersonal development of athletes. Participants also described the influence of organizations, community, media, and interpersonal relationships as playing a role in the construction of sport culture. In regard to safety, participants attributed education efforts and specialization as both barriers and facilitators to injury prevention. Conclusions: These findings suggest that youth sport coaches view themselves as an integral component of sports culture, safety, and injury prevention. As such, athletic trainers and other sports medicine community members should build relationships with youth sport coaches to create a culture of safety for young athletes. Future research is needed to determine how coach perceptions actually influence safety education and injury prevention in youth athletes.

Free Communications, Rapid Fire Oral Presentations: Concussion Management and Recovery

Thursday, June 28, 2018, 7:00AM-8:00AM, Room 206–207; Moderator: Tamerah Hunt, PhD, AT, FACSM

Concussion Management Among NCAA Swim Programs

Valovich McLeod TC, Marshall AN, McLeod IA, Robinson K, Mistry DJ, Choe MC, Rodeo S: A.T. Still University, Mesa, AZ; Dignity Health Medical Group, Phoenix, AZ; USA Swimming, Colorado Springs, CO; Berkana Rehabilitation Institute, Fort Collins, CO; UCLA Mattel Children's Hospital, Los Angeles CA; Hospital for Special Surgery, New York, NY

Context: The unique nature of swimming makes the application of traditional return-to-activity progressions following concussion challenging. The presence of specific concussion management protocols used to return swimmers to the water is important in optimizing patient care. **Objective:** To describe athletic training services and concussion management protocols among NCAA swim programs and compare between NCAA divisions. Design: Cross-sectional. Setting: Selfreported online survey. Patients or Other Participants: 228 athletic trainers (ATs) assigned to or with knowledge of their institution's swim program from a convenience sample of 539 ATs (response rate = 42.3%). Interventions: Participants were solicited via email to complete a concussion management survey. The survey included 8 questions, 4 regarding provision of athletic training services for swimming and 4 related to concussion management, baseline testing, and return-to-swim protocols. Main Outcome Measures: The independent variable was NCAA division (D1, D2, D3) and dependent variables were participants' responses to the survey items. Descriptive statistics described institutional and concussion protocol demographics. Separate Kruskal-Wallis tests assessed differences between NCAA divisions on provision of athletic training services, baseline testing of swimmers, and specific return-to-swim progressions. Differences were explored further with Mann Whitney U tests (p < .05). A one-way ANOVA compared the number of concussions by division (p <.05). Results: Of the respondents, 216 had a varsity-level swim program, participating in the D1 (46.8%, n = 101), D2 (12.5%, n = 27) and D3 (40.7%, n = 88) levels. Athletic training services were provided to 98.6% (214/217) of programs. Provision of athletic training services did not differ by division (p = 1.0). Athletic training services were provided by 1.6 ± 1.0 ATs (range 1-6) having 5.5 ± 4.2 years of experience with the swimming program. Nearly 80% (164/207) of programs administered baseline concussion testing to swimmers, with differences observed between divisions (p < .001). Baseline testing was more likely to occur in D1 compared to D2 (p = .03) or D3 (p=<.001), with no differences between D2 and D3 (p = .231). No differences (p = .108) in the number of concussions sustained by swimmers in the past academic year was noted between D1 (1.9 \pm 1.7), D2 (1.5 \pm 1.9), or D3 (1.4 \pm 1.5). Specific return-toswim protocols were reported by 55.6% (115/207) of respondents with no differences in the presence of a specific return-to-swim protocol between divisions (p = .790). The majority of respondents (98.3%, 113/115) were satisfied with their return-to-swim protocol. Athletic trainers were primarily responsible (88.7%, 102/115) for overseeing the return-to-swim progression and only 15.9% (33/207) indicated that confusion existed regarding progressing a swimmer in the water. Conclusions: While concussions are reported less frequently in swimming than other sports, appropriate medical care, including a specific return-to-swim protocol, is warranted. Consideration needs to be made regarding appropriate to transitions from land-based activity progression to water-based activity progression, including the appropriate time to reintroduce swim-specific skills such as flip turns and diving from the blocks.

The Effect of a Brief Aerobic Training Program on Concussion-Like Symptoms in Healthy University Students Teel EF, Register-Mihalik JK, Appelbaum LG, Battaglini CL, Carneiro KA, Guskiewicz KM, Marshall SP, Mihalik JP: The University of North Carolina at Chapel Hill, Chapel Hill, NC; McGill University Health Centre, Montreal, Quebec; Duke University, Durham, NC

Context: Previous research investigating the effect of acute exercise on concussion-like symptoms in healthy cohorts is mixed. Aerobic training programs are an increasingly popular concussion rehabilitation strategy. No studies have evaluated how a training intervention, as opposed to a single exercise bout, influences concussion assessments in healthy cohorts. As symptom resolution in injured populations often signals the start of return-toplay protocols, understanding the effect of aerobic training on symptom outcomes in healthy populations is critical to informing post-injury clinical decisions. **Objective:** To determine if a brief aerobic training program scheduled to mimic concussion recovery timelines influences symptom outcomes in healthy participants. Design: Randomized controlled trial. Setting: Laboratory. Patients or **Other Participants:** Forty recreationally active $(30 + \text{minutes exercise} \ge 3 \text{ days})$ week) individuals with no contraindications to exercise (males = 20; females = 20; age = 20.8 ± 2.1 years; height = 173.9 ± 10.2 cm; mass = 71.4 ± 11.8 kg). Interventions: Participants were equally randomized into acute concussion therapy intervention (ACTIVE) training or non-training groups. All participants completed maximal cardiopulmonary exercise tests on a stationary bicycle at two test sessions approximately 14 days apart. During this 2-week study period, ACTIVE training participants completed six 30-minute cycling sessions, progressing from 60-80% of the participant's individualized maximal oxygen consumption. Non-training participants received no intervention between test sessions. Main Outcome Measures: The Graded Symptom Checklist was administered within 5 minutes before and after each maximal exercise test. Separate 2 (group) by 2 (session) ANOVAs were run for total symptom score pre-exercise (rested), total symptom score post-exercise (exerted), and symptom score change from pre to post-exercise at each test session. **Results:** A significant interaction effect was found for rested total symptom score $(F_{136} = 4.41, P = 0.043)$. The ACTIVE training participants had significantly reduced symptoms at the second test session under rested conditions (Session $1 = 5.1 \pm$ 5.8, Session $2 = 1.9 \pm 3.6$), with changes driven primarily by improvements in cognitive (Session $1 = 2.0 \pm 2.6$, Session $2 = 0.7 \pm 1.6$) and sleep-related (Session $1 = 1.9 \pm 2.4$, Session $2 = 0.9 \pm 1.4$) symptoms. A significant interaction was present for symptom score change pre to post-exercise ($F_{1,35} = 4.24$; P = 0.047), with ACTIVE training participants showing reduced symptom increases following exercise at the second test session relative (ACTIVE: Session 1 $\Delta = 3.0 \pm 4.5$, Session $2 \Delta = 1.6 \pm 4.2$; Controls: Session $1 \Delta = 2.3 \pm 5.1$, Session $2 \Delta = 1.4 \pm 3.8$). No differences were observed for exerted total symptom score. Conclusions: A brief aerobic training program improves concussion-like symptoms in healthy cohorts in a rested state, and reduces symptoms pre- to post-exercise. These changes stem from improvements in cognitive and sleep-related symptoms, in partial agreement with previous literature. While statistically significant, changes in symptom scores were modest and within previously reported reliable change index values. Aerobic exercise can target the physiological mechanisms underlying concussive deficits; future studies should continue to investigate the effect of aerobic exercise on symptom, cognitive, and balance domains in concussed cohorts.

Return to Learn: Academic Effects of Concussion in High School and College Student-Athletes

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Context: Concussion management in classroom settings is proven elusive, where the "return-to-learn" guideline is often driven by physicians' opinions. Students with concussions are often expected to "keep up" with their academic responsibilities. Empirical evidence in this area is urgent, to establish a concussion management guideline in the academic setting. **Objective:** To evaluate post-concussion ability in regards to academic tasks (math, reading, writing, computer usage and concentration) and their limit of tolerance. Additionally, to examine the academic effects of concussion on gender and age. Design: Crosssectional study. Setting: Online study. Patients or Other Participants: Onehundred thirty-four student-athletes, 67 males and 67 females, (mean age, male 18.24 ± 1.08 and female 18.36 ± 1.14 years old) gave consent on an IRB approved form. Interventions: The independent variables were age (high school vs. college) and gender. Dependent variables are the level of difficulty with various classwork-related activities on a 5-point Likert scale (1-extremely easy and 5-extremely difficult) and duration of academic engagement before their symptoms reappeared on a 7-point Likert scale (less than 1 hour, 1-2 hours...more than 6 hours). A two-step chain referral sampling method was utilized for data collection. An email was distributed to 3,000 certified athletic trainers via the NATA Survey Service Program. The email contained a survey link for certified athletic trainers to forward to qualifying student-athletes who had sustained a sport-related concussion within the past year. Kruskal-Wallis test for mean differences and Spearman correlation for relationships between age and responses were used in this study. Main Outcome Measures: The survey includes questions that ask about level of difficulty with math, reading, writing, computer usages and concentration, and duration of academic engagement before symptoms reappeared. Results: There were significant gender effects in reading and use of computer/projector screen, where females experienced more difficulty in these tasks (female vs. male: reading, 1.92 vs. 2.28, H(1) =6.231, p = 0.0126; computer, 1.95 vs. 2.16, H(1) = 3.807, p = 0.05). Robust differences were also observed between high school and college student-athletes that high school students (1.98) reported significantly more difficulty in math than college students (2.46, H(1) = 8.732, p = 0.003), while college students experienced more difficulty in reading and use of computer than high school students (college vs. high school: reading 1.94 vs. 2.26, H(1) = 5.465, p = 0.019; computer 1.66 vs. 2.05, H(1) = 6.104, p = 0.014). There were statistical significant relationships between age on math ($r_{e} = 0.200$, p = 0.037), computer (r = 0.205, p = 0.033), and reading (r = 0.033)= 0.259, p = 0.007). There was a significant correlation between age and duration of academic engagement (r. = 0.246, p = 0.01), where symptoms reappeared quicker with younger age. Conclusions: The results illustrate the students' challenges in academic tasks while recovering from concussion. Age- and gender-dependent difficulties in math, reading, and computer usage indicate the urgent need of establishing return to learn guideline that is specific to education levels and gender.

Understanding the Athletic Trainer's Role in the Return-To-Learn Process at NCAA Division II and Division III Institutions Runyon LM, Welch Bacon CE, Neil ER, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER)

Laboratory, Indiana State University, Terre Haute, IN; A.T. Still University, Mesa, AZ

Context: Student-athletes who are returning to the classroom post-concussion should do so using a slow, gradual, step-wise process to ensure that symptoms are not exacerbated by cognitive activities related to coursework. Often these student-athletes are patients under the care of an institutions athletic trainer. The NCAA has mandated that its affiliated institutions develop and submit return-to-learn (RTL) policies and procedures to ensure patients are supported as they return to the classroom. **Objective:** To investigate RTL policy development and implementation in NCAA Division II and Division III institutions. Design: Phenomenological qualitative inquiry. Setting: Individual phone interviews. Patients or Other Participants: Fifteen athletic trainers (ATs) participated in interviews (7 Males, 8 Females, n = 15; age = 40 ± 11 y; clinical practice experience = 16 ± 9 y; employment term = 9 ± 9 y), representing NCAA Division II (n = 6) and Division III (n = 9). The majority of the ATs were employees of private institutions (n = 11, 73.3%). Data Collection and Analysis: Interviews were transcribed verbatim by an external transcriptionist and checked for accuracy by the primary investigator. Using a systematic process, the two-member data analysis team independently coded a portion of the transcripts and met to discuss a consensus codebook. The codebook was then applied to the remaining transcripts, confirmed, and then externally reviewed for trustworthiness. **Results:** Four major themes emerged: (1) institutional autonomy, (2) patient advocacy, (3) collaborative practices,

and (4) approach. Each institution appeared to identify a different member of the RTL team that triggered the process to inform stakeholders: the AT, coordinating medical director, and an office related to academic accommodations. Participants made it very clear that their role in the RTL process, as well as the return to play process, was to advocate for the patient. They indicated that the patient was a student first and foremost, and that the accommodations for academics were as important than those for returning to play. Collaborative practices were described as a key component for successful development and implementation of the RTL. These interactions included interprofessional collaborations beyond healthcare providers, such as working with faculty and academic support. Collaborative practices also included working to bridge barriers and to educate the faculty and stakeholders about the importance and purpose of RTL policies and procedures. The participants approach was often described as evidence driven and individualized to patient needs. The participants thought their role was to facilitate patient care and actively communicate with all members of the RTL team and the patient. Conclusions: To develop and implement a successful RTL policy there must be strong communication and interprofessional approach, beyond the healthcare field. The members of the healthcare team must establish a working network with academic stakeholders and other partners to develop a policy that is appropriate given the institutions' available resources and patient needs.

Vestibular Rehabilitation for Management of Sport-Related Concussion

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Context: 'Dizziness' is often attributed to longer return-to-play outcomes following concussion but is rarely directly addressed during recovery. Objective: Determine the effect of vestibular rehabilitation (VR) on dizziness and balance in concussed athletes. Data Sources: PubMed was searched using iterations of "vestibul*", "concussion", and "rehabilitation" through 9/17 and limited to studies published after 2010. Study Selection: Selection criteria required included studies 1) included participants who sustained a concussion and were experiencing unresolved vestibular symptoms or deficits; 2) were clinical trials or case studies, 3) utilized VR to treat concussion-related dizziness or balance deficits. Data Extraction: Two investigators extracted the following data 1) dizziness, measured by the Dizziness Handicap Inventory (DHI) [25 items, 100 points is 'worst symptoms'], and the Numeric Pain Rating Scale for dizziness (NPRS-dizziness) [11 items, 10 points is 'worst symptoms']; 2) balance, measured by the Activities-specific Balance Confidence scale (ABC) [100 points, 100 points is 'best confidence in balance]; and 3) return-to-play (RTP). Means, standard deviations, and sample sizes were extracted for continuous data. Frequencies were extracted for dichotomous data, presented for RTP (return, no return), DHI (no dizziness, dizziness), NPRSdizziness (dizziness, no dizziness), and ABC (perceived balance problems, no perceived balance problems). For continuous data, Hedge's g effect sizes (ES) [95% CIs] were calculated to determine the pre-to-post treatment effects on individuals who underwent VR. For dichotomous data, risk ratios (RR) [95% CIs], relative risk increase (RRI), and numbers-needed-to-treat

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to benefit (NNTB) were calculated for the effect of VR vs. Standard Care for RTP, absence of dizziness, and balance confidence. The PEDro scale was used identify potential threats to validity. Data Synthesis: Three studies met selection criteria. Study design varied (1 prospective, 2 retrospective) and included a randomized, controlled trial (VR vs Standard Care), a case series of patients experiencing persistent symptoms after concussion, and a retrospective account patients who underwent VR for post-concussion symptoms. The effect of VR from pre-to-post testing for the reduction of dizziness and improved perception of balance was strong (pooled ES = 3.3 [0.9, 5.8], p < .006). There was a substantial effect for VR treatment on RTP (RR = 9.5[4.0,22.7], RRI = 8.5, NNTB = 2[2,3]);the DHI (RR = 2.9 [1.2, 7.1], RRI = 1.9, NNTB = 3 [2,13]); the NPRS-dizziness (RR = 3.1 [0.2,47.2], RRI = 2.1, NNTB = 2 [2,3]; and the ABC (RR = 1.9) [0.8, 4.4], RRI = 0.9, NNTB = [-10, 2].PEDro scores ranged 5-8. All studies lacked blinding of therapists and outcome assessors. Conclusions: Strong evidence supported VR to attenuate clinical symptoms of dizziness and balance deficits compared with rest alone. Approximately 2-3 patients would need to be treated with VR to completely dissipate vestibular symptoms in one patient. Individuals treated with VR were 8.5 times more likely to return to participation compared to those who rested. ATs should identify concussion patients who are experiencing persistent vestibular symptoms through assessments of dizziness and balance, and be prepared to refer concussed athletes with vestibular symptoms for appropriate rehabilitation. Ultimately, future research may indicate a need for AT education to eventually include training in vestibular rehabilitation.

Vestibular Rehabilitation for Dizziness and Imbalance McGinnis IW, Cobb JL, Tierney RT, Russ AC: Temple University, Philadelphia, PA

Context: Dizziness and imbalance, predictors of protracted recovery, are reported by 23-81% of patients in the initial days following concussion and may not resolve spontaneously. **Objective:** To determine the effects of vestibular rehabilitation on balance and self-reported dizziness in patients experiencing prolonged concussion symptoms. Data Sources: PubMed and SPORTDiscus were searched in January and February of 2017 using the Boolean phrase: vestib* AND rehab* AND (concussion OR "mild traumatic brain injury" OR mTBI OR traumatic brain injury" or TBI) AND dizziness AND balance. Study Selection: Titles were reviewed for relevance, then abstract, then full text. Articles were included based on their ability to answer the research question and matching clinical outcome measures. Only studies from the previous ten years were considered. Articles incorporating cervical rehabilitation and aerobic exercise were excluded. Data Extraction: The Strobe Checklist for cohort studies and the Centers for Evidence Based Management critical appraisal of a case study forms were used to address internal and external validity. Outcome measures were representative of balance and self-reported dizziness. For balance, the measures included were the Balance Error Scoring System (BESS) and the Sensory Organization Test (SOT). For self-reported dizziness, the measures included were dizziness severity, Activities-specific Balance Confidence Scale (ABC), and Dizziness Handicap Inventory (DHI). 95% Confidence Intervals (CI) and Cohen's d were calculated where applicable. Data Synthesis: The search returned 52 articles and 3 were selected for inclusion. Two cohort studies had an appraisal score of 20/22 and 18/22, one case study scored 8/10. For each outcome measure, substantial improvements were observed. In one cohort study, dizziness severity scores decreased from 21 (SD = 22; 95% CI = 15.5, 26.5) to 12 (SD = 18; 95% CI = 7.5, 16.5; ES = 0.448), ABC increased from 64 (SD = 27; 95% CI = 57.45, 70.55) to 84 (SD = 17; 95% CI = 79.88, 88.12; ES = 0.89), DHIdecreased from 49 (SD = 21; 95% CI = 43.94, 54.06) to 30 (SD = 22; 95%) CI = 24.7, 35.3; ES = 0.88), and SOT composite score increased from 48 (SD = 19; 95% CI = 39.9, 56.1) to 71 (SD = 13;95% CI = 65.46, 76.54; ES = 1.41). In a second cohort study, DHI decreased from 56.5 (SD = 12.26;95% CI = 44.24, 68.76) to 32 (SD = 23.21; 95%) CI = 8.97, 55.21; ES = 1.32) and BESS tests decreased from 31.5 (SD = 2.38; 95% CI = 29.12, 33.88) to 16.5 (SD = 6.45; 95% CI = 10.5, 22.95; ES = 3.09). The cased study showed improvements of 9.5, 18, and 24 in the ABC, DHI, and SOT composite score respectively. Conclusions: Preliminary research on vestibular rehabilitation to treat symptoms of dizziness and imbalance shows significant improvement in most, but not all patients. Patients should be evaluated on a case-by-case basis and vestibular rehabilitation should be considered as an option if appropriate. Future research should determine appropriate duration and intensity guidelines for therapeutic exercises. In addition, control groups should be implemented so that the therapeutic effect of time can be taken into account.

An Investigation of the Effects of Concussion on Metabolism and Caloric Intake

Daniell B, Walton SR, Malin SK, Higgins MJ, Resch JE: University of Virginia, Charlottesville, VA

Context: Severe traumatic brain injury has been shown to change whole-body resting energy expenditure (REE) in animal and human models immediately after injury and throughout recovery. Sports-related concussions (SRCs) have also been shown to promote intracranial metabolic changes in humans; however, limited data exists examining the effect of acute SRC on REE. Objective: Examine the impact of SRC on REE, caloric intake (CI), and energy balance in high school and collegiate student-athletes. **Design:** Descriptive laboratory study. Setting: Laboratory. Patients or Other Participants: Participants consisted of high school student-athletes (n = 6; 3 females, 3 males) who were 16.0 + 1.5 y, 171.1 + 6.5 cm, and 62.7 + 6.1kg as well as collegiate student-athletes (n = 4; 2 females, 2 males) who were 19.5 + 1.0 y, 180.0 + 5.7 cm and 76.8+ 12.2 kg. Interventions: Indirect calorimetry (VMax® Metabolic Cart) was used to assess participants REE at <72hr (T1), 7d (T2), and 14 d (T3) following diagnosis of SRC by a certified athletic trainer. Symptom burden for the previous 24hrs was assessed using the Revised Head Injury Scale at each time point. A dietary recall journal and FitBitTM were used to estimate CI and physical activity level (PA), respectively, for 3 days following each assessment. Main Outcome Measures: Data from both high school and collegiate participants were pooled as there was not a significant difference between these settings in our participants for any of the outcomes. A repeated measures ANOVA was used to assess REE, total energy expenditure (TEE; REE x PA), CI, and energy balance (CI-TEE difference) across time. Post-hoc analyses were performed using paired *t*-tests. Pearson correlations (r) were calculated between each outcome and SRC-related symptoms. Results: There were no differences across time for REE (F[2,18] =1.53, p = .24, $\eta^2 = .15$) or TEE (F[2,18] = 2.29, p = .13, $\eta^2 = .20$). Mean REE values were 837.1 + 109.3 kcals at T1, 871.3 + 137.8 kcals at T2, and 924.4 + 233.2 kcals at T3. Mean TEE was 1384.9 + 410.8 kcals at T1, 1586.7 +

480.7 kcals at T2, and 1544.6 + 526.7 kcals at T3. A significant main effect was found for CI (F[2,18] = 4.73, p =.02, $\eta^2 = .35$), with a significant decrease at T3 compared to T2 (t[9] = 2.456, p =.04). Mean CI was 1977.4 + 690.9 kcals at T1, 1,991.3 + 741.1 kcals at T2, and 1,605.9 + 514.8 kcals at T3. A significant main effect was also observed for CI-TEE difference (F[2,18] = 4.35, p= .03, η^2 = .33) with participants having a significantly smaller magnitude of CI-TEE difference at T3 compared to T1 (t[9] = 2.442, p = .04). Mean CI-TEE difference values were 592.5 + 604.2kcals at T1, 404.6 + 598.4 kcals at T2, and 61.3 + 397.5 kcals at T3. No significant correlations were observed between symptom burden and any other outcome variable. Conclusions: Our preliminary findings suggest that SRCs do not impact REE or TEE in high school and collegiate student-athletes. However, CI initially increased following SRC and decreased throughout recovery. Further research is necessary to examine the effects of SRC on metabolism and food intake to optimize concussion recovery protocols.

Resting Energy Expenditure Total Energy Expenditure Caloric Intake Energy Balance Conversion Conve

Energy Expenditure and Energy Consumption Over Time

* - Significant difference between 7 days and 14 days; ** - Significant difference between < 72 hours and 14 days

Predictors of Sports-Related Concussion Injury Perception in Collegiate Student-Athletes Competing in High-Risk Sports Beidler E, McAllister-Deitrick J, Wallace J, Anderson M: Duquesne University, Pittsburgh, PA; Coastal Carolina University, Conway, SC; Youngstown State University, Youngstown, OH; Michigan State University, East Lansing, MI

Context: Sport-related concussion (SRC) non-disclosure continues to be a barrier for sports medicine clinicians. It may be beneficial to gain a better understanding of the SRC culture within collegiate sports by considering how collegiate student-athletes perceive SRCs and what factors influence their perception. This information could be used to construct more informed education interventions that address the specific needs of this population. **Objective:** To determine if sex, SRC knowledge, and SRC history predict SRC injury perception in collegiate student-athletes participating in SRC high-risk sports. Design: Cross-sectional survey study. Setting: Paper/pencil or web-based survey. Patients or Other Participants: A total of 998 collegiate student-athletes [age mean (SD) = 19.68(1.40) years] from 28 different sports completed the survey. After excluding for age, current SRCs, SRCs in the past 3-months, and incomplete responses there were 859 participants remaining. The SRC highrisk participants (n = 595, 69.3%) were then separated from the SRC low-risk (n = 264, 30.7%) sports for analyses. Of the 595 SRC high-risk sport participants included in analyses, there were 374 (62.9%) male and 221 (37.1%) female NCAA [D-I, n = 216 (36.3%); D-II, n = 323 (54.3%); D-III, n = 53 (8.9%); missing,n=3(.5%)] collegiate student-athletes. Interventions: The study survey included items on personal/sport demographics, SRC history, Concussion Perception Questionnaire (CPQ), and aSRC Knowledge assessment. The 24-item CPQ (Cronbach- $\alpha = 0.71$) assessed 7-dimensions of SRC injury perception. The

SRC Knowledge assessment (Cronbach-a = 0.72) had 47-items that focused on signs and symptoms, injured structures, and mismanagement complications. A total of 6 institutions participated and athletic trainers liaised the connection between the researchers and their sports teams. Data collection occurred in athletic training clinics or at team practices/meetings. The 10-minute survey was distributed in paper/pencil or via an online Qualtrics survey on an iPAD. Main Outcome Measures: The dependent variables were the CPQ composite outcomes of consequences (C), personal control (PC), treatment control (TC), symptom timeline acute versus chronic (STAC), symptom timeline cyclical (STC), understanding (U), and emotion (E). A series of linear regression models were used to assess the predictive utility of sex, SRC knowledge, and SRC history on the composite scores for the CPQ. An alpha level was set aprior at .05. Results: The model was significant at predicting the PC composite [mean (SD) = 3.68 $(.56); R^2 = .14, F_{3.591} = 33.78, P < .001], TC$ composite [mean (SD) = 3.27 (.66); R²= $.01, F_{3,591} = 3.29, P = .02$], the U composite [mean (SD) = 3.69 (.66); R² = .08, F_{3.591} = 17.59, P < .001], the STC composite [mean (SD) = 3.43 (.56); R^2 = .06, $F_{3.591}$ = 13.01, P < .001], and the E composite [mean (SD) = 3.27 (.77); R^2 = .02, $F_{3.591}$ = 4.57, P < .001] scores. The model did not significantly predict the C composite [mean (SD) = 3.38 (.62); R² = .01, F_{3.591} = 2.46, P = .06], the STAC composite $[\text{mean} (\text{SD}) = 2.97 (.61); \text{R}^2 < .001, \text{F}_{3.501} =$.344, P = .79]. <u>Conclusions:</u> Given these findings, it may be important to consider athletes' sex and knowledge about SRCs, which may stem from a personal history of SRCs, as this may influence their perceptions towards this injury. Future research should further explore SRC perception and its relationship to injury disclosure behaviors.

Free Communications, Oral Presentations: Patient Beliefs and Activity After Anterior Cruciate Ligament Reconstruction

Thursday, June 28, 2018, 8:15AM-9:30AM, Room 206-207; Moderator: Jennifer Howard, PhD, LAT, AT

Evaluating the Contact Nature of Acute ACL Injury Using a Well-Defined Patient-Reported Operational Definition

Peck KY, DiStefano LJ, Marshall SW, Padua DA, Svoboda SJ, Beutler AI, de la Motte SJ, Cameron KL: Keller Army Community Hospital, United States Military Academy, West Point, NY; University of Connecticut, Storrs, CT; University of North Carolina, Chapel Hill, NC; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Anterior cruciate ligament (ACL) injuries are devastating injuries that increase the risk for post-traumatic osteoarthritis. A first step in preventing these injuries includes accurate identification of injury incidence, including the contact nature of injuries. Previous studies have not used precise operational definitions for contact status. **Objective:** Describe the contact nature of acute traumatic ACL injury events using a patient-reported operational definition. **Design:** Prospective cohort. Setting: United States Service Academy. Patients or Other Participants: 388 (124 women) cadets of 15,856 (incidence proportion 2.45%) enrolled in a prospective cohort study sustained an acute ACL injury between 2004 and 2017. Interventions: To identify potential risk factors for injury, a questionnaire asked participants about the circumstances of their injury including sports activity, surface conditions, footwear, competition level, and time of injury relative to practice/game session and competitive season. Participants were also asked to describe the contact nature of the injury event and categorize the injury as either "contact (direct contact to the knee)," "indirect contact/ knocked off balance (contact to body, not knee)," or "non-contact (no contact by any other person or object)."

Main Outcome Measures: Contact nature of ACL injury as determined by patient-reported operational definitions. Frequencies and proportions were calculated for all variables and Chi-square or Fisher's exact test were used to examine associations between these variables. Results: Among men, 57% of injuries were non-contact, 23% were indirect contact, and 19% were direct contact. Among women, 64% were non-contact, 23% were indirect contact, and 14% were direct contact. When combined, indirect contact and non-contact injuries accounted for 81% of all injuries among men and 86% among women. Sixty-four percent of injuries occurred during competitions. The majority of injuries occurred in the beginning of the season (32.5%), followed by the end of the season (21.3%), middle of the season (14.4%), pre-season (13.7%), off-season (9.4%), and post-season (8.7%). There were no differences in injury proportions when subjects reported injuries as occurring during the beginning (30%), middle (38%), or end (32%) of a practice/ game session. Among tackling sports, male rugby players were 3.75 (CI: 0.75,17.34) times more likely to sustain a direct contact injury compared to football players. Male and female rugby players were 5.22 (CI: 1.98,13.56) times more likely to sustain a direct contact injury compared to athletes in other matched sports. Conclusions: Using a precise operational definition for the contact nature of acute ACL injury suggests that less than 20% of ACL injuries are due to direct contact mechanisms. Furthermore, the pattern of injuries observed is consistent with the current literature reporting higher injury rates early in the season. Given the relatively high number of direct contact injuries in rugby, it would be prudent to consider rule changes to minimize the risk associated with this sport.

A Comparison of Daily Activity Levels Between College Females With Ruptured Anterior Cruciate Ligament History and Healthy Matched Controls Breymeier MM, Morrison KE, Cattano NM: West Chester

University of Pennsylvania, West Chester, PA

Context: Although some anterior cruciate ligament injured individuals successfully return to pre-injury levels despite poor patient reported outcomes, most do not and will likely develop osteoarthritis within 10 years of injury. With limited research available, it remains unknown if individuals are maintaining healthy activity levels in comparison to those without ACL injury history. Objective: The objective of this study was to compare physical activity levels between ACL injured females and matched healthy controls. The secondary purpose was to compare PROs between groups and analyze the relationship between physical activity levels and PROs. Design: Prospective Cohort Study Setting: Division II University Patients or Other Participants: Forty physically active college females between the ages 18 to 25 participated. ACL participants (n=20, age: 20.5±2.5y, body mass index (BMI): 25.45±5.95 kg/m2) had ACL reconstruction within 5 years of study participation and were medically cleared for physical activity. Healthy control participants (n = 20, age: $20\pm 2y$, BMI: 23.85±3.65kg/m²) were matched by age, mass, height, and physical activity level. Interventions: The independent variable was group (ACL or Control). Participants completed a health history questionnaire, International Physical Activity Questionnaire (IPAQ), and Knee Osteoarthritis Outcome Score (KOOS) at baseline. Their physical activity (step count) and KOOS scores were reported daily over 10 days. The primary aims were analyzed using independent t-tests and Mann-Whitney U tests while the secondary aims utilized Pearson correlations. A priori statistical significance was defined as $P \leq 0.05$. Main Outcome Measures: Dependent variables were PRO scores at baseline, IPAQ scores, daily step counts and daily PRO scores in the 5 KOOS subscales. Covariates considered were concomitant lower extremity injuries, time since injury, treatment method, medications or supplementation, return to play protocol, and reoccurrence rate of injury. Results: Significant differences existed between each KOOS subscale scores between group for every day excluding KOOS activities of daily living, Day 4 (ACL:95.70±6.225; CON:98.15±4.694; P=0.093) and Day 6 (ACL:95.55±6.716; CON:98.35±4.404; P=0.084). Conclusions: These findings indicate that ACL history individuals report poorer outcome scores on a

daily basis, yet complete similar daily physical activity as healthy individuals. There was no relationship between self-reported activity and objectively measured activity. However, it is yet to be determined whether ACL history individuals will continue to uphold normal activity levels due to poor PROs.

Table 2. Dependent	t Variables	Between .	ACL an	d Control	Groups
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	ACL	ACL $(n = 20)$		CONTROL $(n = 20)$		
Variable	MEAN	SD	MEAN	SD	Т	Р
Total Steps	90167.50	90167.50	83328.30	16323.285	1.012	0.319
Daily AVG Steps	9016.75	2545.292	8332.83	1632.329	1.012	0.319
IPAQ Score	2859.60	2815.068	3038.55	3253.630	-0.186	0.853

* Indicates a between-groups difference (P < .05).

Abbreviations: ACL, Anterior Cruciate Ligament; SD, Standard Deviation; AVG, Average; IPAQ, International Physical Activity Questionnaire

Examination of Physical Activity Levels and Fear-Avoidance Beliefs in Participants Post-ACL Reconstruction

Baez SE, Hoch MC, Hoch JM: University of Kentucky, Lexington, KY

Context: The impetus of ACL reconstruction (ACLR) is to facilitate return to preinjury levels of function and remain engaged in a physically active lifestyle. It is recommended by the Centers for Disease Control and Prevention (CDC) that individuals take 10,000 steps/day to reduce the risk of chronic disease development. However, biopsychosocial impairments, such as fear-avoidance beliefs (FAB), may impede patients post-ACLR from engaging in the necessary 10,000 steps per day. **Objective:** To examine average daily step counts in participants post-ACLR and to compare differences in FAB in participants who reached the physical activity requirement (ACLR-PA) compared to those who did not (ACLR-NOT). Design: Cross-sectional. Setting: Field Research. Patients or Other Participants: Twentyfour participants (17 females; age = 24.5 \pm 4.4 years; height = 167.9 \pm 8.9 cms; mass = 75.4 ± 16.9 kg) who were at least one year post-ACLR participated. Participants were excluded if they had a history of bilateral ACLR. Interventions: Participants completed a demographic survey, which assessed anthropometric measurements and injury history, and the Fear-Avoidance Beliefs Questionnaire (FABQ). Participants were instructed to wear a pedometer and to track daily step counts for one-week. Main Outcome Measures: The FABO is a patient-reported outcome measure designed to assess FAB through two subscales: FABQ-Sport (FABQ-S) and FABQ-Physical Activity (FABQ-PA). There is a total of 10 items on the FABQ-S, and 5 items on the FABQ-PA scored on a 7-point Likert scale. Each subscale was scored separately (0-42, 0-24 respectively), and higher scores indicated elevated levels of FAB. Participants were instructed to wear the pedometer on their hip at all

times except when sleeping, showering, or swimming, and document their total step count each evening. Average daily step counts and scores on the FABQ subscales (mean \pm standard deviation) were calculated. Independent t-tests examined differences between the ACLR-PA and ACLR-NOT groups (p < 0.05), Hedge's g effect sizes (ES) examined the magnitude of the difference between groups. Results: This sample of participants post-ACLR averaged a total of $8,758 \pm 2151$ steps per day during the one-week observation period. The recommended 10,000 steps per day was not achieved by 70.8% of the participants (n = 17) who were included in the ACLR-NOT (7607.9 ± 1867.6) group; the ACLR-PA group averaged 11557.6 \pm 1221.3 steps per day. The ACLR-PA group (29.9 ± 17.7) exhibited significantly greater FABQ-S scores compared to the ACLR-NOT group (22.0 \pm 12.1; p = 0.03, ES = 0.93) No significant differences were observed between the ACLR-PA (9.7 ± 5.7) and ACLR-NOT $(10.4 \pm 8.3, p = 0.54, ES = 0.06)$ groups for the FABQ-PA. Conclusions: Most participants post-ACLR (70.8%) did not average 10,000 steps/day. Additionally, both groups reported elevated levels of FAB. However, FAB may be greater in the ACLR-PA group (>10.000 steps/day) because of their exposure to fear-eliciting stimuli, such as jumping and cutting, while engaging in physical activity. Future research should explore interventions to treat biopsychosocial impairments in both post-ACLR groups as both groups demonstrated elevated levels of FAB.

Fear-Avoidance Beliefs and Health-Related Quality of Life in Post-ACL Reconstruction and Healthy Athletes Hoch JM, Houston MN, Baez SE, Hoch MC: University of Kentucky, Lexington, KY; Keller Army Community Hospital, West Point, NY

Context: While many athletes who sustain an ACL injury and undergo reconstruction (ACLR) do not return to pre-injury levels of performance, others complete their structured rehabilitation and return with lingering physical or mental health impairments. Examining health-related quality of life (HRQL) and contextual factors such as fear-avoidance beliefs across the spectrum of non-injured athletes and athletes with a history of ACLR may provide further insight into targeted therapies warranted for this population. **Objective:** To examine differences in fear-avoidance beliefs and general HRQL in collegiate athletes with a history of ACLR not participating in sport (ACLR-NPS), a history of ACLR participating in sport (ACLR-PS), and healthy controls with no history of injury participating in sport. Design: Crosssectional Setting: Survey. Patients or Other Participants: Fifty collegiate athletes (31 females; age = 19.5 ± 1.3 years; height = 172.4 ± 11.6 cm; mass = 71.5 ± 13.6 kg) that indicated a history of ACLR and were participating (n = 16) or not participating (n = 10)in athletics, or had no history of injury and were participating in athletics (control, n = 24) were included from a cohort of 467 collegiate athletes. Interventions: Participants completed a demographic survey that assessed participation demographics, anthropometric measurements, and injury history information. Participants also completed the modified Disablement in the Physically Active Scale (mDPA) and Fear-Avoidance Beliefs Questionnaire (FABQ). Main Outcome Measures: The mDPA is a generic patient-reported outcome (PRO) instrument used to
assess general HRQL. The two summary components, mDPA-Physical and mDPA-Mental were scored separately, and higher scores indicated more disablement. The FABQ is a dimension-specific PRO used to assess fear-avoidance beliefs with subscales for Sport (FABQ-Sport) and Physical Activity (FABQ-PA). Each scale was scored separately, and higher scores indicated greater fear-avoidance beliefs. A one-way ANOVA and LSD post-hoc tests were performed to identify significant group differences (p <0.05). Results: mDPA-Physical scores were significantly different (p < 0.001). ACLR-NPS (30.3 ± 8.4) had greater levels of disablement than ACLR-PS $(7.4 \pm 7.5, p < 0.001)$ and controls (3.7) \pm 6.4, p < 0.001). There was a significant difference in FABQ-Sport scores (p < 0.001); ACLR-NPS (28 8 ± 8.2) reported greater fear-avoidance beliefs than ACLR-PS $(14.2 \pm 9.4, p < 0.001)$ and controls $(6.2 \pm 8.4, p < 0.001)$. FABQ-PA scores were also different between groups (p < 0.001); ACLR-NPS (18.9 ± 4.4) had elevated levels compared to ACLR-PS (10.1 \pm 7.1, p = 0.001) and controls (4.3 \pm 5.4, p < 0.001). Interestingly, ACLR-PS scores for FABQ-Sport (p = 0.006) and FABQ-PA (p = 0.003) were elevated compared to controls. No significant differences were identified for the mDPA-Mental scores. Conclusions: As expected, ACLR-NPS had decreased HRQL and elevated levels of fear-avoidance beliefs compared to ACLR-PS and controls. However, ACLR-PS had increased values in both FABQ subscales compared to controls. These findings support the need for additional cognitive-behavioral therapies to address fear-avoidance beliefs in the returned to sport population. Future research should investigate effective therapies for these individuals. Furthermore, effective intervention strategies for patients after ACLR who have not returned to sport are also warranted.

Knee-Related Self-Efficacy Can Be Predictive of Patient-Oriented Outcomes Following ACL-R Zaichenko D, Medina McKeon JM: Ithaca College, Ithaca, NY

Context: Regardless of full knee recovery, many athletes never return to their pre-injury level of ability or sport. Following injury, injury-related self-efficacy may be an important indicator of how well a patient will rehabilitate the injured body part, however is rarely assessed in clinical practice. Objective: To quantify the effect of documented self-efficacy on knee-related clinical outcomes in ALC-R patients participating in physical rehabilitation. Data Sources: PubMed was searched through September 2017. Search terms included iterations of "ACL", "rehabilitation", "adhere", "psychology", and "postoperative". The search was limited to studies published within the last 10 years. Study Selection: Selection criteria required investigation of knee-related self-efficacy as related to clinical outcomes after ACL injury or surgery **Data Extraction:** The factor assessed was knee-related self-efficacy on "acceptability" of knee outcomes (acceptable/not acceptable). Two separate self-efficacy predictors were utilized; 1 for current self-efficacy of knee function, 1 for future knee performance. The specific outcomes were 1) patient-reported outcomes (PROs), measured by the Knee Injury and Osteoarthritis Outcome Score and Lysholm Knee Scale; 2) strength, as measured by single-limb knee extension, knee flexion, and leg press; and 3) function, as measured by single-limb hop for distance, single-limb countermovement jump, and 30s single-limb side hop. Higher scores indicated better self-efficacy, PROs, strength, or function. Means, standard deviations, and sample sizes for selected outcomes were extracted by two investigators. Individual Hedge's g effect sizes (ES) [95%CIs] were calculated. Six summary models (3 for current self-efficacy of knee function, 3 for self-efficacy of future performance) evaluated the effect of self-efficacy on PROs, strength,

and functional tests. Data Synthesis: Three studies met selection criteria and were analyzed. Study design varied: 2 studies were RCTs; 1 study was a nonrandomized clinical trial. For current assessment of self-efficacy there was a weak effect for those with 'acceptable' vs. 'not acceptable' outcomes, with CIs that encompassed zero for all three models; these were pooled together (ES = 0.3 [0.1, 0.5], p = 0.01). However, for assessment using future knee-related self-efficacy, there was a strong predictive effect for 'acceptable' outcomes for PROs (ES = 0.8 [0.4, 1.2], p < 0.001) and functional tests (ES = 0.7 [0.0, 1.3], p = 0.06), but a weak effect for strength (ES = 0.1 [-0.3, 0.6], p = 0.50). Included studies had PEDro scores of 4/10, 4/10, and 8/10. All 3 studies failed to blind patients and treating therapists. Two studies did not randomize participants or conceal group allocation. Conclusions: Projected knee-related self-efficacy had a strong effect on rehabilitation success as measured by PROs and functional tests; however, has a weak effect on acceptable strength measures. Perhaps self-efficacy is better at capturing PROs, such as subjective and objective assessments of function, but is less likely to accurately predict disease-oriented, impairment-based outcomes. Assessing knee-related self-efficacy in patients undergoing ACL-R may assist in the chance of effective rehabilitation.

Free Communications, Oral Presentations: Neuromotor Consequences of Concussion

Thursday, June 28, 2018, 9:45AM-11:15AM, Room 206-207; Moderator: Robert Lynall, PhD, ATC

Worsening Dual-Task Gait Costs After Concussion and Their Association With Subsequent Sport-Related Injury

Howell DR, Buckley TA, Lynall RC, Meehan III WP: The Micheli Center for Sports Injury Prevention, Waltham, MA: Sports Medicine Center, Children's Hospital Colorado, Aurora, CO; University of Colorado School of Medicine, Aurora, CO; Department of Kinesiology and Applied Physiology, University of Delaware, Newark, DE; Interdisciplinary program in **Biomechanics and Movement** Science, University of Delaware, Newark, DE; UGA Concussion Research Laboratory, Department of Kinesiology, University of Georgia, Athens, GA; Division of Sports Medicine, Department of Orthopaedics, Boston Children's Hospital, Boston, MA; Departments of Orthopaedic Surgery and Pediatrics, Harvard Medical School, Boston, MA

Context: Prior studies suggest that sustaining a concussion may lead to an increased risk of a subsequent sport-related injury. Mechanisms underlying this apparent association have yet to be determined, although dual-task deficits have been suggested as one contributing factor. Objective: To compare symptom and dual-task gait outcomes among athletes who sustained a concussion and either did or did not sustain a time-loss injury in the year after their concussion. Design: Prospective cohort study. Setting: Sports medicine clinic and athletic training facility. Patients or Other Participants: A sample of athletes (n = 41; 51%) female, mean age = 16.8 ± 3.2 years) were seen for care after a sport-related concussion, evaluated at two post-injury time points, and completed a questionnaire one year post-concussion documenting any new sport-related injuries since the concussion. Interventions: Participants completed the protocol within the first 21 days of concussion (T1), and again once they had been deemed clinically recovered (T2). The protocol consisted of a symptom inventory and instrumented dual-task gait evaluation, where they walked and completed a cognitive task (months backward, serial 7s backward, or spelling words backwards) while wearing an instrumented sensor system. Approximately one year post-concussion, they reported any acute sport-related injury since returning to sports. Main Outcome Measures: Outcome measures included symptom severity (Post-Concussion Symptom Scale: PCSS) and average gait speed dual-task cost. The dual-task cost was calculated as the percentage change in average gait speed between single-task and dual-task conditions. Using repeated measures ANOVAs, we compared dual-task costs and PCSS scores at T1 and T2 between those who sustained a time-loss acute injury during the year following concussion to those who did not. Results: Participants were assessed initially after concussion (median=5 days post-injury; range = 1-20 days) and again after they were deemed clinically recovered (median = 39 days post-injury; range = 12-196 days). The group who went on to sustain an acute injury (n = 15; 38%)demonstrated significant average walking speed dual-task cost worsening across time $(T1 = -17.9 \pm 9.1\% \text{ vs. } T2 = -25.1 \pm 12.5\%;$ p = 0.005). In contrast, the group who did not sustain an injury walked with similar dual-task cost values at both time points (T1 $= -25.8 \pm 8.9\%$ vs. T2 $= -25.1 \pm 8.5\%$; p = 0.45). Symptoms improved for all participants (PCSS T1 = 24.8 ± 17.1 vs. T2 = 2.9 \pm 7.6; p < 0.001), but did not differ between groups (p = 0.78). Conclusions: Significant dual-task gait cost worsening throughout concussion recovery was associated with sustaining a time-loss injury during sports in the year after a concussion. These findings indicate that worsening ability to successfully execute a concurrent gait and cognitive task may relate to the risk of incurring an injury during sports after clinical concussion recovery.

Impact of Cognitive Tasks on Gait Parameters in Collegiate Athletes

Burns KN, Roos K, Talley P, Wu WF, Nakajima MA: Center for Sport Training and Research, California State University, Long Beach, CA

Context: Motor and cognitive tasks are a complex but integral part of performing activities of daily living. From gross movements to more intricate sport movement, communication between the brain and the body is important in making these motions occur. A single task (ST) assessment is commonly used when trying to determine deficiencies in function, usually after sustaining an injury like a concussion, on either motor or cognitive task ability. However using dual task (DT) tests, which combine both motor and cognitive skills, are more useful in identifying deficiencies that may occur. Objective: The purpose of this study was to determine the effect of dual task tests on gait parameters in collegaite student athletes. Design: Cross-sectional Setting: Athletic Training Laboratory Patients or Other Participants: Fortysix participants (age: 19.57 (1.25) years; height: 181.13 (7.72) cm; mass: 83.67 (18.00) kg) from a convenience population participated in this study. No participants dropped out or were excluded. An individual was eligible to be included in the study if they were a current collegiate student-athlete and did not have: a lower extremity deficiency or injury which may affect normal gait pattern; history of cognitive deficiencies; history of three or more previous concussions; history of attention deficit hyperactivity disorder; and/or have a previously documented concussion that occurred within the past year. Interventions: The participant was fitted with an accelerometer at L5. The participant stood at one end of a marked 10-meter walkway that was clear of any distractions or obstacles and was instructed to walk at a self-selected pace to the end of the

walkway for five trials. DT trials one through three consisted of Serial 7s, where the participant counted backwards from 100 by seven. Trials four and five the participant was instructed to spell common five letter words backwards. The participant was not explicitly told where to focus their attention. Main Outcome Measures: Step count, gait cycle, cadence, nominal speed, peak medial lateral acceleration, peak anterior aceleration, and postural sway were measured. Results: Paired samples t-tests showed all gait parameters, including step count (ST = 15.48 (1.38), DT = 17.47 (1.98); t(45) = -13.301, p <.001), gait cycle (ST = 8.72 (1.07, DT = 11.05 (1.65); t(45) = -14.710, p < .001), cadence (ST = 107.27 (7.02), DT = 95.85 (7.74); t(45) = 12.132, p < .001), nominal speed (ST = 1.17 (0.14), DT = 0.93 (0.13); t(45) = 18.229, p < .001),peak medial lateral acceleration (ST = 12.34(3.49), DT = 11.30(2.12); t(45) = 2.948, p = .005), peak anterior acceleration (ST = 4.60(0.52), DT = 4.30(0.41); t(45) = 7.005, p < .001), and postural sway (t(45) = 5.355, p < .001) were statistically different between ST and DT. Conclusions: During the single task trials, participants walked faster, took less steps, and had higher acceleration and postural sway values than they did during the dual task trials. Clinicans can utilize normative reference values of single and dual task gait parameters to determine deficiences in either cognitive or postural control function following an injury.

Collegiate Athletes With Mild Traumatic Brain Injury Demonstrate Lingering Dynamic Balance Decrements Compared to Controls Moore MT, Carlson JM, Kangas KJ, Susa TR, Schmidt ML: Northern Michigan University, Marquette, MI

Context: Dynamic balance is a complex process involving visual, vestibular and neuromuscular control and can reliably be measured by the Biodex Balance System SD. Neuroimaging studies have shown decreased brain activity in the prefrontal cortex after mTBI. Functional near infrared spectrometry (fNIRS) examines hemodynamic activity in the prefrontal cortex during testing. Little research has examined this low cost approach to testing in mTBI compared to controls after the individual has completed a graduated return to play protocol. Lingering effects after the acute phase could put the individual who is returning to full contact sport at risk for re-injury. **Objective:** The purpose of this research is to examine the differences between mTBI and matched controls dynamic balance and hemodynamic activity measured by fNIRS 14-42 days after injury and full return to play. Design: Case-Control Setting: Quiet laboratory Patients or Other Participants: There were 15 matched pairs for ex, sport and age (age 18-29, N = 30). Athletic trainers referred participants after completing a graduated return to play protocol and full return to sport (within 14-42 days). Interventions: Participants completed dual limb support testing on the Biodex Balance System SD while monitored across the prefrontal cortex via fNIRS. Limits of Stability (LOS) testing at moderate skill level (75%) involved center of gravity control within their base of support. The clinical test of sensory integration (mCTSIB) and balance tested stability and sway indexes within four conditions (eyes open/ closed on firm vs foam surface) for 30 second intervals. fNIRS recorded from a 16-channel array over the prefrontal cortex at wavelengths 690 and 830 nm measuring oxygenated (HbO₂), deoxygenated (HbR) and total hemoglobin (HbT). Main Outcome Measures: Oneway mixed ANOVA determined relationships between LOS and mCTSIB between groups. Correlations with fNIRS determined the relationship between HbO, and HbR oxygenation in the prefrontal cortex and task by group. Results: A one way ANOVA revealed significant differences [F(1,28) = 5.486 p = .027]between mtbi (M = $2.612 \pm .682$), and controls (M = $2.126 \pm .426$) in dynamic sway balance on a foam surface with the eyes closed. Correlations between balance performance and fNIRS were significant for mTBI patients. They were strongly correlated with Channel 8 (HbO, r = .76, HbR r = .80, HbT r = .84) and Channel 9 (HbO₂ r = .86, HbR r = .76, HbT r = .88) and moderately correlated with Channel 7 (HbT r = .67),10 (HbT r = .71), 11(HbT r =.6) and 12 (HbT r = .57). LOS revealed no significant differences between groups (p = .03 - .91). <u>Conclusions:</u> These differences appear to be linked to prefrontal cortex fNIRS oxygenated and deoxygenated hemoglobin levels during dynamic balance. Lingering effects of mTBI cause individuals to exhibit difficulty with center of gravity shifts during dynamic balance settings. This study suggests possible persistent deficits in proprioception and vestibular deficiencies after mTBI.

Relationship Between Post-Concussion Step Counts and Time to Asymptomatic: A Pilot Study in College Students Feltner CO, Hoffman NL, Schmidt MD, O'Connor PJ, Lynall RC, Schmidt JD: University of Georgia, Athens, GA

Context: Consensus guidelines recommend refraining from strenuous mental and physical activities following concussion until asymptomatic. Recent evidence suggests that 48 hours after concussion, individuals may gradually implement physical activity throughout recovery. However, it is currently unknown if the amount of physical activity immediately following the acute period post-concussion is associated with the time it takes to become asymptomatic. **Objective:** To determine the relationship between the amount of physical activity during days 3-5 post-injury and the number of days to asymptomatic in concussed college students. Design: Prospective cohort. Setting: Clinical Research Laboratory. Patients or Other Participants: Twenty-three college students were diagnosed with a concussion by a physician within 72 hours of injury. Participants self-reported no learning disabilities, psychiatric disorders, migraine disorders, or history of 3+ concussions. Individuals with incomplete data (n = 2), prolonged recovery of 30+ days (n = 3), or did not meet valid wear time of 10 hours per day (n = 3) were excluded. The final sample of participants (n = 15; 8 males, 7 females, age = 21 ± 2 years, height = 173 ± 11 cm, mass = 74.2 ± 12.1 kg) included a mixture of student-athletes (n = 8) and general university students (n = 7). All concussed individuals were instructed to avoid physical activities that increased symptoms. Interventions: Participants were instrumented with a wrist-worn Actigraph GT9X Link accelerometer within 3 days of concussion and were instructed to wear the device continuously until their next follow-up visit when they became asymptomatic (based on number of symptoms and severity, neurocognitive function, and balance performance). Participants were not provided real-time measures of physical activity from the accelerometer to avoid motivation to be more active. Main Outcome Measures: We analyzed the average step count (number of steps) across days 3-5, as well as each day individually. A Spearman's Rho correlation was conducted to examine the relationship between days to asymptomatic and average step count ($\alpha =$ 0.05). Results: No significant relationships existed for days to asymptomatic $(13.8 \pm 6.9 \text{ days})$ and the step count averaged across days 3-5 $(11,954 \pm 2,924)$ steps, $r_s = -0.31$, p = 0.255). However, a moderate negative relationship existed on day 3 post-injury between step count and days to asymptomatic, where individuals with a greater step count $(9,970 \pm 2,729 \text{ steps}, r_s = -0.68, p =$ 0.005) became asymptomatic quicker. No significant relationships existed for days 4 and 5 post-injury. Conclusions: Participants who were more active 3 days following concussion became asymptomatic quicker. Moderate physical activity, such as walking to class, early after concussion might benefit clinical recovery time. However, the optimal time frame for resuming physical activity needs further exploration. Future studies using accelerometer-assessed physical activity hold promise for generating a better understanding of relationships between physical activity and concussion recovery.

Lingering Gait Speed Deficits Following Concussion Symptom Resolution: A Meta-Analysis Wood T, Hsieh K, Ballard R, An R, Sosnoff J: University of Illinois at Urbana-Champaign, Urbana, IL

Context: Numerous research studies have suggested that gait speed may remain impaired months and years following concussion symptom resolution. However, no study has quantitatively synthesized the existing data on altered gait speed following a concussion via meta-analysis. Objective: The objective of this study is to utilize a meta-analysis to quantitatively synthesize the pooled effect of the existing evidence of lingering gait speed deficits following a concussion. Data Sources: PubMed, CINAHL, and SPORTDiscus were searched using the terms: concussion, mild traumatic brain injury, sport concussion, walk, gait, mobility, locomotion, motor control, and postural balance. Study Selection: Studies had to include adult participants who sustained at least one concussion and were more than 14 days after injury, report single task or dual task gait speed, were peer-reviewed publications, and written in English. Data Extraction: Two investigators independently conducted abstract screening and jointly determined the list of articles for full-text review. Gait speed was extracted from six investigations, which included a total of 235 participants. Study quality assessment was adapted from Littell et al (2008) and conducted independently by the same two investigators; study quality was not used for study selection. Studies scored an average of 15.8 out of 20 (range 15-17) on the study quality assessment. Data Synthesis: All statistical analyses were conducted using the Stata 14.2 SE version (StataCorp, College Station, TX). All analyses used two-sided tests, and *p*-values less than 0.05 were considered statistically significant. A meta-analysis was performed

to estimate the pooled effect size for single task gait speed and dual task gait speed. During single task gait speed trials, concussed participants walked 0.053 m/s slower than healthy controls (p=0.004; 95% confidence interval -0.09 to -0.02; I²=39.3%). Subtraction dual task gait speed trials found a 0.043 m/s decrease in concussed participants compared to healthy controls. (p=0.017; 95% confidence interval -0.08 to -0.01; I²=0.0%). Conclusions: The present study indicates that concussed individuals may experience gait speed declines for months or years after injury. However, the clinical implications of the changes in gait speed are unclear. More research is needed to understand how gait may be applied to concussion assessment and management in an athletic training setting. Adding a simple gait speed assessment into an athletic trainer's concussion assessment toolkit may potentially provide better concussion assessment and management.



Notes: CI denotes confidence interval

Figure 1: Forest plot of meta-analysis of single task and dual task gait speed.

Free Communications, Oral Presentations: Just Breathe: Mind and Body in Athletic Training Settings

Thursday, June 28, 2018, 5:15PM-6:45PM, Room 206–207; Moderator: Susan Falsone, MS, PT, ATC

Investigation of the Effects of iRest Yoga Nidra on Pain Management in Rehabilitation of Sports Injury Callahan MJ: Texas State

University, San Marcos, TX

Context: Psychological reaction to injury is often overlooked by clinicians. A negative psychological reaction to injury has been shown in research to manifest as reduced performance, increased disuse and disability as a result, and withdrawal from valued activities. Previous research has found positive results using mindfulness-based interventions with injured athlete populations. The current study uniquely focuses on implementing an iRest yoga nidra practice among injured collegiate athletes. **Objective:** To investigate the effects of iRest yoga nidra on adherence to rehabilitation, fear-avoidance behaviors, and pain acceptance in injured collegiate athletes limited by chronic pain. Design: Case-series. Setting: NCAA Division-I University. Patients or Other Participants: Four female NCAA Division-I collegiate athletes (ages 19-21) from individual and team sports, and the board certified athletic trainers who supervised the rehabilitation of the athletes were included in the case-series. Inclusion criteria: a minimum of 2-weeks in a rehabilitation program, reporting persistent pain associated with the current injury, and attaining a minimum score of 25 or greater on the Athlete Fear Avoidance Questionnaire (AFAQ). Athletic participation restrictions varied at baseline with time lost from practice/ competition ranging from 0-97 days. Each participant reported a baseline level of disability, scores ranging from 40-61 on the Disability of the Physically Active scale (DPA). Interventions: iRest mp3 "Resting in Stillness" by Dr. Richard Miller was used as a non-invasive mindfulness meditation intervention requiring use 2x/week for 4-weeks. Participants listened to the mp3 in a quiet environment where they could not be disturbed for approximately 20-minutes prior to participating in rehabilitation. Main Outcome Measures: Sports Injury Rehabilitation Adherence Scale (SIRAS), Chronic Pain Acceptance Questionnaire (CPAQ-8) and AFAQ measured at baseline, 4-weeks, and 1-week follow-up. An activity log tracked each participant's completed minutes/session each week and documented participant experiences or feelings following each session. Descriptive statistics and time series figures were used to analyze trends in participant outcome measure responses. Qualitative analysis extracted basic themes present in participant activity log responses. Results: SIRAS mean scores suggests rehabilitation adherence was not influenced by the intervention from baseline (x = x) 13.63 ± 1.601) to follow-up (x⁻ = 13.13) \pm 1.931). AFAQ mean scores suggest a positive trend exists from baseline (x = x) 32.00 ± 4.967) to follow-up (x = 21.00 ± 7.257) between the intervention and lower fear-avoidance behavior in collegiate athletes. CPAQ-8 mean scores show an inconsistent trend among participants for levels of pain acceptance from baseline $(x = 30.00 \pm 8.246)$ to follow-up (x = 32.25 ± 10.532). Qualitative analysis revealed themes of relaxation. stress reduction, mood improvement, contentment, impatience, and restlessness; a sense of control over painful experiences from respective injuries was reported among participants. Conclusions: Use of iRest yoga nidra shows promising trends toward improvement of fear-avoidance behavior in collegiate athletes who report persistent pain with athletic injuries. Considering that iRest yoga nidra is a novel intervention, it is recommended that future research focus on utilizing experimental designs to provide more evidence in the sports medicine setting among injured athletes.

The Effectiveness of a 4-Week Yoga Intervention on the Activation and Timing of Core Musculature, Pain and Functional Disability Sagadore T, Selkow NM, Begalle RL: Illinois State University, Normal, IL; Daemen College, Amherst, NY

Context: Low back pain (LBP) poses a significant long-term health problem and requires the exploration of complementary alternative medicines, such as yoga. LBP patients often present with a delay in the onset of contraction of core musculature, which is necessary to stabilize the spine in dynamic movements. **Objective:** The aim of this study was to determine the effectiveness of a 4-week yoga intervention on the timing and activation of the transversus abdominis (TrA) and lumbar multifidus (LM) muscles. Secondarily, determine the effectiveness of a 4-week yoga intervention on the visual analogue pain scale (VAS) and functional disability levels as measured by the Oswestry Disability Index (ODI) among LBP participants. Design: Controlled laboratory study. Setting: Clinical laboratory and yoga studio. Patients or Other **Participants:** Healthy participants (n = 10; M = 3, F = 7; age = 22 ± 4.24 years; height = 170.4 ± 17.9 cm; mass = $66.9 \pm$ 23.1 kg) and those with LBP (n = 14; M $= 6, F = 8; age = 23.5 \pm 7.8$ years; height $= 173.1 \pm 23.4$ cm; mass $= 93.1 \pm 30.8$ kg) participated in the study. Inclusion criteria for the LBP group included: >3 episodes of LBP in the past year that resulted in limited ADLs or >5 times in their lifetime, have an ODI score between 2-40%, have back pain for <6 weeks during an episode, and have a pain intensity of >1/10 at the time of testing. Healthy participants could not have had any injury to the body in the past 6 weeks, including no history of LBP. Interventions: All participants underwent a 30-minute bi-weekly

4-week hatha yoga intervention for LBP taught by a certified yoga teacher. The sessions incorporated 10 minutes of breathing, meditation, and relaxation and 20 minutes of yoga pose exercise. Verbal feedback was provided to achieve proper form and modifications were implemented if needed. Statistical analyses of the results were performed using 2x2 analysis of variance for group comparison of the outcomes measures, and t-tests were used for intra-group comparison of the LBP participants. Main Outcome Measures: ODI, VAS, and TrA and LM muscle activation and timing were measured before and after the 4-week intervention. Results: There were no significant differences between groups for muscle timing or thickness after 4 weeks of yoga for either TrA (p > .101) or LM (p > .437). VAS scores were not significantly different between pre and post-intervention for the LBP group (p = .239), but there was a strong effect size (0.87 (0.11-1.63)) indicating yoga may help with pain reduction. The ODI scores for the LBP group were statistically significant (p = .049) but had a weak effect size and confidence interval that crossed 0 (0.2 (-0.55-0.94)). Conclusions: Participants with LBP may experience pain relief following 4-weeks of yoga. However, changes to functional disability and core function were not observed during this timeframe.

A Comparison of Stress Levels and Coping Skills of Collegiate Freshmen Athletes and Non-Athletes

Jochum JE, Vetroczky N, Kuchenberg M, Dybwad L: University of Indianapolis, Indianapolis, IN

Context: Despite knowing the factors that increase stress levels in collegiate freshmen, there is limited research that compares the stress levels and coping mechanisms between collegiate, freshmen athletes and freshmen non-athletes. Objective: Investigate differences in perceived stress levels and coping mechanisms in collegiate freshmen athletes and non-athletes. Design: Cross-sectional study Setting: National Collegiate Athletic Association Division II University. Patients or Other Participants: A convenience sample of 147 (athlete = 68, non-athlete = 69) (female = 86, male = 49) freshmen non- athletes and in-season spring sport athletes completed the online questionnaire. Interventions: Along with collecting demographic information, the online questionnaire consisted of two valid and reliable instruments: Perceived Stress Scale (PSS-10) and Brief COPE. The 10-item PSS-10 was used to measure the degree to which an individual appraises his/her situation as stressful. The 28item Brief COPE measured the frequency of positive, neutral and negative coping mechanisms on fourteen different scales. Main Outcome Measures: An independent t-test was conducted to compare mean scores of the PSS-10, and Mann-Whitney U tests were used to compare Brief COPE scales. A Spearman's rho correlation was used to determine relationships between perceived stress levels and coping mechanisms. Alpha level was set a priori at P < .05; the strength of the correlation coefficient was set at R < .30. **Results:** Analysis revealed no statistical difference between athletes and non-athletes on perceived stress or coping mechanisms. All participants rated a high level of perceived stress on the PSS-10, (females 29 (SD = 6) males 26 (SD = 5)) out of 40 possible points, yielding a statistical difference between genders, (t(133) = -3.117, P = 0.002). Of the 14 coping strategies measured, four were found to be statistically significant for females: emotional support (P < .001), instrumental support (P = 0.03), venting (P < .001), and self-blame (p = 0.05). A positive correlation exists between increased stress levels and eight coping mechanisms. The two highest correlations were disengagement (R = .422, P < .001) and self-blame (R = .523, P< .001). Conclusions: No significant difference was observed regarding perceived stress levels between collegiate freshmen athletes and non-athletes. All freshmen perceived high levels of stress. Females perceive higher levels of stress than males, and tend to select negative coping mechanisms. The higher levels of perceived stress, the more likely the person would be to use disengagement and self-blame as coping mechanisms. Health care professionals working on college campuses should be aware of the gender differences in perceived stress levels and coping mechanisms. In addition, college campuses should make available the necessary mental health resources to provide care and support to students.

Association Between Life-Event Stress and Quality of Life in Collegiate Athletes

Russ AR, Davis ER, Mitchell J, Mansell JM: Temple University, Philadelphia, PA; University of Valley Forge, Phoenixville, PA

Context: The Stress-Injury Model explains a relationship between psychosocial factors, including history of stressors, and musculoskeletal injury. Quality of life (QoL), a patient-reported measure, is a way to determine one's physical, mental, and social well-being. **Objective:** The purpose of this study is to examine the relationship between life-event stress and QoL in healthy collegiate athletes. Design: Cross-sectional. Setting: Controlled laboratory setting. Patients or Other Participants: 29 NCAA Division I athletes [10 males and 19 females (age 20.03 + 1.40 years; mass = 64.67 +8.22 kg)] with no history of injury in the previous 6 months volunteered for this study Interventions: All participants completed the Life Events Survey for Collegiate Athletes (LESCA) and the SF-36v2. The LESCA measures the absolute impact, positive or negative, of life-event stressors within the previous year. There are 69 events and for each event, the participant selects a score of -4 (extremely negative) to +4 (extremely positive) rating how that event affected one's life. A higher LESCA score is indicative of greater stress. Reported reliability ranges from .72 to .83. The SF-36v2 is used to assess QoL. The instrument produces a Mental Component Summary (MCS) and Physical Component Summary (PCS) generated from 8 health domain scores. Software analyzed the SF-36 scores and created the summary measures using z-scores normalized to the general population (50 \pm 10). Scores above 50 indicate higher QoL, while those below 50 are associated with lower QoL. Reliability ranges from .70 to .85. Main Outcome Measures: Total LESCA score. SF-36 MCS score. SF-36 PCS score. Multiple Pearson

correlations were used to determine the relationship between LESCA and SF-36. The a priori alpha level was set at p < .05. **Results:** LESCA = 23.72 \pm 13.50. MCS = 47.11 \pm 9.11. PCS = 58.05 \pm 3.94. LESCA and MCS: r =-.25, p = .20. LESCA and PCS: r = .115, p = .115, pp = .42. <u>Conclusions</u>: Athletes reported lower MCS scores than the general population, but had higher PCS scores. Additionally, 5 participants scored below the threshold (MCS = 42) for depression screening. There were no significant associations between life-event stress scores and QoL as measured by the SF-36. Although QoL is a measure of well-being, one's history of stressors is not related to QoL in healthy individuals. If using QoL measures, clinicians should be aware that a history of stressful events may not be reflected in the score. Instead, a multifaceted approach should be used when screening for psychosocial measures.

Observable Changes in Breathing Pattern Based on Body Position

Horris HB, Anderson BE, Bay RC, Huxel Bliven KC: A.T. Still University, Mesa, AZ; Middlebury College, Middlebury, VT

Context: The diaphragm has respiratory and postural stability roles, with normal function resulting in efficient respiration and improved core stabilization. Altered diaphragm function creates changes in breathing mechanics, including reduced abdominal excursion and superior migration of the rib cage during inhalation. The hi-lo and lateral rib expansion (LRE) tests are commonly used to assess breathing patterns, and are typically performed in supine or seated positions. It is unknown how body positions with increased stability demands affect breathing mechanics. Objective: To determine whether breathing patterns differ among body positions. Design: Prospective cross-sectional study. Setting: University laboratory. Patients or Other Participants: 50 healthy males (n = 18) and females (n = 18)= 31) were tested (age: 29.3 ± 4.1 years, height: 170.0 ± 10.4 cm; mass: $70.7 \pm$ 15.1 kg). Interventions: Participants completed one testing session, which included a demographic and health history questionnaire followed by hi-lo and LRE tests in supine, seated, standing, and half-kneeling body positions. All breathing tests were recorded and later scored by a single examiner (a priori intra-rater reliability >.80). A generalized estimated equation with breathing test and body position as factors was used for analysis. Pairwise comparison with Bonferroni correction was used to adjust for multiple tests. Statistical significance was set at p = .05, 2-tailed. Main Outcome Measures: Breathing mechanics and diaphragm function were assessed using the hi-lo and LRE tests. Hi-lo test criteria included abdominal excursion and superior rib cage migration. LRE test criteria included LRE and superior rib cage migration. Criteria were identified as present/ absent and used to categorize breathing as functional or dysfunctional. Results: There was a significant breathing test x body position interaction (P < 0.001) for breathing category and main effect for breathing test (P < 0.001) and body position (P < 0.001). When assessed with both the hi-lo and LRE tests, breathing pattern changed across body positions (P < 0.001). For the hi-lo test, functional breathing patterns were identified in 96.0% (n = 47) of participants in supine, 59.2% (n = 29) in seated, 38.0% (n = 19) in standing, and 42.0%(n = 21) in half-kneeling. For the LRE test, supine, seated, and standing body positions presented similar breathing patterns (P = 1.000) while significantly more dysfunctional breathing patterns were observed in half-kneeling (P <0.001). Conclusions: The hi-lo and LRE tests appear to measure different components of breathing mechanics and diaphragm function. Hi-lo test results were more highly dependent on body position, suggesting that breathing patterns change in positions with increased postural demand. LRE test results did not change across supine, seated, and standing body positions, suggesting that LRE is not as susceptible to changes in postural stability demands. Clinicians should use both hi-lo and LRE tests in combination; furthermore, the hi-lo test should be administered in multiple positions to ensure a complete assessment of breathing mechanics and diaphragm function.

Inter-Rater Reliability of Clinical Tests to Assess Breathing Pattern

Anderson BE, Horris HB, Bay RC, Huxel Bliven KC: A.T. Still University, Mesa, AZ; Middlebury College, Middlebury, VT

Context: Altered breathing mechanics and poor diaphragm function are linked to chronic, non-specific low back pain and movement dysfunctions. Clinical tests to assess breathing identify causes of these conditions, yet such tests are difficult to validate. It is important to establish the reliability of clinical tests to ensure consistency across multiple clinicians. The hi-lo and lateral rib expansion (LRE) tests are used to assess breathing patterns; however, little is known about their reliability and validity. **Objective:** To determine the inter-rater reliability of the hi-lo and LRE tests. Design: Blinded inter-rater reliability study. Setting: University laboratory. Patients or Other Participants: Three athletic trainers with varied experience were raters (rater 1:2 yrs certified, 2 yrs clinical experience; rater 2:20 yrs certified, 5 yrs clinical experience; rater 3:20 yrs certified, 20 yrs clinical experience). Interventions: Live test sessions of 50 healthy participants were recorded. Participants performed the hi-lo and LRE tests in four body positions: supine, seated, standing, and half-kneeling. Recordings (n = 400) were edited to de-identify participants and create eight sets of videos organized by breathing test (n = 2) and body position (n = 4). Raters met twice to determine scoring criteria and review five pilot test recordings before scoring data. Raters then independently viewed and scored each set of videos. Absolute agreement (%) between raters for video sets (n = 8) was calculated for breathing tests in each position. Kappa values do not accurately estimate concordance between raters for these data due to substantial imbalance in the marginal totals. Main Outcome Measures: Raters independently scored each breathing test performance as functional or dysfunctional. Pre-determined criteria for the hi-lo test included presence/ absence of abdominal excursion and superior rib cage migration. Functional breathing was defined as presence of abdominal excursion and absence of superior rib cage migration. For the LRE test, presence/absence of LRE and superior rib cage migration were assessed. Functional breathing was defined as presence of LRE and absence of superior rib cage migration. Results: The range of mean absolute agreement between raters for the hi-lo test was 73.8 to 80.4%. The highest agreement was in standing (80.4%) and half-kneeling (80.4%) compared to supine (73.8%) and seated (73.8%) body positions. The range of mean absolute agreement between raters for the LRE test was 72.9% to 82.2%. The highest agreement was in seated (82.2% followed by half-kneeling (79.3%), standing (73.8%) and supine (72.9%). Conclusions: The hilo and LRE tests were reliable when conducted in different body positions by multiple raters with varied experiences. The hi-lo and LRE tests are used to identify altered breathing mechanics and diaphragm function, and when used clinically can help identify factors contributing to chronic low back pain and movement dysfunctions. Future research should explore the intra-rater reliability of these clinical tests.

Free Communications, Oral Presentations: Examining Costs of Care in Athletic Training Practice

Friday, June 29, 2018, 7:00AM-7:45AM, Room 206-207; Moderator: Mark Hoffman, PhD, ATC

A Comparison of Estimated Direct Costs of Care Provided by Athletic Trainers Between Mild and Severe Lower Extremity Disorders: A Report From the Athletic Training Practice-Based Research Network

Sauers EL, Marshall AN, Lam KC: A. T. Still University, Mesa, AZ

Context: Data regarding the estimated direct costs of care (DCC) for athletic training services (ATS) provided outside of the Centers for Medicare and Medicaid Services (CMS) system are limited. Estimated costs of care are required to quantify the value of ATS. **Objective:** Compare the estimated DCC for ATS between mild and severe lower extremity disorders (MLED and SLED, respectively). Design: Retrospective analysis of electronic medical records. Setting: Forty-five athletic training facilities (high school = 39, college = 6) across 10 states within the Athletic Training Practice-Based Research Network. Patients or Other Participants: Medical records of 356 patients (MLED = 138, age = $16.7 \pm$ 2.1 yrs, height = 172.4 ± 10.8 cm, mass $= 72.6 \pm 16.4$ kg; SLED = 218, age = 17.6 ± 2.3 yrs, height = 172.8 ± 11.6 cm, mass = 74.4 ± 17.2 kg) diagnosed with a hip/thigh, knee, lower leg, ankle, or foot injury by an athletic trainer (AT). Interventions: Complete data sets from patients who received ATS between February 2009 - April 2014 were reviewed. All patiet records were created by an AT utilizing a web-based electronic medical record. Each injury was defined as a unique case and identified utilizing specific diagnostic codes (ICD-9). MLED was defined as an injury that resulted in 1 day but no more than 9 days of restricted participation, whereas SLED were injuries that resulted in 10 days or more of restricted participation. Main Outcome Measures: Summary statistics were calculated for patient and injury demographics.

Treatment characteristics included duration of care [initial evaluation to last documented episode of care (EOC)], EOC's (number of documented patient encounters), and services provided per EOC. DCC were estimated by applying the 2015-2016 CMS Physician Fee Schedule (MPFS) national payment amount. The MPFS online database was utilized to determine the non-facility (i.e., non-hospital) price for each CPT code. Group differences were evaluated using independent t-tests (alpha = .05, two-tailed). **Results:** A total of 356 injuries (MLED = 138; SLED = 218) were reported. The most frequent region of MLED was the ankle (42.8%) followed by the knee (40.6%). The most frequent region of SLED was the knee (45.4%) followed by the ankle (45.0%). Sprain/strain was the most frequent diagnosis for both MLED (28.3%) and SLED (32.1%). The average duration of care for MLED was 17.2 ± 22.2 days and 45.7 ± 42.7 for SLED (p < .001). The average number of EOC per case was 6.4 ± 6.3 for MLED and 13.2 ± 9.9 for SLED (p < .001). The average total DCC per SLED ($$1,269.96 \pm 1,334.26$) was significantly greater than for MLED ($$443.75 \pm 656.49$; p < .001), as were the average number of ATS per case (SLED = 32.0 ± 27.2 ; MLED $= 14.2 \pm 17.3$; p < .001). The average costs per EOC were significantly lower for MLED ($$69.75 \pm 51.22$) compared to SLED ($\96.36 ± 59.06; p < .001) and fewer ATS were provided per EOC for MLED (2.2 ± 1.3) versus SLED $(2.4 \pm$ 1.4; p < .001). Conclusions: These data provide important information about the differences in estimated DCC of ATS for MLED and SLED provided outside of the CMS system.

Cost and Treatment Characteristics for Sport-Related Knee Injuries Managed by Athletic Trainers: A Report From the Athletic Training Practice-Based Research Network

Lam KC, Marshall AN: A.T. Still University, Mesa, AZ

Context: Knee injuries are common during sport participation. However, little is known about the overall management and estimated direct cost of care (DCC) associated with these injuries when under the care of athletic trainers (ATs). Objective: To describe treatment characteristics and DCC for athletic training services (ATS) provided for knee injuries by ATs. Design: Retrospective analysis of electronic medical records. Setting: Twenty-four athletic training facilities (high school = 19, college = 5) across 8 states within the Athletic Training Practice-Based Research Network. Patients or Other Participants: Seventy-three ATs (female = 60.3%, age = 28.8 ± 7.4 years, years certified = 3.8 ± 5.5 , years employed at site = 1.3 ± 3.0) practicing in athletic training facilities during the study period. Interventions: Complete patient cases (i.e. cases with completed injury demographic, injury evaluation, daily treatment, and discharge forms) were identified using ICD-9 diagnostic codes and reviewed. ATs created patient records between 2009-2014. Main Outcome Measures: Summary statistics were calculated for patient demographics (sex, height, weight, sport, diagnosis), treatment characteristics, and DCC. Treatment characteristics included type of ATS (CPT code), duration of care (days between intake and discharge), episodes of care (EOC; number of documented patient encounters), and amount of care (number of ATS provided). DCC were estimated by applying the 2016 Centers for Medicare and Medicaid Services Physician Fee

Schedule for non-facility (ie, non-hospital) organizations. CPT codes were priced in accordance with the number of 15-minute units recorded and DCC for each EOC was estimated. Results: One hundred fifty-five (male = 101, age = 17.9 ± 2.5 years, height = 172.6 \pm 12.4 cm, weight = 76.9 \pm 18.9 kg) knee injuries were identified during the study period. The most common injuries were cruciate ligament sprain (27.1%, n = 42), medial collateral ligament sprain (14.2%, n = 22), and knee pain (12.9%, n = 20). Injuries occurred most frequently during football (39.4%, n = 61), soccer (10.3%, n = 16), and basketball (9.7%, n = 15). A total of 4772 ATS were recorded across patient cases with therapeutic exercise (CPT-97110 = 32.6%), hot/cold pack (CPT-97010 = 27.2%), AT re-evaluation (CPT-97006 = 9.7%), strapping of the knee (CPT-97030 = 6.7%), and manual therapy techniques (CPT-97140 = 4.5%) most frequently reported. The average duration of care was 48.0±56.6 days across 13.0 ± 11.3 EOC per patient case. The average amount of care was 30.8 ± 30.3 ATS per patient case and 2.4 \pm 1.3 ATS per EOC. The average total cost of care was $$1277.14 \pm 1437.41$ per patient case and 98.53 ± 57.92 per EOC. Conclusions: These findings provide insight into the treatments and DCC associated with knee injuries under the care of ATs. Knee injuries have demonstrated greater time-loss when compared to other lower extremity injuries. Thus, it is unsurprising that knee injuries are associated with higher duration and amount of care and higher DCC as compared to other lower extremity injuries such as ankle sprains. Future efforts should seek to understand the effectiveness of common treatment strategies and aim to identify treatments that can reduce costs and improve patient outcomes.

The Management and Estimated Direct Costs of Care of Ankle Sprain Injuries at the Point-of-Care: A Report From the Athletic Training Practice-Based Research Network Marshall AN, Lam KC: A.T. Still University, Mesa, AZ

Context: Although the National Athletic Trainers' Association's (NATA) position statement provides guidance on the management of ankle sprain injuries, little is known about treatment patterns of athletic trainers (ATs) at the point-of-care. **Objective:** To describe treatment characteristics and estimated direct costs of care (DCC) for athletic training services (ATS) provided for ankle sprain injuries by ATs. Design: Retrospective analysis of electronic medical records. Setting: Forty-three athletic training facilities (high school = 39, college = 4) across 11 states within the Athletic Training Research Practice-Based Network. Patients or Other Participants: One hundred thirteen ATs (female = 60.2%, age = 30.0 ± 11.2 years, years certified = 3.9 ± 5.1 , years employed at site = 0.71 ± 2.2) practicing in athletic training facilities during the study period. Interventions: Complete patient cases with recorded injury demographic, injury evaluation, daily treatment, and discharge forms were identified using ICD-9 diagnostic codes (845.0-Sprain/ Strain, 845.03-Tibiofibular Ligament Sprain, 845.01-Deltoid Ligament Sprain) and reviewed. ATs created patient records between 2009-2014. Main Outcome Measures: Summary statistics were calculated for injury demographics (diagnosis, sport, mechanism of injury), treatment characteristics, and DCC. Treatment characteristics included type of ATS (CPT code), duration of care (days between intake and discharge), episodes of care (EOC; number of documented patient encounters), and amount of care (number of ATS provided). DCC were estimated by applying the 2016 Centers for Medicare and Medicaid Services Physician Fee Schedule for non-facility

(i.e. non-hospital) organizations. Codes were priced in accordance with the number of 15-minute units recorded and the DCC for each EOC was estimated. Results: One hundred thirty ankle sprains (female = 40%, age = $16.6 \pm$ 1.9 years, height = 172.7 ± 9.9 cm, mass = 72.1 ± 15.5 kg) were identified during the study period. Diagnoses included Sprain/Strain (82.3%), Tibiofibular Ligament Sprain (14.6%), and Deltoid Ligament Sprain (3.1%). Injuries occurred most frequently during football (34.6%), basketball (16.9%), and soccer (15.4%), and via contact (30%), non-contact (23.8%) or fall (17.7%)mechanisms. A total of 2292 ATS were documented by ATs. The most frequently utilized treatment was hot/cold pack (CPT-97010 = 22.6%), followed by therapeutic exercise (CPT-97110 = 22.2%), strapping of the ankle/foot (CPT-97035 = 9.2%) therapeutic activities (CPT-97530 = 6.0%), and electrical stimulation (CPT-97032 = 5.1%). The average duration of care was 21.9 ± 18.5 days across 7.6 ± 5.0 EOC per patient case. The average amount of care was 17.6 ± 12.6 ATS per patient case and 2.3 ± 1.3 ATS per EOC. The average total cost of care was $$522.72 \pm 508.88$ per patient case and $$70.73 \pm 45.60$ per EOC. Conclusions: To our knowledge, this is the first study to describe DCC related to sport-related ankle sprain injuries under the care of ATs. It appears that ATs are generally following treatment recommendations provided in the NATA position statement. However, the most frequently utilized treatment (hot/ cold pack) is not currently recommended due to the lack of quality evidence.

Free Communications, Oral Presentations: Soccer From Head to Toe

Friday, June 29, 2018, 8:00AM-9:00AM, Room 206–207; Moderator: Sandra Shultz, PhD, ATC, FNATA

A Prospective Study on the Incidence, Mechanisms and Risk Factors for Sport Related Concussions in High School Soccer Players

McGuine TA, Schwarz A, Pfaller A, Gallenberger M, McDonald C, Brooks MA: University of Wisconsin, Madison, WI

Context: There is a growing recognition and concern regarding the incidence of Sport Related Concussion (SRC) injuries in high soccer players. However there is limited prospective data regarding the incidence, mechanism and risk factors for SRCs in high soccer players. **Objective:** To prospectively document the incidence, mechanisms and risk factors for SRCs sustained by high school soccer players. Design: Prospective cohort study. Setting: Fifty two high schools in Wisconsin during 2016/17 school year. Patients or Other Participants: A convenience sample of high school (Female and Male, Grades 9 – 12) soccer players. Interventions: Subjects completed a demographic form including their history of previous SRC and concussion symptom and symptom severity scores from the SCAT3. Athletic trainers (ATCs) recorded all (conditioning, practice or competition) soccer exposures (SE) as well as the onset, mechanism and days lost for each SRC sustained during the season. Main Outcome Measures: The main outcome variable is the incidence of SRC. Analyses included frequencies, proportions, symptom and severity scores as well as days lost (Median: [IQR 25th, 75th]. Odds Ratios OR: [95%] were used to compare the incidence of SRC by sex and previous history of SRC. **<u>Results</u>**: A total of 1060 (Female = 50%, Age = 15.9 + 1.1 vrs.) subjects enrolled and participated in a total of 52,294 SE. One hundred fifty eight subjects (15%) reported a previous SRC. The median preseason concussion symptom score = 0.0 [0,3] while the median symptom

severity score = 0.0 [0,4]. Forty one subjects (3.9%) sustained SRCs (SRC per 1000 SE = 0.784). Injured subjects reported a symptom score = 11[8.0,15.75] and symptom severity score = 25.5 [15.0, 44.0] when evaluated by their ATC and missed 15 [12,18] days from soccer. SRCs occurred most often during competition (67%) and sustained by midfielders (44%), goaltenders (21%) or defenders (18%). The head was struck most often in the back (33%) the front (25%) and side (20%) and due to contact with the ball (53%), another player's body (18%), the playing surface (15%) or another player's head (13%). A majority (69%) of the subjects did not see or anticipate the blow while 12% resulted in a penalty being called on the opposing player. Females were more likely to sustain a SRC than males (Females n = 33(6.2%), Males n = 8 (1.5%), OR = 4.41 [2.02-9.65], p = 0.002). Subjects with a previous history of SRC were more likely to sustain a SRC than subjects without a history of SRC. (Yes Previous SRC n = 13 (8.2%), No Previous SRC n = 28 (2.9%), OR = 2.88 [1.46-5.70], p= 0.002). Conclusions: This study provides details regarding specific mechanisms for SRCs in high school soccer players. Further, this study results show that females and players with a previous history of SRC were more likely to sustain SRC than males or players without a history of SRC.

Head and Neck Size and Neck Strength Predict Head Acceleration in Collegiate Women's Soccer Players Kaminski TW, Caccese JB, Lamond LC, Glutting JJ, Buckley TA: Athletic Training Research Laboratory, University of Delaware, Newark, DE

Context: In a controlled-laboratory setting, greater head and neck size and neck strength predicted lower peak linear and rotational acceleration during purposeful soccer heading. However, on-field head accelerations vary across type of impact and strategic heading scenario; therefore, it was unknown if head and neck size and neck strength predicted on-field head accelerations in soccer. Objective: The purpose of this study was to determine if head and neck size and neck strength predicted on-field head accelerations in a cohort of collegiate female soccer players. Design: Prospective study. Setting: Soccer field. Patients or Other Participants: 15 female collegiate soccer players (age = 19 \pm 1 years, weight = 59.7 \pm 2.9 kg, height = 167.3 ± 4.7 cm). Interventions: Onfield head accelerations were measured during all practices (N = 43) and games (N=20) using the Smart Impact Monitor (SIM; Triax Technologies, Norwalk, CT), which was secured to the back of the head, just above the greater occipital protuberance, using a custom tight-fitting elastic headband. Head mass, neck girth (i.e. circumference), and sternocleidomastoid and upper trapezius isometric strength were also evaluated. Main Outcome Measures: Peak linear acceleration (g) season mean, median, and total were calculated for each participant. Results: Results from the direct-entry regression model suggested that head mass $(4.9 \pm 0.2 \text{ kg})$, neck girth $(32.5 \pm 1.1 \text{ cm})$, sternocleidomastoid $(7.1 \pm 2.4 \text{ kg})$ and upper trapezius $(11.6 \pm 4.0 \text{ kg})$ isometric neck strength explained 53.3% of the variance ($R^2 =$ 0.533, F = 2.856, p = 0.081, $f^2 = 1.141$)

Journal of Athletic Training

in mean peak linear acceleration (19.5 \pm 5.5 g), 45.1% of the variance (R² = $0.451, F = 2.056, p = 0.162, f^2 = 0.0821)$ in total peak linear acceleration (805.2 \pm 1029.6 g), and 42.5% of the variance $(R^2 = 0.425, F = 1.848, p = 0.196, f^2 =$ 0.739) in median peak linear acceleration $(16.3 \pm 4.4 \text{ g})$, although these findings were not statistically significant. Conclusions: Our results suggest that head and neck size and neck strength may predict on-field head accelerations, whereby greater neck size and neck strength are associated with lower peak linear acceleration. However, our study was underpowered, so these regression models did not reach statistical significance. Greater neck girth may suggest higher neck stiffness resulting in greater effective mass opposing the oncoming ball/athlete during head impact and thus lower head acceleration. Similarly, greater neck strength allows for better coupling of the head, neck, and trunk, and higher effective mass of the system again yielding lower head acceleration. Future research should look to establish a relationship between head and neck size and neck strength and peak linear and rotational acceleration in other cohorts of soccer players (i.e. youth, male).

Lower Extremity Movement Quality Influences Early Season Workloads in Collegiate Soccer Athletes: A Pilot Study Aguilar AJ, Condon TA, Wikstrom

EA, Frank BS, Eckard TG, Padua DA: The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Clinicians can use movement screenings to identify individuals who may be at increased risk of sustaining a lower extremity (LE) injury. Injury risk identification is often performed during pre-season examinations, which includes the assessment of an athlete's LE movement quality. The Landing Error Scoring System (LESS) is a reliable and valid movement screening tool used to identify movement errors that are associated with increased risk of LE injury. In-season injury risk can be evaluated by monitoring trends in internal training load (ITL). Session rated perceived exertion (sRPE) can be used to monitor athlete response to training. It is currently unknown if LE movement quality influences ITL. Objective: The purpose of this investigation was to examine the influence of an athlete's LE movement quality (LESS score) on relative ITL (acute:chronic workload ratio [ACWR]) during a collegiate soccer season. Design: Prospective cohort study. Setting: NCAA Division I collegiate soccer team. Patients or Other Participants: Fourteen male soccer players (age: 20.3 ± 1.5 yrs, height: 1.82 ± 0.06 m, mass: 75.58 ± 6.82 kg) participated in this pilot study as part of their standard care. Prior to participating in the study, all subjects provided written informed consent. Interventions: Prior to the start of their season, athletes were assessed using the LESS. Daily session RPE (sRPE) (utilizing an 0-10 modified Borg scale) and session duration were collected after all official team practices and games during the regular season. Main Outcome Measures: sRPE and duration were used to calculate weekly absolute ITL and ACWR. ACWR is defined as the ratio between

the acute load (current absolute weekly TL) compared to the chronic load (mean absolute weekly TL of the previous four weeks). Independent samples t-tests were used to compare early season absolute ITL and ACWR between individuals with poor LE movement quality (LESS scores (≥ 8) and excellent movement quality (LESS scores (\leq 4)). Cohen's effect sizes were also calculated. Results: The poor movement quality group had a significantly higher overall mean ACWR compared to the excellent movement quality group $(1.07 \pm 0.39 \text{ v}, 0.64 \pm 0.16, \text{ p} = 0.02)$ and this difference was associated with a large effect size (d = 1.55). The poor movement quality group also experienced a significantly greater absolute ITL (1815.14 \pm 325.80 v. 1228.00 \pm 326.77; p = 0.01, d = 0.70) in week 5 compared to the excellent movement quality group. This relationship was not observed during the earlier weeks (1-4) between the poor and excellent movement quality group. Conclusions: Our results suggest that LE movement quality is associated with increased injury risk and may influence relative ITLs in collegiate male soccer athletes. This is the first study to examine the relationship between LE movement quality and TL in American collegiate soccer athletes. Future investigations should continue to explore the influence of movement quality on TL responses.

External Load Monitoring to Improve Return to Sport Following Surgery: Combining Rehabilitation With Sports Science: A Level 1 Validation CASE Report

Hardin SN, Phillips J: Minnesota United Football Club, Minneapolis, MN

Background: Following injury or surgery it can be challenging to determine the amount of activity to prescribe while gradually returning a patient to performance. Undoubtedly, a myriad of factors play into this decision-making process. Rehabilitation specialists commonly utilize clinical and functional testing to determine a patient's readiness to participate. Often, this testing focuses on the ability to perform specific tasks or movements rather than considerations of total loading. Objectively measuring both internal and external loading can play key roles in keeping patients safe and healthy as they progress through the return to sport continuum. Acute:chronic workload ratio (ACWR) is an external load ratio that can be calculated from GPS (or other tools) data by dividing selected variable(s), in this example total distance, completed in one week (acute) by the workload of the previous four weeks (chronic). Multiple authors have demonstrated the relationship between ACWR and injury risk; however, its use is not mainstream. Patient: Patient is a 33 year-old professional male soccer player of 13 years who underwent core muscle reconstruction with bilateral adductor repair after a self-reported threeyear history of intermittent abdominal and adductor-related groin pain. Pain was reported during athletic activity such as change in direction and striking a ball, and also during ADLs such a coughing and sneezing, lifting household objects and rolling over in bed. Clinical examination results suggesting injury to the integrity of the adductor and abdominal musculature, as well as underlying bilateral femoroacetabular impingement with labral pathology, were corroborated with radiographic and magnetic resonance imaging. Intervention or Treatment: Following surgery the patient underwent rehabilitation focused on functional hip and core stability as well as restoring proper mobility, biomechanics and breathing patterns. Acute:chronic workload ratio was monitored by athletic training beginning in week two when the patient began running and on-field rehabilitation. Rehabilitation sessions were planned considering ACWR as the patient recovered. Outcomes or Other Comparisons: The patient began participation in modified team training at week six, progressed to full training during week nine and completed 90 minutes of game play in week 13. The

aim was to keep ACWR within (0.8 minimum) 1.00-1.25 (1.5 maximum), with respect to stage of tissue healing, due to its relation with increased injury risk. ACWR monitoring was transferred for supervision by the sports science department at week 17 after the patient had returned to full sport for four weeks. <See Graph 1> Conclusions: ACWR measured via GPS may not be financially accessible for high school or lower-funded collegiate teams. Alternatively, individual session rate of perceived exertion (RPE), which is correlated with ACWR, specific to a predetermined training distance may be used to measure internal loading; however, it too is not without limitations. Challenges with both exist with collecting data due to team factors (travel vs. game vs. training opportunities) and individual factors (internal duty, school breaks, compliance), which may impact the usefulness of these tools. While ACWR has an established body of literature, Murray et al. have recently presented an alternative ratio providing a more sensitive indicator of injury likelihood. More research is needed to support these findings. Clinical Bottom Line: Acute to Chronic Workload Ratio (ACWR) monitoring can be used prospectively as a framework to systematically monitor external load as part of a comprehensive, evidence-based return to sport program.



Acute:Chronic Workload Ratio

Free Communications, Oral Presentations: Developing Clinical Reasoning in Athletic Training Students

Friday, June 29, 2018, 10:45AM-12:00PM, Room 206-207; Moderator: Paul Geisler, EdD, ATC

Effects of Mandatory Peer Assessment/Feedback After Training on Psychomotor Skill Performance

Snyder MM, Peterson TD: Western Carolina University, Cullowhee, NC

Context: Peer assessment/feedback (PAF) is a pedagogic technique that falls under the peer assisted learning umbrella. Peer assessment is defined as students judging the level or quality of a fellow student's understanding or work and peer feedback involves providing information on what was performed correct and incorrect in order to improve understanding. Documented benefits of PAF include enhanced learning, improved critical thinking, self-assessment, increased reflective thinking and collaboration. **Objective:** Examine the effects of mandatory PAF after training on psychomotor skill performance. Design: Prospective cohort study. Setting: Undergraduate athletic training program in a mid-sized public university in the southeast. Patients or Other Participants: Fifty-seven sophomore athletic training students enrolled in a lower extremity orthopedic evaluation course over two years participated in the intervention and completed all required parts of the study. A control group consisted of 53 students that took the course during the previous two years; the course was constructed the same, with the exception of no PAF training and no mandatory PAF. Interventions: Participants in the intervention group completed a 2 hour workshop that covered proper mechanisms to assess, provide feedback, and receive feedback. Training also included analysis of videotaped scenarios and practice scenarios. Participants were also required to complete PAF of the skills prior to the practical exams. Main Outcome Measures: The critical dependent variable was participation in the PAF training and mandatory PAF prior to practical exams. Scores of 4 practical exams were compared through 4 separate independent samples t-test using SPSS. Results: The experimental group performed better on all four 60 point practical exams. The differences were statistically significant for exams 1 and 3. Exam 1 covered neurological and ankle [t(108) = 4.95, p = 0.00, means: experimental 52.80 ± 5.24 , control 47.85 ± 5.25]. Exam 3 covered the hip [t(108) = 2.27], p = 0.03, means: experimental 51.40 \pm 5.00, control 49.02 ± 6.75]. There were no statistical significant differences for exams 2 and 4. Exam 2 covered knee and patellofemoral joint [t(108) = 1.87], p = 0.07, means: experimental 52.35 \pm 5.00, control 50.66 \pm 4.46]. Exam 4 was a cumulative practical exam [t(108) = 4.95, p = 0.08, means: experimental 51.77 ± 6.25 , control 51.36 ± 5.58]. Conclusions: PAF training and mandatory PAF improved practical exam grades for 2 of the 4 exams; PAF did not hinder student learning. PAF can be a helpful tool to increase the amount that a student practices skill, and increase the amount of feedback students receive. This can be especially with helpful with large classes.

The Effectiveness of Online Videos in Improving Clinical Skills Involving Musculoskeletal Injury Assessment

Slaughter NJ, Lam KC: A.T. Still University, Mesa, AZ; Southern Utah University, Cedar City, UT

Context: Advances in technology has increased the popularity of online methods for distance learning and continuing education efforts. While evidence suggests that the use of online methods (e.g. online videos) increases learner knowledge, it is unclear if similar benefits exist for improving hands-on clinical skills such as musculoskeletal injury assessment. Objective: To determine the effectiveness of online videos in improving knowledge and handson clinical skills for musculoskeletal injury assessment. Design: Pre-test post-test. Setting: Classroom and online. Patients or Other Participants: Thirty-four undergraduate students (male = 13, female = 21, age = $22.6 \pm$ 2.15 years) participated in this study. Interventions: Participants were asked to complete the same written and practical examinations on Days 1 (pre-test) and 7 (post-test). For the practical examination, the same rater and model were used for both testing sessions to preserve inter-participant and inter-session reliability. Following the pre-test examinations, participants were given access to an online video that reviewed the proper testing procedures of the Lever Sign for assessing anterior cruciate ligament pathologies. Participants were asked to view the online video at least once between the two testing sessions, but were allowed to view the video as many times as they wished. The online video was developed by examining current evidence and reviewed by a content expert prior to testing. Participants were blinded from their pre-test scores. Main Outcome Measures: Knowledge and hands-on clinical skills were operationalized by written and practical examination scores, respectively. Both examinations consisted of 10-items that assessed each participant's knowledge of and ability to properly perform the Lever Sign including patient/clinician positioning, hand placement, proper amount of force applied, and interpretation of results. The written and practical examinations consisted of fill-in-theblank and binary items, respectively. Examination scores were reported as percentages, with higher scores indicating better knowledge and ability. We used a Wilcoxon Signed Rank Test to evaluate score differences between testing sessions (alpha = .05, two tailed). Participants scoring over 70% were classified as being competent. Results: Participants demonstrated significantly higher scores at post-test for the written (P < .001) and practical (P < .001) examinations. At pre-test, the average scores for the written and practical examinations were 40.3% (range = 0%-80%) and 32.4% (range = 0%-90%), respectively, with 14.7% (5/34) and 17.6% (6/34) of participants demonstrating competency on the written and practical examinations, respectively. At posttest, the average scores for the written and practical examinations were 85.0% (range = 60%-100.0%) and 87.4%(range = 70%-100.0%), respectively, with 82.3% (28/34) of participants demonstrating competency on both examinations. Conclusions: Preliminary findings suggest that online videos can improve knowledge and hands-on skills associated with musculoskeletal injury assessment. These findings may support the use of online videos to facilitate distance and continuing education efforts in athletic training. Future investigations should determine factors that may impact retention of knowledge and skills associated with online learning.

Using Standardized Patients to Measure Outcomes in Competence and Confidence in Clinical Skills of First Year Physical Therapy Students Cuchna JW, Walker SE, Mariano MH, Van Lunen BL: Longwood University, Farmville, VA; Ball State University, Muncie, IN; Old Dominion University, Norfolk, VA

Context: Outcomes are limited concerning the use of standardized patients (SPs) in physical therapy educational programming. Examination of outcomes could assist with student success and program development. Objective: The purpose of this investigation was to explore the effects SP implementation had on doctor of physical therapy (DPT) student's communication and patient interviewing skills and confidence in those skills. Design: Comparison group, repeated measures design with the collection of four survey instruments at pre-test and two posttest time points. Setting: The experimental portion of the study was conducted at a regional comprehensive academic medical center which has 16 simulated patient examination rooms where the SP encountes were completed. The survey instrument collections were completed at two separate peer-matched, regionally accredited academic institutions. Patients or Other Participants: A convenience sample of 60 first year, DPT students (23 males and 37 females; 23.17 ± 2.65 years of age). Interventions: A comparison group (N = 23) and experimental group (N =37) completed four self-administered survey instruments three sperate times. The instruments measured aspects of self-efficacy, communication competence, and confidence. Both groups completed the survey instrument packet at all three time points, however, only the experimental group received SP encounters prior to the second and final instrument collections. SP encounters involved communication and patient interviewing skills and concluded with an objective performance assessment completed by the SP. The independent variables of interests were group (experimental vs. comparison), gender (male vs. female), additional credentials (no additional credentials vs. one or more additional credentials) and time (pre-test, posttest, and posttest,). All instruments were collected in person by the primary researcher at both the experimental and comparison group institutions. The SP Encounter Content Checklist was only collected for the experimental group participants and was completed by the SP interacting with each individual learner. Main Outcome Measures: The dependent variables were average overall scores on the four survey collection measures and the SP Encounter Content Checklist. A General linear model repeated measures analysis was utilized for data analysis. Results: At baseline the experimental group displayed higher average scores on self-efficacy and communication competence measures, thus making comparisons of the groups for these measures less meaningful. Significant improvements were evident for confidence scores over time for the experimental group. Increase in confidence scores were evident in both groups, however only initially for the comparison group. The experimental group's objective performance scores were significantly higher on the second SP encounter compared to the first. Conclusions: Self-efficacy and communication competence measures were not affected by SP utilization, however, confidence improved. Multiple exposures to SPs is supported by previous research to improve confidence. Additional research is warranted to examine the measures over a longer period of time, and with a larger sampling of students.

Post-Professional Learners' Reflections Following a Standardized Patient Encounter and Debriefing Session

Bush J, Walker SE, Sims K, Winkelmann ZK, Feld SD, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN; Ball State University, Muncie, IN

Context: Simulations are commonly used in medical education to facilitate instructional and assessment experiences for learners. Standardized patients (SP) are a form of simulation with actors trained to present conditions that occur in health care. The most important feature in simulation-based education is feedback; one form of group feedback is debriefing, intended to improve learning, future performance, and patient outcomes. **Objective:** To explore reflections on learning following a SP encounter and debriefing session. Design: Consensual **Oualitative** Research. Setting: One Midwestern University. Patients or Other Participants: 17 post-professional Doctor of Athletic Training students with no previous experience with SPs (age = 25 ± 4 y; male = 5, 29.4%, female = 12, 70.6%; highest degree earned professional Bachelors = 12, 70.6% and post-professional Masters = 5, 29.4%, experience= 24.8 ± 30.5 mo). Data Collection and Analysis: Participants completed one of 3 SP encounters and the following day engaged in a diamond-debriefing session. After both the SP encounter and debriefing session, participants completed a five item open-ended questionnaire. The open-ended questions asked participants to self-reflect on what they learned following the SP encounter and the debriefing session (e.g., what did you learn about yourself, how can you translate this experience into our clinical practice). The questions were evaluated by a panel of qualitative researchers for content and face validity.

Consensual qualitative research data analysis approach was used to analyze all open-ended responses. A 3-person data analysis team identified codes and themes independently and then met to develop a consensus codebook. Each researcher then independently coded the data, and met to reach a final consensus ensuring accuracy and representativeness of the data. Credibility was established by the use of multiple researchers and an external auditor. Results: Our qualitative analysis revealed reflections following both the SP encounter and debriefing session revolved around three overarching themes: organization of clinical exam, vulnerability, and patient-centered care. Participants indicated that the SP encounter helped them to identify weaknesses in the organization of their clinical exam, remarking that they felt disorganized. Vulnerability was evidenced by participants acknowledging weaknesses in their clinical practice, stating that the SP encounter helped to identify gaps in their learning related to non-traditional patient populations (e.g. farmer, school teacher, construction worker) and/or difficult patient cases (e.g. arthritis, low back pain, multidirectional shoulder instability). Participants acknowledged the need to further develop their patient-centered care skills, specifically wanting to empower patients to choose their best treatment option, collaborating with patients to set goals, and inquiring about how their injuries affected their life beyond work and sport. Conclusions: The SP encounter and diamond-debriefing technique did facilitate self-reflection, inform, and motive students to alter their future approach to patient-centered care. Future research could explore if reflection would differ if it occurred immediately following an SP encounter or one-day post SP encounter.

Clinical Decision-Making: Investigating the Students' Process

Paver SR, Frank EM, Potteiger K, Pitney WA: Northern Illinois University, DeKalb, IL, Lebanon Valley College, Annville, PA

Context: As athletic training students' progress through a professional education program they develop and refine their clinical knowledge and skills in the classroom and clinical settings under the direction of faculty and preceptors. These experts should offer cognitive scaffolding to help the students further develop and refine their clinical decision-making skills. Upon graduation, students should have attained the ability to engage in the clinical decision-making process; however, the literature suggests a disconnect between formal education, professional practice, and the students' ability to make sound clinical decisions. **Objective:** Identify the clinical decision-making processes employed by athletic training students. Design: Qualitative design with stimulated recall interviews. Setting: Educational institution. Patients or Other Participants: Fourteen second year athletic training students enrolled in a baccalaureate athletic training program in the Midwest. Data Collection and Analysis: We collected data through direct observations and semi-structured interviews. We video recorded and directly observed each student's evaluation of a standardized orthopedic injury. The purpose of this was to take notes on each individuals' behaviors, reactions, interaction, think aloud process and clinical evaluation process. Furthermore, we formulated additional interview questions to better understand the cognitive process of each student. We conducted the semi-structured interviews immediately after the evaluation. We followed a script with added probing questions which, in part, came from the direct observations. During the interview, stimulated recall was employed while we watched the recorded video with each student after they completed their evaluation. We audio recorded and transcribed all interviews verbatim. Inductive content analysis was employed to analyze the data we gathered. We each read the transcripts before the process of coding began and through conversations and modifications of the coding method, we identified categories and split those into themes that aid in understanding the students' clinical decision-making process. We ensured trustworthiness in three ways: (1) member checking; (2) engagement in data collection to ensure saturation; (3) peer debriefing regarding the process, findings, and interpretations. Results: Four preliminary themes emerged: a) Students engage in anchoring bias; b) Students use their own personal past experiences to form clinical impressions; c) Students model preceptors; and d) Students perceive incongruity between the didactic and clinical environment. Conclusions: Based on these findings, students would benefit from preceptors modeling their consideration of multiple pieces of evidence when making decisions. Under the direction of faculty and preceptors, athletic training students develop and refined their clinical decision-making skills. Before we can further identify how faculty and preceptors can best help develop the clinical decision-making skills in students, we must understand the process which students already employ. Gaining insight into this process has educational implications as curricular changes can be implemented to address shortcomings or foster advances in the students' cognitive thinking process.

Friday, June 29, 2018, 12:15PM-1:30PM, Room 206-207; Moderator: Jennifer Hootman, PhD

A Descriptive Analysis of Injuries Reported in USA Cycling Sanctioned Competitive Road Cycling Events Jancaitis GA, Snyder Valier AR,

Bay RC: Norwich University, Northfield, VT; A.T. Still University, Mesa, AZ

Context: Competitive road cycling is a popular sport with estimates of 280,000 participant-days per year. Cycling injuries often are reported in recreational road cycling, and competitive mountain bike events; yet little is known about the injuries sustained or the on-site care provided to injured cyclists during competitive road race events. **Objective:** To describe the body regions injured and medical disposition during competitive road cycling events. Design: Retrospective data review. Setting: Injury reports were obtained from USA Cycling and represent injuries sustained during competitive cycling events across 30 states. Patients or Other Participants: A convenience sample of 1053 injury reports from male and female (male: n = 650 [61.7%], age $= 33.4 \pm 13.6$ years; female: n = 116 [11.0%], age = 33.3 ± 13.9 years; missing: n = 284 [27.0%]) cyclists who participated in USA Cycling-sanctioned competitive road cycling events during the 2016 competitive season were reviewed. Interventions: Data regarding body region injured (lower extremity, torso/back, upper extremity, head/ neck, face, internal/other) and injury disposition (Ambulance/EMS, Medical Attention, Report Only, Continued Riding, Released to Parent/Personal Vehicle, Referred, Refused Care) were analyzed. Main Outcome Measures: Descriptive statistics including frequencies, percentages, and means \pm SD are reported. Fisher's Exact Test was used to explore the relationship between injury disposition and sex. P < .05 was used to determine significance. Results:

A total of 1808 injuries was reported. The most frequent body regions injured were the upper extremity (46.5%, n =841) and lower extremity (32.2%, n =583). Injuries to the head/neck (10.4%, n = 189), torso/back (5.2%, n = 95), face (4%, n = 87), and internal/other regions (0.7%, n = 13) were less common. On average, 1.37 ± 0.81 injuries were documented per injury report. Injury disposition was reported in 928 cases. The most frequent dispositions following race injury were Medical Attention (34.1%, n = 316), Ambulance/EMS (19.3%, n = 179), Report Only (15% n = 139), Referred (13.0% n = 121), and Released to Parent/Personal Vehicle (12.1% n = 112). Less frequently, injured cyclists Refused Care (4.1% n = 38) or Continued Riding (2.5% n = 23). Males required ambulance/EMS transport (77.8%, n = 105) more frequently than females; (22.2%, n = 30), P = .036;and more medical attention (89.8%, n = 212) than females (10.2%, n = 24), P = .036, but no differences were identified between sexes for other dispositions. Conclusions: Our results suggest that the majority of injuries sustained in competitive road cycling events are to the upper and lower extremity. Following injury, racers often receive medical attention and a substantial percentage require transport by EMS, and these dispositions are more frequent in males. These results only describe the immediate care provided to injured racers and do not address any time-loss due to injuries. Future research should examine factors that may contribute to increased medical attention among male racers and should investigate the long term effects of injuries sustained during competitive road cycling events.

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Epidemiology of Sudden Death in Adult Organized Recreational Sport in the United States, 2007-2016

Endres BD, Stearns RL, Kerr ZY, Hosokawa Y, Huggins RA, Scarneo SE, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Epidemiological data on the incidence of sudden death in the general adult public in the United States during organized recreational sports participation is lacking. **Objective:** To describe the epidemiology of sudden death in organized adult recreational sport in the US between 2007 and 2016. Design: Descriptive epidemiological study. Setting: Organized competitive adult recreational sport in the US. Patients or Other Participants: Adult athletes who suffered sudden death during competitive recreational sport participation. Data Collection and Analysis: Sudden death information between 8/1/2007 and 12/31/2016 was obtained via LexisNexis and other publicly available news or media reports. Cases of sudden death in the US that occurred in athletes ≥ 18 years of age training for or competing in organized recreational sports were included. Athlete age, sex, race, date of death, event type, sport, and speculated cause of death were examined. Data are presented as deaths per year and percent (%) of total sudden deaths. Results: From 2007-2016, 119 cases of sudden death ([mean \pm SD] = 12 ± 6 deaths/year) were reported in organized adult recreational sport in the US. Excluding one case that did not have age reported, the average age of sudden death was [mean \pm SD] 43 \pm 14 (range = 18-86) years. Males (87%, n = 103/119) accounted for nearly 6.5 times as many sudden deaths than females. The majority of deaths occurred in Caucasian athletes (80%, n = 95/119) followed by African American (4%, n = 5/119), Asian (3%, n = 4/119), and Hispanic (3%, n = 4/119) athletes. Race was unreported in 11 cases (9%). Sudden deaths occurring during competition (97%, n = 116/119) exceeded those during training (3%, n = 3/119). Thirty-two percent of sudden deaths (n =38/119) occurred during triathlon competitions followed by half-marathon competitions (20%, n = 24/119). Non-traumatic sudden cardiac death (SCD) was the

most common cause of death (75%, n =89/119) followed by traumatic brain injury and drowning (6%, n = 7/119, respectively). Of the total non-traumatic SCDs, 76% (n = 68/89) occurred in individuals over the age of 35. Conclusions: From 2007-2016, 119 recreationally competitive athletes experienced sudden death while participating in organized sport in the US. Sudden deaths occurred most often in males (87%), during competitions (97%), and were cardiac-related (75%). Although we were not able to estimate incidence rates of sudden death in this study, future research into this area would benefit from collaborative efforts aimed at creating accessible population data for organized recreational sport participation. In conclusion, our findings were similar to data from youth, collegiate, and secondary school settings in that sudden death occurred most often in males and SCD accounted for the majority of sudden deaths. Continued examination of competitive recreational sport is needed to improve data quality related to incidence and participation rates in order to ultimately enhance health and safety guidelines.

Figure 1: Proportion of Sudden Death in Organized Adult Recreational Sport, 2007-2016



Other includes drowning (n=7), inconclusive/unknown (n=6), blunt force trauma (n=3), hyponatremia (n=1), and rhabdomyolysis (n=1)

Current Trends in Recurrent Anterior Cruciate Ligament Injuries in College and High School Sports: 2009-2010 Through 2015-2016

Chang M, Slater L, Wasserman E, Hart JM: University of Virginia, Charlottesville, VA; Shirley Ryan Ability Lab (formerly Rehab Institute of Chicago), Chicago, IL; Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

Context: Knee injuries are among the most commonly reported sport-related injuries that result in extended time missed from sport participation in high school (HS) and collegiate athletics. Little is known regarding the rates of first-time and recurrent ACL injuries sustained during athletic events and how they are influenced by sex, sports participation level, and game time features. **Objective:** To examine the rates of first-time and recurrent ACL injuries for collegiate and high school athletes in terms of participants' sex, sports level, and game time

feature. Descriptive epidemiology study. Setting: Data from the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP) and National Athletic Treatment Injury and Outcomes Network (NATION). Patients or Other Participants: Collegiate student-athletes participating in sports during the 2009-2010 through 2015-2016 academic years and high school student-athletes participating in sports during the 2011-2012 through 2013-2014 academic years. Interventions: We identified first time and recurrent ACL injuries that resulted in at least 7 days lost from activity, regardless of surgery status. Logistic regression was used to estimate the odd ratios to compare recurrent ACL injuries to first time ACL injuries with accompanying 95% confidence intervals (CI). The number of ACL injuries and odd ratios (ORs) were calculated for sex, competition level (NCAA/high school), and time in game (early/late) for all ACL injuries and restricting to ACL injuries due to non-contact, overuse, or surface contact mechanisms. The alpha level was p < 0.05. Main Outcome Measures:

Prevalence of ACL injuries and odd ratios calculated using logistic regression. Results: 608 total ACL injuries were reported from the databases, including 559 first time injures and 49 recurrent injuries. When restricting to ACL injuries due to non-contact, overuse, or surface contact mechanisms, 346 total ACL injuries were reported including 313 first-time injuries, 33 recurrent injury. NCAA players were 4.5 times more likely of having a recurrent ACL injuries versus first time injuries than high school players. (OR = 4.479 [95% CI = 1.354, 14.815], P = 0.0140,). There was no significant difference in ACL re-injury prevalence for sex or time in game (early vs late). However, there was a trend that recurrent injuries were likely to occur early in game but this was not statistically significant (Table). Conclusions: The prevalence of recurrent ACL injury is influenced by level of competition, but there are no relationship between sex, and time in game and odds of recurrent ACL injuries.

Table: Logistic Regression results comparing recurrent ACL injuries to firsttime ACL injuries that resulted in at least 7 days lost from activity

All ACL injuries (n=608: 559 first-time, 49 recurrent)					
Sex: Female vs Male OR=1.043 [95%CI:0.463, 2.350] P=0.9196					
OR= 4.479 [95%CI:1.354, 14.815], P=0.0140*					
Restricting to ACL injuries occurred during games					
OR=0.490 [95%CI:0.174, 1.382], P=0.1777					
Restricting to ACL injuries due to non-contact, overuse, or surface contact mechanisms (n=346; 313 first-time, 33 recurrent)					
OR=0.709 [95%CI:0.265, 1.900], P=0.4944					
OR=10.326 [95%CI:1.358, 78.510] P=0.0241*					
Restricting to ACL injuries due to non-contact, overuse. or surface					
contact and injuries occurred during games (n=203; 189 first-time, 14 recurrent)					
OR= 0.696 [95%Cl:0.215, 2.253], P=0.5453					

Athletic Exposure Methodology Influences Injury Risk Estimates in Collegiate Sports

Norcross MF, Johnson ST, Bovbjerg VE: Oregon State University, Corvallis, OR

Context: Comprehensive sports injury surveillance systems (ISS) are vital tools for identifying causes of injury, evaluating the effectiveness of preventative interventions or policy changes, and comparing injury risk between different types of activities such as competitions and practices. However, the inferences drawn from these systems may be influenced by the manner in which time at risk is estimated. While several prominent ISS capture the total number of practices and/or competitions that athletes participate in- regardless of the length of their participation-it is unknown if recording more detailed total hours of participation may result in more precise injury risk estimates by capturing the variability in athletes' actual participation that is lost in the former method. Objective: Compare competition to practice injury rate ratios (IRR) calculated using different methods for estimating athletic exposure. Design: Prospective cohort. Setting: Intercollegiate athletic department. Patients or Other Participants: One hundred ninety-seven Division I student-athletes in 5 sports: Football (113), Men's Basketball (16), Women's Basketball (13), Men's Soccer (29), and Women's Soccer (26). Interventions: Athletic trainers recorded injury events using an electronic medical record and athletic exposure using weekly online surveys and a web-based application during the 2016 calendar year. Main Outcome Measures: Aggregate number of: 1) injury events, 2) practices and competitions in which athletes participated (Number), and 3) hours of practice and competition in which athletes participated (Hours) were recorded. IRRs were calculated for each sport and exposure method. Differences between the Number and Hours exposure methods were determined for each sport by evaluating the 95% CIs of the IRR estimates. Results: Competition to practice IRR estimates and 95% CIs for the Number and Hours exposure methods

are presented in the Table. Compared to the Hours method, the Number method systematically underestimated the IRR for the five sports of interest and the results were significant for football, men's basketball, and women's basketball (P <0.05). Conclusions: Failure to account for the variability in the actual time that athletes participate in competition and practices by not recoding actual hours at risk significantly underestimated the competition to practice IRRs for some collegiate sports. Moreover, the magnitude of the IRRs obtained for these sports using the Hours method was 5-8 times greater than for the Number method that is commonly used in current ISS. These findings suggest that potential policy decisions such as the addition of additional games to the NCAA football or basketball seasons could be influenced by the level of exposure (e.g., Hours vs. Number) used in the ISS that are relied upon to inform these policy decisions.

Table. Competition to practice injury rate ratios (IRR) and 95% confidence intervals (CI) by sport obtained when using the two different levels of athletic exposure. *Hours method significantly different from Number method (P< 0.05).

Sport	Number Method	Hours Method		
эрон	IRR (95% CI)	IRR (95% CI)		
Football	7.7 (5.5, 10.6)	60.7 (43.7, 84.4)*		
Men's Basketball	1.1 (0.5, 2.4)	7.0 (3.3, 14.8)*		
Women's Basketball	1.3 (0.6, 2.9)	7.6 (3.4, 16.9)*		
Men's Soccer	3.8 (2.4, 6.2)	5.0 (3.1, 8.0)		
Women's Soccer	2.8 (1.3, 6.5)	4.0 (1.8, 9.1)		

Athletic Trainers' Perceptions of Overuse as a Mechanism of Injury

Roos KG, Marshall SW, Golightly YM, Kucera KL, Myers JB, Rosamond WD: University of North Carolina, Chapel Hill, NC; California State University, Long Beach, CA

Context: Mechanism of injury (MOI) can be difficult to assess, as information from athletes may be incomplete. Additionally, the timing of when athletes seek care can affect the assessment of MOI by Athletic Trainers (ATs). Acute injuries evaluated after several weeks may present clinically as overuse. Overuse injuries may present as acute, if presented at first signs of pain. Such misclassifications can impact injury treatment, return to play, and the long-term health of the athlete. Understanding how ATs identify overuse MOI may help limit such incidents. **Objective:** To describe the perceptions of ATs regarding the role of overuse as a MOI in hypothetical injury scenarios. Design: Cross-sectional online survey. Setting: Populationbased. Patients or Other Participants: All ATs contributing to the National Athletics Collegiate Associations' Injury Surveillance Program (ISP) in October 2014 were eligible for participation. Each of the 293 ATs meeting this criteria were contacted, 113 (38.6% response rate) started and 74 completed the survey (25.3% completion rate). Completed surveys were analyzed. Interventions: The survey presented six hypothetical injury scenarios, involving a variety of overuse injuries, and was developed by the authors and 5 AT volunteers. In-depth, qualitative interviews were conducted with 5 additional ATs. The survey was pilot tested by 8 graduate students. ATs were emailed survey invitations and links on October 1, 2014 followed by 2 reminders. Main Outcome Measures: ATs assessed the role of overuse in each scenario, and described how determinations were made. A directed content analysis (qualitative data analysis using preliminary categories of previously identified themes, adding new themes as analysis progressed), was conducted for all responses to the open-ended question: "How did you reach these conclusions?" Text responses were coded according to themes regarding the ATs' perceptions of the MOI.

Additional themes were added upon analysis. Themes common to multiple ATs in response to individual scenarios were noted. Results: Common themes for assessing the role of overuse in hypothetical injury scenarios involved: 1) the progression of the injury over time, 2) the absence of a specific MOI, 3) the duration of the injury itself, 4) the presence of an acute MOI, and 5) that the injury was a combination of acute and overuse mechanisms. (Table 1) Individual ATs identified more than one theme in their decision-making, and those themes often changed according to the scenario. Themes could be contradictory between ATs regarding the same scenario (e.g. "Worsening of previous injury" vs. "Duration of shoulder pain"), or individual themes could be used in multiple ways. (Table 1) Conclusions: The variability in these themes and their application demonstrate the multitude of ways that practicing ATs identify and classify overuse injuries. Consensus on overuse injury definitions may provide clarity and consistency in the future.

Table 1: Common themes from qualitative analysis of ATs perceptions of overuse as a
mechanism of injury, and examples of those themes.

Theme	Examples
Progression of the	a) "increase of pain as the season progresses."
injury over time	b) "pain brought on that day by one specific mechanism"
Absence of a specific	a) "No acute mechanism reported."
mechanism of injury	b) "No specific MOI or time of injury listed."
Duration of the injury	a) "the fact the pain has been going on for over one
itself	month."
	b) "Because he felt the pain while doing the activity."
Presence of an acute	a) "one specific mechanism that caused immediate
mechanism of injury	symptoms that were not previously present."
	b) "Because an acute injury is what finally tore the labrum
	and biceps."
Injury included both	a) "There was also a specific incident that led to
acute and overuse	worsening pain. Overuse would be a moderate factor in
mechanisms	the final injury because that muscle was already
	problematic."
	b) "Overuse is probably a predisposition. Environmental
	factors and use during the game caused the acute injury."

Free Communications, Oral Presentations: Patient-Reported Outcomes and Function Following Ankle Injury

Friday, June 29, 2018, 1:45PM-3:00PM, Room 206-207; Moderator: Jay Hertel, PhD, ATC, FNATA

Patient-Reported Outcomes and Perceived Confidence Measures in Athletes With a History of Ankle Sprain

Corbett RO, Keith TR, Hertel J: University of Virginia, Charlottesville, VA

Context: Using patient-reported outcome measures (PRO's) and functional performance tests when returning an athlete to play are recommended in the NATA position statement on the prevention and conservative management of ankle sprains. Evaluating perceived confidence during functional performance testing may be another valuable method to evaluate an athlete's readiness to return to play following a lateral ankle sprain (LAS). Objective: To evaluate the relationship between PRO's and perceived confidence when performing functional performance tasks in high school athletes with a history of LAS. Design: Descriptive study. Setting: High school. Patients or Other Participants: 25 high school student-athletes from the soccer, lacrosse and tennis teams (6 males, 19 females, age = 16.2 ± 1.1 years, height = 169.3 \pm 7.7 cm, mass = 63.2 \pm 9.8 kg, 16.8

months since last ankle sprain) who had a history of LAS and were cleared for full athletic participation volunteered. Interventions: None. Main Outcome Measures: The Cumberland Ankle Instability Tool (CAIT), visual analog scale (VAS) for pain, Identification of Functional Ankle Instability (IdFAI), and Tampa Scale of Kinesiophobia (TSK-11) were completed by all participants. Participants then completed a battery of functional performance tests: weight bearing lunge test (WBLT), star excursion balance test (SEBT), lateral, up-down, and triple hop tests, the single-leg vertical jump, and Southeast Missouri agility test (SEMO) and were asked to report their confidence in completing each task using a VAS with a bottom anchor of "no confidence" and a top anchor of "complete confidence". Pearson's r correlations were calculated between measures on the four PRO's and the confidence VAS scores during each of the seven functional tests. Results: The magnitude of statistically significant correlations (p < 0.05) are shown in the Figure. Moderate (-.3 < r > .5)to strong ($r \leq .5$) negative correlations were identified between pain VAS measures and confidence VAS measures for all functional test confidence measures

except the SEBT and vertical jump test. As self-reported pain increased, perceived confidence during functional tests decreased. Similarly, as TSK-11 scores increased, representing greater kinesiophobia, measures of perceived confidence during the SEBT and vertical jump test decreased. Lastly, a moderate positive correlation (r-.46) was identified between CAIT scores and perceived confidence measures during the SEMO indicating that the level of perceived ankle instability was associated with perceived confidence during the agility test. Conclusions: High school athletes with a history of LAS demonstrated significant correlations between several PRO's and perceived confidence during various functional performance tests. Exploring the clinical value of perceived confidence measures during functional performance testing when making return to play decisions after LAS warrants further investigation.



	CAIT:SEMO VAS	.46
•	TSK 11:SEBT VAS	46
٠	TSK 11: Vert VAS	45
	Pain VAS: WBLT VAS	40
•	Pain VAS: Up-Down Hops VAS	47
	Pain VAS: Lateral Hops VAS	55
*	Pain VAS: Triple Hop VAS	57
	Pain VAS: SEMO VAS	47
No	te: All reported r-values are statis	tically significant; p <.05

The Correlation Between Self-Reported Function and Clinician Measured Function in Individuals With Chronic Ankle Instability: Pilot Study

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Context: Between 30-70% of all lateral ankle sprains result in chronic ankle instability (CAI) which is a condition associated with ROM deficits, pain with activity, prolonged weakness, functional impairments, and decreased health-related quality of life (HRQoL). Current research has focused rehabilitation on the physical deficits associated with this condition to improve function. However, the impact of functional measures on HROoL or self-reported function is unknown. **Objective:** To examine the correlation between self-reported function and clinician measured function in individuals with CAI. Design: Cross-sectional. Setting: Research Laboratory Patients or Other Participants: Twelve physically active individuals with self-reported CAI (Male = 5, Female = 7, Age = 25.92 \pm 10.38 yrs, Height = 167.16 \pm 13.71 cm, Mass = 80.43 ± 26.38 kg, Previous Ankle Sprains = 6.17 ± 7.67 , Episodes of Giving Way = 5.50 ± 7.43 , Cumberland Ankle Instability Tool = 14.92 ± 3.18 , Ankle Instability Instrument = $6.25 \pm$ 1.22) participated in this study. Exclusion criteria included history of lower extremity injury or condition that would affect balance. Interventions: Participants completed two one-hour sessions in a two-week timeframe. Sessions were separated by at least 24 hours. Participant completed six patient-reported outcomes during the first session and two functional measures during the second. The Foot Ankle Ability Measure (FAAM) and the FAAM-Sport were used to assess regional specific function. The Disablement of the Physically Active was used to assess global function and includes a physical activity (DPA-PA) and a mental

(DPA-M) subscale. The Fear Avoidance Belief Questionnaire Physical Activity subscale (FABQ-PA) assess fear avoidance beliefs during physical activity. Functional outcomes included the Triple Hop for Distance (THD), and the Modified Hexagon Test (MHT). THD was normalized to body weight (THD-W) and measured the distance of three consecutive hops. MHT involved participants completing a series of single-limb hops in and out of a hexagon on the floor for completion time. Three trials were recorded for each test and the averages were used for analysis. Main Outcome Measures: Spearman's rank correlations were used to examine bivariate relationships between the clinician measures of function (THD, MHT) and self-reported function measures (FAAM, FAAM-Sport, DPA-PA, DPA-M, FABQ-PA). Alpha was set at a-priori p < 0.05. **Results:** No significant correlations were found between THD-W (4.69 [3.32-6.27]) and the FAAM-ADL (86.31 [78.27-89.88], r = -0.284, p = -0.337, FAAM-Sport (75 [66.41-85.94], r = -0.357, p = 0.252),DPA-PA (18 [12-25.25], r = 0.162, p =0.614), DPA-M (3 [1-5.75], r = .198, p = 0.538), and the FABQ-PA (11 [7.25-13.75], r = 0.365, p = 0.243) No significant correlations were found between the MHT (15.1 [7.73-20.16]) and the FAAM (r = 0.470, p = 0.123), FAAM-Sport (r = 0.218, p = 0.495), DPA-PA (r = 0.162, p = 0.614), DPA-M (r = 0.198)p = 0.538) and FABQ-PA (r = 0.365, p = 0.243). Conclusions: There were no significant correlations between self-reported function and clinician measured function. The data in this research aligns with previous findings that indicate a disassociation between self-reported and clinician measured function. In order to maximize rehabilitative success and create a clear picture of the CAI patient, tools that assess both patient perception and traditional measures of clinical function should be captured.

Predictors of Physical Activity Related Fear-Avoidance Beliefs in Those With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have reported increased fear-avoidance beliefs in comparison to healthy individuals. However, it remains unclear if self-perceived impairments or functional loss contribute to heightened fear-avoidance beliefs associated with physical activity in people with CAI. Further examining contributing factors to fear-avoidance beliefs may identify intervention strategies to address this biopsychosocial aspect of recovery. **Objective:** To determine if self-reported impairments, limitations or restrictions predict physical activity related fear-avoidance beliefs in participants with CAI. Design: Cross-sectional. Setting: Laboratory. Patients or Other Participants: Sixtytwo participants with self-reported CAI (44 females, age = 23.8 ± 5.8 yr, height $= 168.9 \pm 9.3$ cm, mass $= 71.5 \pm 13.6$ kg) were recruited from a large university. Participants were included if they reported ≥ 1 ankle sprain, ≥ 2 episodes of "giving way" in the past three months, answered "ves" to ≥ 5 questions on the Ankle Instability Instrument, and scored <24 on the Cumberland Ankle Instability Tool (CAIT). Interventions: Participants completed the Fear-Avoidance Beliefs Ouestionnaire-Physical Activity subscale (FABQ-PA), the modified Disablement in the Physically Active Scale (mDPA), the Foot and Ankle Ability Measure-Sport (FAAM-S), and the CAIT. The FABQ-PA contained five items scored on a 7-point Likert scale. FABQ-PA scores ranged from 0-24 with greater scores indicating greater fear-avoidance. The mDPA contained sixteen items scored on a 5-point Likert scale. The FAAM-S contained eight items scored on a 5-point Likert

scale. The CAIT contained nine items with various Likert scales. These scales were selected because they measure a broad range of self-perceived impairments, limitations and restrictions relevant to CAI patients. Main Outcome Measures: All items from the mDPA, FAAM-S, and CAIT were examined as predictor variables for FABQ-PA scores. To reduce the number of predictor variables, bivariate correlations examined the relationship between the individual items from the mDPA, FAAM-S, and CAIT and FABQ-PA scores. Items with a significant correlation to FABQ-PA scores were retained for regression analysis. A backward multiple linear regression model was implemented with FABQ-PA scores as the criterion variable and remaining scale items as the predictor variables. Descriptive statistics were reported as Median (IQR). Alpha level was set a-priori at p < 0.05. Results: Ten items from the mDPA (Items 1, 2, 5, 13, 16), FAAM-S (Items 4, 6, 8), and CAIT (Items 6, 9) were correlated to FABQ-PA scores (p < 0.05). Once entered into the regression model, CAIT Item 9 (Perceived Recovery Time from Ankle Rolling; 1.00 (1.00)) and DPA Item 1 (Pain in Past 24 hours; 0.00 (2.00)) were identified as predictors of FABQ-PA scores (12.00 (6.00), $R^2 =$ 0.28, p < 0.001). Conclusions: Longer perceived recovery time from episodes of ankle rolling and greater pain in the past day were associated with greater fear-avoidance beliefs. Strategies to reduce the severity and frequency of episodes of giving way and mitigate pain may diminish barriers to recovery cre-

Objective and Subjective Functional Test Measures in Interscholastic Athletes With a History of Time Loss Ankle Sprain

Keith TR, Corbett RO, Hart JM, Hertel J: University of Virginia, Charlottesville, VA

Context: There are limited empirical reports of objective and subjective functional performance measures in high school athletes with a history of lateral ankle sprain (LAS) in the sports medicine literature. **Objective:** To identify differences in functional performance test performance and perceived confidence when performing these tests in high school athletes with and without a history of a time loss LAS, and to examine the relationships between these objective and subjective measures. Descriptive study. Setting: High school. Patients or Other Participants: 33 interscholastic athletes (6 males, 27 females, age = 15.7 ± 1.2 years, height = 169.1 \pm 8.4 cm, mass = 62.4 \pm 11.0 kg) who were cleared for full participation volunteered. The participants were divided into 2 groups based on their injury history, a time loss LAS group (n = 17), and healthy controls with no history of LAS (n = 16). The average time since injury for the time loss group was 17 months, and the average time lost was 10.8 days. Interventions: None. Main Outcome Measures: Functional performance tests included isometric inversion and eversion ankle strength, star excursion balance test, weight bearing lunge test, lateral, up-down, and triple hop tests, single-leg vertical jump, and Southeast Missouri agility test (SEMO). Perceived confidence on a 10cm visual analog scale with anchors of "no confidence" and "complete confidence" were recorded after completion of each functional performance test. Independent t-tests were performed to compare differences in the performance scores and perceived confidence measures between the two groups. Pearson rcorrelation coefficients were calculated

to evaluate the relationship between performance measures and the corresponding confidence scores within each group. Correlation coefficients were interpreted as weak (00.5). An a priori alpha level of p < 0.05 was used for all analyses. Results: No significant differences were identified for any of the performance measures between the two groups (p > .05). The LAS group (7.22 \pm 2.06 cm) reported decreased perceived confidence compared to the healthy group $(8.41 \pm 1.09 \text{ cm})$ for the strength tests (p = 0.04). In the LAS group, moderate to strong correlations were found between functional test performance and perceived confidence for the SEMO agility test (r = -0.60, p = 0.02) and inversion strength (r = 0.48, p = 0.05). In the healthy group, a strong correlation was identified between functional test performance and perceived confidence for the triple hop test (r = 0.63, p = 0.02). For all significant correlations, as performance improved, perceived confidence also improved. Conclusions: High school athletes with a history of a time loss LAS demonstrated functional performance and perceived confidence scores that were similar to the healthy controls. Future research should examine the relationship of these objective and subjective functional performance measures in athletes recovering from acute ankle sprains as results may differ closer to the time of injury.

ated by fear avoidance.

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Free Communications, Rapid Fire Oral Presentations: Taking Care of Youth and Adolescent Athletes

Friday, June 29, 2018, 3:15PM-4:45PM, Room 206–207; Moderator: Anh-Dung "Yum" Nguyen, PhD, ATC

Athletic Training Athlete Encounters and Services Provided in the Middle School Setting

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Context: Participation in middle school athletics has increased, resulting in a need for athletic trainers (AT) to provide medical care for these student-athletes. Previous research has investigated services provided by AT in secondary school settings. To date, services provided by ATs to student-athletes in the middle school setting has not been investigated. **Objective:** To describe daily athlete encounters (AE) and services provided by ATs in a large metropolitan middle school setting. Design: Prospective cohort. Setting: Middle school sports. Patients or Other Participants: All student-athletes in grades 6, 7 and 8 (age = 12.1 ± 0.9 years) participating in a school-organized sport and provided care by the AT were included in this study. Each middle school had 12 school-sponsored sports with an AT onsite to provide medical care for student-athletes during all practices and competitions. Interventions: Attendance, AE, and services provided by the ATs were recorded daily across 9 large public middle schools during the 2015-2016 and 2016-2017 school years. Data were recorded by each AT during organized sporting events using a customized electronic record keeping application Main Outcome Measures: Attendance, AE, and services provided by the ATs recorded daily across 9 large public middle schools during the 2015-2016 and 2016-2017 school years **Results:** During the 2-year study period, the ATs reported 9092 AE and 19492 services. Football (n = 1526, 16.8%), followed by girls' basketball

(n = 1228, 13.5%) and wrestling (n = 1228, 13.5%)1151, 12.7%), accounted for the most AE. Overall, most AE were for new injury services (n = 11472, 58.9%), followed by existing injury services (n = 5724, 29.4%), and then preventative services (n = 2316, 11.9%). The most common new injury services provided were evaluation (n = 3453, 30.1%), education (n = 2443, 21.3%) and ice-ortaping application (n = 1229, 11.3%). Overall, evaluation (n = 4814, 24.7%), and education (n = 4405, 22.6%) were the most common services provided followed by consultation (n=3183, 16.1%). Conclusions: Our findings are the first to quantify the amount of AE coupled with services provided by ATs in the middle school athletic setting. Our findings demonstrate the important role that ATs play in delivering health and safety education to athletes, coaches, parents and school staff in middle school athletics. Collectively, our tracking of AE and services provides valuable evidence to understand the daily responsibilities and demonstrates the value of ATs in the middle school athletics settings. Our findings support employing ATs to care for middle school student-athletes in school-sponsored sports. Future research should include larger and more geographically diverse samples of public and private middle schools and youth sports leagues.

Differences in Athletic Performance Measures Between Youth Athletes With Previous Lower Extremity Injury Across Maturation

Begin MM, Trigsted SM, Frank B, Huxford R, Bailey J, Zuk EF, Boling MC, DiStefano LJ, Ford KR, Taylor JB, Nguyen A: High Point University, High Point, NC; University of North Carolina at Chapel Hill, Chapel Hill, NC; North Carolina FC, Cary, NC; University of Connecticut, Storrs, CT; University of North Florida, Jacksonville, FL

Context: While previous lower extremity injury and changes through maturation have been suggested to increase risk of knee and ankle injuries in youth athletes, mechanisms to explain this relationship have not been examined. Athletic performance measures of power, speed, agility, and endurance could also potentially influence injury risk. Understanding whether athletic performance measures differ between youth athletes with previous lower extremity injury and across maturation may provide insight toward identifying those at greater injury risk. Objective: To determine if athletic performance measures differ between youth athletes with self-reported history of lower extremity injury and across stages of maturation. Design: Cross-sectional. Setting: Field setting. Patients or Other Participants: Two hundred and eighty-eight youth soccer players (131M, 157F: 14.6 ± 1.2 yrs, 152.0 ± 14.5 cm, 42.9 ± 9.0 kg) volunteered. Interventions: Self-reported lower extremity injury history was used to classify injury history groups into those with any lower extremity injury (INJ) and no injury history (NOINJ). Percent of adult stature (% AS), using the Khamis-Roche method, classified participants into pre-pubertal (PRE), pubertal (PUB), and post-pubertal (POST) maturation groups. Performance measures of power, speed, agility, and endurance were assessed during a 10m-dash, 30m-dash, arrowhead

agility test, and the vo-vo endurance test, respectively. Main Outcome Measures: History of injury to the hip, knee, lower leg, or ankle discriminated the INJ (N = 100) and NOINJ (N = 188) groups. Based on peak height velocity estimates, participants were classified as PRE (N = 112) with less than 80% AS, PUB (N = 108) with 80-92% AS, and POST (N = 68) with greater than 92% AS. Time of completion [seconds (s)] for 10m-dash, 30m-dash, arrowhead agility, and level achieved on the yo-yo endurance test were used for analyses. Two (injury: INJ, NOINJ) by three (maturation: PRE, PUB, POST) ANOVAs examined differences in performance measures. Post-hoc LSD comparisons were performed when appropriate. Results: Significant main effects of maturation groups were observed for 10m-dash (P < 0.001), 30m-dash (P <0.001), arrowhead agility (P = 0.004), but not the yo-yo endurance test (P = 0.142). Specifically, during the 10m-dash, PRE was slower than PUB (mean difference = 0.048 s, P = 0.006) and POST (mean difference = 0.085 s, P < 0.001,) while PUB was slower than POST (mean difference = 0.044 s, P = 0.010). During the 30m-dash, PRE (mean difference = 0.331s, P < 0.001) and PUB (mean difference = 0.266 s, P < 0.001) were slower than POST. During the arrowhead agility, PUB was slower than PRE (mean difference = 0.564 s, P = 0.002) and POST (mean difference = 0.783, P < 0.001). There were no significant interactions between injury and maturation groups, or main effects for injury group (P > 0.05). Conclusions: Athletic performance measures did not differ based on self-reported history of injury. Athletic power and speed increase across maturation stages. However, youth athletes in the pubertal stage appear to experience a decrement in agility performance, which may be a result of neuromuscular changes during this stage of maturation. Further work is needed to determine if athletic performance differences contribute, prospectively, to lower extremity injury.

Influence of Trunk and Pelvis Motion, and Hip Strength on Lower Extremity Kinematics During a Single Leg Landing in Youth Athletes

Crisafulli GA, Trigsted SM, Whicker CR, Zuk EF, Boling MC, Ford KR, Taylor JB, DiStefano LJ, Nguyen A: High Point University, High Point, NC; University of Connecticut, Storrs, CT; University of North Florida, Jacksonville, FL

Context: Decreased hip strength has been suggested to alter lower extremity motion during single-leg landing tasks and can lead to compensatory changes in trunk and pelvic positions and motions that decrease the demand on the hip muscles. Identifying the compensatory strategies of the trunk and pelvis during landing and their influence on lower extremity motion could improve the effectiveness of intervention programs aimed at improving at risk landing patterns. **Objective:** To examine the influence of hip strength and trunk and pelvis motion on lower extremity kinematics during a single-leg landing task in youth athletes. **Design:** Descriptive study. Setting: Field Setting. Patients or Other Participants: One hundred and four (62 M, 42 F: 11.0 ± 1.9 yrs, 38.8 ± 10.8 kg, 146.3 ± 15.6 cm) youth soccer athletes participated. Interventions: Isometric strength of the hip extensors (HEXT), external rotators (HER), and abductors (HABD) was assessed using a hand-held dynamometer. Three-dimensional hip and knee kinematics were assessed using an electromagnetic motion analysis system during three trials of a single-leg hop (SLH) over a hurdle (height = 12.7 cm) set 40% of the subject's height from a force plate. All measures were assessed on the left limb. Main Outcome Measures: Normalized peak isometric hip strength (%BW), trunk and pelvic angles (relative to world coordinate) at initial contact (IC = vGRF > 10 N) and displacement during the deceleration phase (IC to peak knee flexion), and peak hip and knee kinematics during

the deceleration phase of the SLH were used for analyses. Separate step-wise, linear regressions determined the extent to which hip strength and trunk and pelvis position predicted hip and knee kinematics in youth soccer athletes. Results: Less HEXT strength $(22.16 \pm 18.53 \text{ %BW}, \text{R}^2 = 0.091, P =$ 0.002), less contralateral trunk rotation at IC (0.41 \pm 8.24°, $R^2_{change} = 0.044$, P = 0.026), and greater contralateral pelvic drop displacement (-7.97 \pm 3.87°, $R_{change}^2 = 0.053, P = 0.012$) predicted less peak knee flexion $(49.80 \pm 14.63^{\circ})$; less HEXT strength (22.16 \pm 18.53 %BW, $R^2 = 0.174$, P < 0.001) predicted greater peak hip flexion (-40.55 \pm 17.23°); less contralateral pelvic rotation at IC (10.55 $\pm 14.22^{\circ}$, R²=0.252, P<0.001), less ipsilateral pelvic tilt at IC $(9.93 \pm 6.91^{\circ})$, $R_{chance}^2 = 0.167, P < 0.001$), less ipsilateral trunk lean at IC ($4.51 \pm 8.24^\circ$, R^2_{change} = 0.014, P = 0.047), and less contralateral pelvic drop displacement (-7.97 \pm 3.87°, $R_{change}^2 =$ 0.219, P < 0.001) predicted greater peak hip adduction $(4.35 \pm 10.09^{\circ})$; less contralateral pelvic rotation at IC (10.55 \pm 14.22°, R²= 0.041, P = 0.039) predicted greater peak hip internal rotation $(9.01 \pm 19.82^{\circ})$. Conclusions: Decreased strength of the hip extensors was the strongest predictor of sagittal plane hip and knee landing kinematics, while trunk and pelvis position and motion were the strongest predictors of frontal and transverse plane hip kinematics. These findings suggest that interventions aimed at improving lower extremity motion during dynamic tasks should include exercises to increase hip extensor strength and movement feedback that effectively corrects compensatory trunk and pelvis positions in youth athletes.

Clinical Measures of Neuromuscular Control Detect Differences in Children Zuk EF, Root HJ, Beltz EM, Burland JP, DiStofano LJ:

Burland JP, DiStefano LJ: University of Connecticut, Storrs, CT; A.T. Still University, Mesa, AZ

Context: The Landing Error Scoring System (LESS) and Balance Error Scoring System (BESS) are validated clinical measures of neuromuscular control (NMC), commonly utilized in lower extremity musculoskeletal injury risk screenings. These tasks, however, potentially challenge different aspects of NMC. There is limited knowledge about the relationship between the LESS and BESS, and whether they differ across grade divisions in children, who are often a target population for injury risk. Better understanding the relationship between tasks across grade divisions would improve efforts to develop more efficient NMC screenings that can inform interventions, and ultimately reduce injury risk in children. **Objective:** To evaluate the association between LESS and BESS scores in children. A secondary objective was to examine if differences exist in the LESS and BESS between elementary and middle school age divisions. Design: Cross-sectional study. Setting: School. Patients or Other Participants: 105 children (n = 66M, 59 F; height, 117.7 \pm 61.9 cm; mass, 44.6 \pm 14.1 kg) in grades 4-8, between the ages of 9-14 years old, volunteered to participate. Interventions: Participants completed a single test session in the school gymnasium. All participants performed three trials of a standardized jump-landing task, which was captured and graded with a depth camera and markerless motion capture software (PhysiMax Technologies Ltd, Tel Aviv, Israel) using the LESS. Participants also performed all 6 stances of the BESS, which was graded by one of two trained, reliable raters. Main Outcome Measures: The average total LESS score across 3 trials was calculated for a single LESS score per participant. Total number

of BESS errors per participant was also calculated. Composite LESS and BESS scores were used for all analyses. Participants were divided into Elementary (grades, 4-5; n = 24 M, 30F; height, 133.8 ± 63.3 cm; mass, 41.5 \pm 9.6 kg) or Middle (grades, 6-8; n = 22 M, 29 F; height, 127.2 ± 62.7 cm; mass, 52.3 ± 15.2) School grade divisions. Pairwise correlations were used to evaluate the relationship between LESS and BESS scores, controlling for sex. Separate one-way analyses of variance compared LESS and BESS scores between age divisions, while controlling for sex. Results: BESS and LESS scores had a significant, weak association (R = 0.38, P = 0.03). BESS scores were not statistically different between grade divisions (Elementary: 9.26 ± 7.31 errors; Middle: 8.78 ± 6.34 errors. P = 0.73). LESS scores were not significantly different between grade divisions (Elementary: 7.15 ± 1.96 errors; Middle: 6.25 ± 1.74 errors, P = 0.06) Conclusions: The weak correlation between the LESS and BESS demonstrate that these tools are evaluating different aspects of lower extremity neuromuscular control in this population. The potential clinical significance needs further exploration, but these data suggest that both tasks should be included in injury risk screening. No differences were found in either task between the elementary and middle school grade division, which suggests that similar intervention programs can likely be used for this entire population.

Adolescent Female Participants at Return to Sport (RTS) After Anterior Cruciate Ligament Reconstruction (ACL-R) Demonstrate Within Limb Differences in Energy Absorption Contribution During a Single Limb Squat Garrison JC, Fitch CA, Goto S, Hannon JP, Bothwell JM: Texas Health Sports Medicine, Fort Worth, TX

Context: Restoration of symmetrical quadriceps strength and joint loading in patients who have undergone ACL-R is often difficult. The relative contribution of the hip, knee and ankle joint while loading and the relationship to quadriceps strength at time of return to sport (RTS) is unclear. **Objective:** To compare energy absorption contribution (EAC) of the hip, knee and ankle joints during a single limb squat (SLS) task and quadriceps strength between the involved (INV) and uninvolved (UNV) limbs at RTS for adolescent females post-operative ACL-R. Design: Within-Subjects Design. Setting: Hospital based outpatient clinic. Patients or Other Participants: Twenty-five adolescent female ACL-R participants who were at time of RTS (Age = 15.1 \pm 1.1 yrs; Ht = 162.5 cm \pm 7.5 cm; Mass = 63.4 ± 8.8 kg). Interventions: Net power of the hip, knee, and ankle joints was assessed while participants performed five consecutive SLS repetitions. Isokinetic quadriceps strength at 60 deg/sec was measured using an isokinetic dynamometer as average peak torque. All measurements were collected bilaterally. Main Outcome Measures: Energy absorption of the hip, knee, and ankle joints were normalized to height and weight, and the contribution of each joint was calculated in relation to the total EA (EA of all joints) as a percentage (%) during the loading phase of the middle three trials of a SLS task. EAC is expressed clinically as eccentric loading Separate paired t-tests were calculated to examine the differences between limbs in EAC of each joint and quadriceps strength of each limb, ($\alpha \le 0.05$). **<u>Results</u>**: The involved limb demonstrated significantly greater EAC at the hip (INV = $39.4\% \pm 10.4\%$; UNV = $31.1\% \pm 11.3\%$; p < 0.001) and less EAC at the knee (INV = $41.5\% \pm$ 8%; UNV = $50\% \pm 10\%$; p < 0.001) compared to the uninvolved limb. No significant difference was observed with EAC at the ankle between limbs (p = 0.81). The involved limb revealed decreased strength compared to the uninvolved limb (INV = 1.26 ± 0.34 ; UNV $= 1.67 \pm 0.37$; p < 0.001). Conclusions: ACL-R participants demonstrate different eccentric loading strategies during a SLS task at time of RTS between limbs. Deficits in quadriceps strength at RTS may contribute to avoidance of the knee joint and greater usage of the hip and ankle. Increasing quadriceps strength may improve symmetry between the hip, knee and ankle joint EA strategy.

Side-to-Side Spatiotemporal Postural Control Asymmetry in Adolescent Basketball Players McKeon PO, Hoch MC, Medina McKeon JM: Ithaca College, Ithaca, NY; University of Kentucky, Lexington, KY

Context: Single-leg balance asymmetry is a risk factor for lower extremity injury in adolescent basketball players. Time-to-boundary (TTB) is a spatiotemporal postural control assessment technique used to capture single-leg balance alterations related to lower extremity injury and rehabilitation. TTB side-toside asymmetry may provide valuable insight into injury risk in adolescents as it takes into account center of pressure (COP) excursions in the context of the size of the foot. **Objective:** To evaluate potential side bias and the typically occurring side-to-side asymmetry in single leg-balance using TTB and develop reference values for healthy adolescents. Design: Cross-sectional study. Setting: Local High School Gymnasia Patients or Other Participants: Ninety-five adolescents participating in high school basketball from 9 high schools (36 males, 59 females; age: 15.8 ± 1.4 yrs; height: 174.0 ± 10.3 cm; mass: 70.1 \pm 14.6 kg) participated. All athletes were cleared for basketball participation and did not report a history of lower extremity injury. Interventions: Participants performed 3, 10-second trials of eyes open and eyes closed single-leg stance on a force plate on their right and left limbs. Main Outcome Measures: TTB was calculated using the COP position and velocity data for the mediolateral (ML) and anteroposterior (AP) directions in relation to the boundaries of their base of support. TTB minima were then identified, which represent the theoretical points within the COP profile where a person is likely to lose balance if a change in direction does not occur. The mean of TTB minima was calculated for both the AP and ML directions with eyes open and closed. Limits of agreement analysis assessed the potential for side bias (SB=right-left) and

95% confidence intervals (Asymmetry-CI₀₅) around the side-to-side differences assessed side-to-side asymmetry for the mean of TTB minima in the ML and AP directions with eyes open and closed. Asymmetry was then expressed as a percentage (%Asymmetry = Asymmetry-CI₉₅/mean of TTB minima *100). Results: For eyes open, the mean of TTBML minima (Right: 1.73 ± 0.49 s, Left: 1.76 ± 0.52 s, SB: 0.03 ± 0.43 s; Asymmetry-CI₉₅: 0.85 s, %Asymmetry: 49%) and TTBAP minima (Right: 4.83 ± 1.31 s, Left: 4.76 ± 1.36 s; SB: -0.07 ± 1.07 s; Asymmetry-CI₀₅: 2.11 s, %Asymmetry: 44%) demonstrated low SB with large side-to-side asymmetry. In eyes closed, the mean of TTBML minima (Right: 0.79 ± 0.24 s, Left: 0.79 ± 0.25 s, SB: 0.00 ± 0.25 s; Asymmetry-CI₉₅: 0.49 s, %Asymmetry: 62%) and TTBAP minima (Right: 2.18 ± 0.75 s, Left: 2.21 ± 0.80 s, SB: 0.03 ± 0.63 s; Asymmetry-CI_{os}:1.23s, %Asymmetry: 56%) also revealed low SB, but higher %Asymmetry than eyes open TTB. Conclusions: In healthy adolescents participating in basketball, there does not appear to be SB on the mean of TTB minima in both the ML and AP directions with eyes open or closed. TTB substantially decreased with the removal of vision in both ML and AP directions, but the side-to-side asymmetry increased. Based on the asymmetry-CI₉₅, there does appear substantial TTB asymmetry, ranging up to approximately 60%. Future research should explore whether adolescent basketball players with TTB asymmetries that fall outside of the asymmetry-CI₉₅ established are at increased injury risk.

Preseason Star Excursion Balance Test Identifies Adolescent Female Basketball Athletes With a History of Ankle Sprain

Beltz EM, Root HJ, Scarneo SE, Burland JP, Devaney LL, DiStefano LJ: University of Connecticut, Storrs, CT; A.T. Still University, Mesa, AZ

Context: Ankle sprains are the most common injury in high school athletics and have a high re-injury rate. Female basketball athletes have the highest rate of ankle sprains among high school athletes. The Star-Excursion Balance Test (SEBT) is a dynamic balance measure that is associated with self-reported feelings of ankle instability and has been shown to predict lower extremity injury in high school basketball athletes. **Objective:** To determine if baseline SEBT scores can identify history of ankle sprain in adolescent female basketball athletes. Design: Cohort. Setting: Field study. Patients or Other Participants: Seventy-five competitive female basketball athletes (mean \pm SD: 13 \pm 2 y, 166.1 \pm 9.7 cm, 56.5 ± 12.1 kg) volunteered. Interventions: Participants completed a baseline questionnaire that inquired about ankle sprain history. Participants were screened with a modified SEBT, using the anterior (ANT), posteromedial (PM) and posterolateral (PL) reach directions. Limb length was measured from the anterior superior iliac spine to the medial malleolus. Main Outcome Measures: The SEBT stance limb defined the laterality of the test. The average of three trials normalized to limb length was used for analyses regarding individual reach directions. A composite SEBT score for each limb was calculated according to previous research and normalized to limb length. Participants were assigned to either ankle sprain (INJ) or no ankle sprain (CON) groups, based on their self-report on the baseline questionnaire, as well as by laterality of injury (R-INJ, L-INJ). Two separate one-way multivariate ANOVAs were used to compare SEBT composite score and reach directions (ANT, PM, PL) between groups (R-INJ, CON; L-INJ, CON). Univariate ANOVAs were utilized for post-hoc comparisons. Two separate paired t-tests were used to evaluate right and left composite SEBT scores in CON and INJ participants ($\alpha =$ 0.05). Results: Twenty-five participants $(13 \pm 2 \text{ y}, 65.5 \pm 3.8 \text{ cm}, 56.5 \pm 12.4 \text{ kg})$ reported history of ankle sprain (R-INJ: n = 16; L-INJ: n = 11), including 2 participants that reported a history of bilateral ankle sprain(s). Forty-seven participants (CON: 14 ± 2 y, 65.4 ± 4.0 cm, 57.3 ± 11.4 kg) did not report history of ankle sprain. Significant differences were detected for left-sided composite and directional SEBT scores between L-INJ and CON (p = 0.04). Post-hoc comparisons revealed significant differences in the PM (p = 0.03; L-INJ = $0.89 \pm 0.09\%$ limb length, CON = 0.80 \pm 0.12%) and PL (p = 0.01; L-INJ = $0.92 \pm 0.07\%$, CON = $0.84 \pm 0.09\%$) directions. There were no differences in SEBT scores between R-INJ and CON (p = 0.55). Significant composite SEBT side-to-side differences were present in the INJ group (p = 0.02; R $= 0.88 \pm 0.07\%$, L $= 0.89 \pm 0.09\%$); no significant side-to-side differences were present in the CON group (p = 0.72). Conclusions: These data indicate that side-to-side composite SEBT score asymmetries, with increased left-sided scores, can identify athletes with previous history of ankle sprain. While the findings from this investigation conflict with previous research that indicated decreased left-sided SEBT values predict lower extremity musculoskeletal injury, both investigations support SEBT asymmetries as an identifier of increased lower extremity injury risk.

The Utility of the Functional Movement Screen and Health-Related Fitness for Mitigating Injury in Youth Sport

Pfeifer CE, Ortaglia A, Beattie PF, Monsma EV, Goins JM, Stodden DF: Lander University, Greenwood, SC; University of South Carolina, Columbia, SC

Context: Millions of youth participate in sport every year. The number of youth injured from sport continues to rise, highlighting the need to mitigate the risk of injury in sport. Adequate movement ability and health-related fitness (HRF) of youth sport participants is imperative for performance in sport and the reduction of risk factors of injury. The development of movement ability is linked to the development of HRF. The secular decline in both of these constructs in youth may predispose millions to injury related to the high physical demands sport places on the body. **Objective:** To assess if the combination of HRF and movement ability has utility for identifying odds of injury in youth sport. Design: Cohort study. Setting: Field. Patients or Other Participants: 136 volunteers (63 male, 73 female) age 11-18 (16.01 + 1.35) were recruited from a variety of sports and sport organizations. Participants were healthy and free of movement or participation limiting musculoskeletal injury within the past six months. Interventions: Functional Movement Screen (FMS[™]) performance and HRF variables (Body Mass Index (BMI), percent body fat, strength [grip], lower body power [long jump], VO, Max [Progressive Aerobic Cardiovascular Endurance Run], and muscular endurance [curl up]). The FMS[™] movement evaluation was coded by individuals trained and reliable (inter/intra-rater $\kappa_{w} = 0.70$ to 1). Main Outcome Measures: Injury: any physical insult or harm resulting from sports participation, requiring an evaluation from a health or medical professional and time modified/lost from sport participation. Logistic regressions were utilized to examine odds of injury as a function of HRF, composite FMS[™] score, sex, and age. Results: Sex was the significant predictor (P < 0.05) of injury when modeling from sex (OR = 13.02 for males, CI 4.46-38.04) and composite FMSTM score (OR = 0.95, CI 0.81-1.12). For all HRF variables, significant predictors of injury were sex (OR = 9.74, CI 2.46-38.55), VO, Max (OR = 0.84, CI 0.74-0.95), and lower body power (OR = 1.03, CI 1.00-1.05). When combining composite FMS[™] and HRF variables, significant predictors of injury included sex (OR = 10.55, CI 2.37-47.01), VO, Max (OR = 0.85, CI 0.75-0.97), and lower body power (OR = 1.03, CI 1.01-1.05). Conclusions: The most salient factors when modeling injury from all HRF variables and movement ability were sex, muscular power, and cardiorespiratory endurance. Sport choice may alter risk of injury, as the majority of males participating in collision sports were injured. Individuals with decreased cardiorespiratory endurance and lower body power may be at higher odds of injury due to the negative effect lower extremity and global fatigue has on movement ability. Those in the youth setting may benefit from a long-term athlete development stance towards sport competence and injury prevention efforts.

Patellofemoral Chondral Defect in a Preadolescent Skier: Consequences of Early Sport Specialization

DePhillipo NN, Cinque ME, Kennedy NI, Moatshe G, Chahla J, LaPrade RF: The Steadman Clinic, Vail, CO; The Steadman Philippon Research Institute, Vail, CO

Background: A healthy 11yearold male competitive alpine skier presented with a 6week history of recurrent swelling of his right knee and persistent anterior knee pain while skiing without evidence of any specific history of injury or traumatic event. The athlete is a competitive skier who competes six days per week during the season and trains year round, specializing in downhill ski racing. The athlete attempted a bout of conservative treatment including physical therapy and a 2week rest period with no skiing. After 4weeks of generalized knee strengthening, the athlete and his parents presented to our clinic seeking further orthopaedic evaluation due to recurrent knee effusions and persistent anterior knee pain. The patient denied any specific injury or fall that he could attribute to his knee pain and swelling. The patient presented with a slight limp during gait that was non-painful. He had full knee range of motion (ROM) with a 2+ moderate effusion and tenderness to palpation over the medial aspect of the patella. His patellar mobility was equal bilaterally with no crepitation and his knee was stable during ligamentous testing. Differential Diagnosis: Patellar tendinopathy, Osgood Schlatter's, Sinding-Larsen-Johansson, medial suprapatella plica irritation, Osteochondritis Dissecans. **Treatment:** Radiographs were obtained and revealed an anatomic variant, a bipartite patella, but no other acute bone abnormalities. Magnetic resonance imaging was ordered and revealed an articular cartilage defect of the medial patellar facet. The patient underwent diagnostic arthroscopy the next day, which showed a 10 mm wide Outerbridge grade IV focal cartilage defect with delamination on the medial facet of his patella. The chondral defect was treated with an arthroscopic chondroplasty to ensure that the cartilage defect did not continue to delaminate and cause recurrent effusions and pain with activity. Postoperatively, the patient was allowed to weight bear as tolerated with the use of crutches for 2weeks. A major emphasis was placed on rest from skiing and sports activities and allowing the patient's knee pain and swelling to subside before increasing activity. At 12weeks postoperatively, the patient presented with a normalized gait, no knee effusion, full knee and patellar ROM symmetric to his contralateral limb, and no patellar crepitation or painful palpation on physical exam. The patient

was released to begin return to sport progression at 12weeks, and was cleared for full activities with a return to competitive skiing at 15weeks postoperatively. At 16weeks postoperatively, he won an international alpine ski race in Europe for his age group. Uniqueness: In this report, a preadolescent athlete developed a patellofemoral chondral defect without history of prior injury or traumatic event. The cause was most likely due to focused early single sport specialization (ESS), which is an increasingly popular method of sport performance in today's youth athletics. The American Orthopaedic Society for Sports Medicine consensus statement defined ESS according to 3 criteria: 1) participation in intensive training and/or competition in organized sports greater than 8 months per year; 2) participation in 1 sport to the exclusion of participation in other sports; and 3) involving prepubertal children (grade 7 or roughly age 12 years old). In this case report, the athlete satisfies the criteria of ESS because of his single sport specialization, prepubertal age, and intensive ski competition >8 months year round. Conclusions: Allied health care professionals should consider patellofemoral chondral injury in the competitive youth athlete with persistent anterior knee pain and recurrent effusions. This case report may provide insight to the detrimental consequences of overuse and underdevelopment associated with ESS in young skiers.



Miscellaneous Best Practices Forum: Does Prediction Lead to Prevention? Discussing and Translating the State of Evidence for Injury Risk Screening

Wednesday, June 27, 2018, 8:00AM-9:00AM, Room 208–210; Moderator: Jay Hertel, PhD, ATC, FNATA Discussants: Sarah de la Motte, PhD, ATC; Timothy Gribbin, MEd, ATC

Free Communications, Oral Presentations: Prevention, Recognition, and Follow-Up for Heat Illness

Wednesday, June 27, 2018, 9:15AM-10:45AM, Room 208–210; Moderator: Mike Ferrara, PhD, ATC, FNATA

Heat Tolerance Test Results From Exertional Heat Stroke Patients Receiving Cold Water Immersion Treatment

Stearns RL, Belval LN, Hosokawa Y, Huggins RA, Jardine JF, Davis RJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Falmouth Hospital, Falmouth, MA

Background: To ensure survival from exertional heat stroke (EHS), cold-water immersion (CWI) within 30 minutes of collapse is the standard of care. Additionally, following EHS, heat tolerance testing (HTT) has been recommended as a supportive measure to determine readiness to return to activity. Current literature reports HTT responses in complicated EHS cases or those that did not receive CWI as well as in healthy populations without EHS history. Currently, there is no literature within the civilian population demonstrating typical HTT responses when the standard of care (CWI) for EHS is appropriately utilized. Patient: Five patients that were diagnosed with EHS and received CWI within 10 minutes of collapse were included in this case series. All participants were participating in an endurance race (>11.3km) at the time of their EHS. Four male and one female patient participated, see table for background demographic and medical histories. Intervention or Treatment: All patients conducted a standard HTT (5km/hr walk, 40° C, 40% humidity for 120 min) with VO, max assessment following physician clearance. Average timeframe from EHS date to HTT was 107 days (range = 51-288). Passing criteria was set at a rectal temperature (Tr) of $\leq 38.5^{\circ}$ C, with heart rate (HR) <150 bpm. Rating of perceived exertion (RPE) was also collected during the HTT. Outcomes or other Comparisons: Patients successfully arrived and maintained hydration during the HTT (Mean \pm SD; body mass loss = $0.19 \pm 0.45\%$, pre-HTT urine specific gravity = 1.014 ± 0.009). Of the five cases, all were considered fit for their age, but four successfully passed the HTT. Of these four, the average finish outcomes were: $Tr = 37.9 \pm 0.39^{\circ} C$, $HR = 107 \pm 16$ bpm, $RPE = 11 \pm 4$. In the case that did not pass the HTT, the largest differentiating factor was the patient's history of two other previous EHS episodes within the last 5 years. This patient disclosed no EHS related genetic predisposing factors, however, did fail the HTT within 20 min. All subjects reported being able to return back to normal exercise activity within 28 days from their EHS. In contrast to previous literature describing HTT results, these patients all received the standard

of EHS care and the resulting HTT success rate was 80%. For those without a history of multiple EHS, the HTT success rate was 100%. Conclusions: For those who suffered an EHS for their first time and received immediate CWI care, HTT results were favorable for return to activity. This case series is not sufficient to provide any changes to current practice recommendations for recovery following EHS, however it may be the first to describe typical presentation of EHS recovery, as measured by the HTT, when standard of care (CWI) is provided. Clinical Bottom Line: HTT success is favorable when CWI is provided within 10 minutes of EHS collapse, if the EHS is the first episode experienced by the patient.

Participant	Age (yr)	Sex	Body mass (kg), (Body surface area (m ²)	VO ₂ max (ml•kg•mi n ⁻¹)	vVO ₂ max (km/h)	Number of previous EHS episodes	Peak EHS Tr (°C)	HTT result	Days between EHS and HTT
А	25	male	85.8 (2.08)	NA	NA	0	42.1	pass	288
В	26	female	57.0 (1.56)	56.2	16.1	0	41.1	pass	68
С	24	male	81.9 (2.02)	68.4	19.3	0	42.2	pass	64
D	48	male	73.4 (1.89)	55.4	16.9	2	41.7	fail	64
Е	59	male	78.9 (2.06)	43.9	13.0	0	40.6	pass	51
Average	36		75.4 (1.92)	56.0	13.1		41.5		107

Note: yr=years, mph=miles per hour, EHS=exertional heat stroke, Tr=rectal temperature, HTT=heat tolerance test, NA=not available

The Effect of the National Athletic Trainers Association **Inter-Association Task Force** (NATA-IATF) Preseason Heat **Acclimatization Guidelines on High School Football Preseason Exertional Heat Illness Rates** Kerr ZY, Register-Mihalik JK, Pryor RR, Pierpoint LA, Scarneo SE, Adams WM, Marshall SW, Kucera KL, Casa DJ: University of North Carolina, Chapel Hill, NC; California State University, Fresno, CA; University of Colorado Anschutz, Aurora, CO; University of Connecticut, Storrs, CT; University of North Carolina, Greensboro, NC

Context: Most exertional heat illnesses (EHIs) in high school athletes occur during preseason football. In 2009, the National Athletic Trainers' Association (NATA) Inter-Association Task Force (NATA-IATF) released preseason heat acclimatization guidelines to help football athletes become better conditioned to environmental conditions contributing to EHI. **Objective:** Using high school surveillance data, we modeled EHI rates in preseason football during 2005-2016, comparing time periods when state athletic association mandates were and were not compliant with NATA-IATF guidelines, controlling for variations in ambient temperature. Design: Quasi-experimental time-interrupted series design. Setting: Preseason high school football, 2005-2016. Patients or Other Participants: High school football players, 2005-2016 preseasons. Interventions: Using Korey Stringer Institute data, we identified the states and years in which state athletic association-mandated guidelines met NATA-IATF guidelines. Thus, all state-years in the dataset were categorized with a binary variable (state met versus did not meet guidelines). Main **Outcome Measures:** Athletic Trainers (ATs) collected EHI and athlete-exposure (AE) data via the High School Reporting Information Online system. Preseason EHIs were identified as those: (1) diagnosed as heat-related and/or dehydration-induced; (2) occurring as a result of participation in a school-sanctioned preseason practice; and (3) requiring medical attention by an AT or physician. Because HS RIO does not stratify practice AE by time in season (e.g., preseason), data from the High School National Athletic Treatment, Injury and Outcomes Network surveillance program estimated the overall proportion of practice AE in the football preseason (40.3%). Generalized Estimating Equations (GEE) Poisson regression models were used to model yearly preseason EHI rates and estimate EHI incidence rate ratios (IRR) and 95% confidence intervals (CI) using robust variance methods. The main exposure was the presence of athletic association-mandated guidelines meeting NATA-IATF guidelines. Covariates included: average August temperatures for each state-year (from the National Centers for Environmental Information); yearly deviations from each state's August average temperature across the study period; and calendar year (to control for linear trends in EHI incidence and/ or reporting). Results: Data were available for 455 state-years from 48 states; 32 state-years (7.0%) from 8 states had mandates meeting NATA-IATF guidelines (states with 1 state-year n = 1; 3 stateyears n = 1; 4 state-years n = 3; 5 stateyears n = 2; 6 state-years n = 1). Overall, 190 EHIs were reported during an estimated 2,697,089 AEs (rate = 0.70/1000 AE; 95% CI: 0.60-0.80). Controlling for August temperature variations and linear secular trends, the presence of state athletic association-mandated guidelines that met NATA-IATF guidelines was associated with a 55% reduction in high school football preseason EHI rates (IRR = 0.45; 95% CI: 0.23-0.87). Conclusions: State athletic association-mandated heat acclimatization guidelines that met the NATA-IATF guidelines were associated with a 55% reduction in the incidence of EHI. High school ATs should implement NATA-IATF guidelines in their settings as research continues to identify factors that promote compliance of implementation.

How Accurate Are Weather Conditions Obtained From A Commonly-Used Mobile Weather Application Compared to Measures Obtained From a Real-Time Monitoring Device? Gorrell P, Lopez RM, Del Rossi G: University of South Florida, Tampa, FL

Context: Although wet-bulb globe temperature (WBGT) is a better measure of the heat stress an individual is exposed to when working or playing in direct sunlight, the Heat Index (HI) is also commonly used to determine when extra precautions are needed to protect individuals from heat-related illnesses. The HI is a single value that indicates how hot the weather feels and is derived by taking into account ambient temperature (T_{amb}) and relative humidity (RH). These two measures can be obtained using a weather monitoring device (WMD) or a mobile weather application (App). Since athletic trainers may not have access to expensive WMDs, they may rely heavily on their smart phones to obtain weather-related information. **Objective:** To determine if weather data obtained via App is as accurate as data obtained directly using a real-time WMD. Design: Longitudinal observational study. Setting: Outdoor athletic facility (i.e., football field). Patients or Other Participants: Ten athletic trainers assisted in the collection of weather data. Data Collection and Analysis: Athletic trainers stationed at 10 different high schools within the same county were asked to collect real-time T_{amb} and RH readings using a Kestrel 5400 portable WMD (Kestrel Instruments, Minneapolis, MN) and from their mobile phones using the most recent version of The Weather Channel App. Data was collected at the start of practice each day (usually 4:00PM ± 30 minutes), and this was repeated every day throughout the duration of the regular football season. In order to collect live weather data, the WMD was stationed at a location that mirrored the environmental conditions that football
athletes were exposed to at their respective schools. A paired-samples T-test was used to determine how App data compared to real-time weather data obtained by WMD (significance set a priori at P < 0.05). <u>**Results:**</u> Mean T_{amb} was $87.2 \pm 7.1^{\circ}$ F for WMD and $86.2 \pm 6.7^{\circ}$ F for App. Mean RH was $58.6 \pm 16.6\%$ for WMD and $59.0 \pm 15.6\%$ for App. The mean absolute deviation in T_{amb} and RH between WMD and App was 2.3° F and 5.6%, respectively. Paired samples t-tests revealed a statistically significant difference between methods in $T_{amb}(t_{419} = 6.329; p < .001)$ but not in $RH(t_{420} = .943; p = .346)$. <u>Conclusions:</u> The HI chart published by the National Weather Service is arranged such that index values change for every increase or decrease of 2°F in temperature and 5% in relative humidity. The findings from this investigation suggest that using weather data derived from the Weather Channel App may not offer the most accurate information necessary to assess current weather conditions. Current heat policies require the use of WBGT or accurate T_{amb} and RH data to be able to modify or cancel practices. Therefore, to be able to implement necessary precautions to avoid heat-related illnesses, athletic trainers should utilize methods that provide the most accurate data possible.

Possible Heat Illness With Delayed Onset Concussion Symptoms in a College Football Athlete

Zoghbi AC, Felton SD, Craddock JC, Howard JD: Florida Gulf Coast University, Fort Myers, FL; Ave Maria University, Ave Maria, FL

Background: For this level 3 case report, a male collegiate football player was diagnosed with a concussion but presented with exertional heat illness symptoms two days after being cleared from a concussion with SCAT 5, cranial nerve assessment and VOMS. This case is unique because of the time of these medical conditions. An estimated 1.6 to 3.8 million concussions occurs each year from sports. Research indicates that athletes with a history of concussions typically have symptoms associated with exertional heat illness. Also, athletes with a history of concussions may be at risk for exertional heat illness, due to the brain regions that regulate the autonomic nervous system. Studies indicate that document the long-term effects of concussion on the autonomic nervous system may identify a mechanism by which risk for exertional heat illness is increased. Patient: Athlete was a 19-year-old (177.8 cm 71.58 kg) male collegiate football player with two years of collegiate athletics experience in football diagnosed with delayed onset of concussion symptoms three days after being cleared from a concussion. Intervention or Treatment: A symptom evaluation sheet, SCAT 5, cranial nerve screening was conducted at the time of the head injury. The athlete passed all evaluations and was cleared of a concussion. Three days following the injury, the athlete presented with possible heat related illness symptoms. The athletic training staff submerged him in a cold whirlpool and dialed 911. The athlete was released by the hospital and they diagnosed him with a concussion. Three days after the hospital visit the athlete was still symptomatic but continued to show improvement, at this time he was progressed to be at team

meetings and attend classes. The next day he stated to have no symptoms, took the baseline test and was ready to start his return to play protocol. The athlete had no symptoms while preforming each phase to the return to play protocol. Two months later the athlete had told the athletic training staff that he has been continuing to receive headaches but had quit the team weeks later. Outcomes or Other Comparisons: The relationship between a concussion and the possibility of exertional heat illness support the findings that you may have an increased risk of receiving heat illness symptoms while being concussed. Conclusions: This case highlighted an athlete's possibility of receiving heat illness symptoms while being concussed due to the brain regions that regulate the autonomic nervous system. The challenge associated with this case was the athlete coming forward with having symptoms months later having beliefs that he may not have been honest during his return to play protocol. Clinical Bottom Line: The patient experienced delayed onset of concussion symptoms but presented with exertional heat illness symptoms three days after being cleared for a concussion. This case study highlights the potential relationship between concussion symptoms and exertional heat illness symptoms.

Rhabdomyolysis/Heat Exhaustion in Preseason Football: Level 3 Case Study

Jones K, Barandica S, Matuseski N: Kean University, Union, NJ; Westfield High School, Westfield, NJ

Background: Evaluation of cramping is critical due to a variety of differential diagnoses, including rhabdomyolysis. Rhabdomyolysis is a breakdown of muscles tissue that releases myoglobin into the blood. This condition requires immediate medical attention and can easily go misdiagnosed, leading to permanent kidney damage. With cramping being so common in athletics, tunnel vision of dehydration is no longer acceptable. Patient: A 17-year-old male high school football player received medical attention for an extended period of bilateral lower extremity cramping after a humid preseason practice. Athlete has a family history of muscle cramping and was sent to emergency care for intravenous fluids two years prior. After a half hour of conservative cramping treatment with no signs of symptom reduction, he was referred to emergency care for rehydration. Due to the athlete's African American ethnicity, a concern for the sickle cell trait lead to blood testing. Tests results were negative for sickle cell but, showed enzyme levels five times higher than normal. This lead to the diagnosis of rhabdomyolysis and heat exhaustion. Intervention or Treatment: Initial treatment of the athlete diagnosed with rhabdomyolysis, was removal from activity for two weeks, allowing enzyme levels to decrease to appropriate levels. During those two weeks hydration and pain reduction was monitored. Urine was examined to check protein levels and kidney function. Athlete then underwent a rehabilitation program to check cardiovascular fitness and symptom reoccurrance. Athlete returned to play after two weeks and advised to stretch and foam roll prior to normal warm ups with the team, a well as maintaining hydration. Before any football activity, including

games, athlete is given Medi-Lyte to replenish electrolytes and decrease the risk of a cramping episode to occur again. These precautions are necessary to keep his risk of kidney issues to a minimum and avoid rhabdomyolysis from reoccuring. Outcomes or Other Comparisons: Every case of rhabdomyolysis is unique and each treatment should fit the extent of the diagnosed condition and athlete's ability. In cases where rhabdomyolysis has reoccured in the patient, initial treatment requires a longer period of time under medical attention and further examination for injury to the kidneys. Conclusions: Prevention of rhabdomyolysis includes paying attention to athletes being overworked, hydration levels, and weather during practice times. Enzyme levels can be elevated from vigorous excercise, muscle inflammation, injuries to the muscles, etc. In addition, being sure they are wary of performance-enhancing supplements can help avoid damage to muscle, leading to rhabdomyolysis. Clinical Bottom Line: Many issues could be concluded from the normal cramping of muscles. It is important to understand the risks of cramp related conditions and be able to recognize when a closer look needs to be taken. Working with young athletes makes it critical to not treat cramps lightly.

Free Communications, Oral Presentations: Lower Extremity Movement Assessment and Injury

Wednesday, June 27, 2018, 11:00AM-12:30PM, Room 208-210; Moderator: John Goetschius, PhD, ATC

Landing Biomechanics Influence Lower Extremity Lean Mass in Female Athletes

Frank BS, Battaglini CL, Blackburn T, Hackney AC, Padua DA: The University of North Carolina at Chapel Hill, NC

Context: Lower extremity biomechanics observed during jump-landing tasks are predictive of acute and chronic severe lower extremity musculoskeletal injuries such as ACL rupture and bone stress injury. Skeletal muscle (lean mass) acts as a "stress shield" for bone and ligamentous tissue by attenuating much of the load placed on the skeletal and articular systems during sport and exercise, thus minimizing the mechanical stresses on bones and joints. The influence of movement profile on lower extremity lean mass has not yet been described. **Objective:** To investigate the influence of a low-risk / soft or highrisk / stiff movement profile on lower extremity lean mass. Design: Crosssectional. Setting: Research laboratory. Patients or Other Participants: 41 physically active, healthy, college-aged field or court sport female athletes $(age = 20.4 \pm 1.5 \text{ yrs}, height = 167.4 \pm$ 7.2. cm, mass = 63.1 ± 7.2 kg) volunteered for participation. Interventions: Participants were assigned to a low-risk $/ \text{ soft } (n = 22; \text{ age} = 20.5 \pm 1.9 \text{ yrs, height})$ $= 166.6 \pm 7.0$ cm, mass $= 64.5 \pm 7.8$ kg) or a high-risk/stiff (n = 19; age = $20.2 \pm$ $1.1 \text{ yrs}, \text{ height} = 169.0 \pm 7.7 \text{ cm}, \text{ mass} =$ 61.4 ± 6.3 kg) movement profile group defined by The Landing Error Scoring System (LESS). Participants underwent whole body dual X-ray absorptiometry (DXA) scans. Main Outcome Measures: DXA derived whole body, combined right and left lower extremity subsystem (thigh & shank), and combined right and left lumbo-pelvic-hip complex + lower extremity (trunk, pelvis, thigh, & shank) lean mass estimates were normalized to total body mass (g/ kg). Total body mass normalized DXA scan measures of lower extremity lean mass were compared between low-risk / soft and high-risk / stiff movement profile groups using independent samples t-tests ($\alpha = 0.05$). **Results:** Individuals with a low risk / low load movement profile have greater overall lean mass. Movement profile had a significant, moderate-strong effect on whole body lean mass ($t_{39} = 2.27$, P = 0.029, d = 0.74; low-Risk/soft = 640.30 ± 30.41 g/ kg, high-risk/stiff = 619.36 ± 28.29 g/ kg) and moderate effect on lumbo-pelvic-hip complex + lower extremity lean mass ($t_{39} = 2.05$, P = 0.047, d = 0.64; low-risk/soft = 576.78 ± 25.53 g/ kg, high-risk/stiff = 560.33 ± 25.74 g/ kg). There was no significant effect of movement profile on lower extremity lean mass ($t_{39} = 1.12$, P = 0.27, d = 0.40; low-risk/soft = 234.49 ± 16.88 g/ kg, high-risk/stiff = 229.12 ± 13.32 g/ kg). Conclusions: Female athletes with a low-risk / soft movement profile have on average 1.3 kg and 1.0 kg greater normalized total body and lumbo-pelvic-hip complex + lower extremity lean mass compared to female athletes with a high-risk / stiff jump-landing profile. These findings suggest that female athletes with a low-risk / soft landing profile may possess a greater volume of skeletal muscle and increased capacity to attenuate loads placed on their skeletal and articular systems during sport and exercise, protecting them from injury. Improving lower extremity biomechanics may facilitate development and utilization of greater skeletal muscle mass to safely control lower extremity motion and attenuate loading during sport and exercise participation.

Validation of a Markerless Motion Capture System Trunk and Lower Extremity Joint Angles During a Jump-Landing Assessment

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Context: Jump-landing kinematics can identify individuals at increased lower extremity injury risk. There is a need for valid, portable motion capture systems that can efficiently identify high-risk kinematic strategies in field based settings. Markerless motion capture systems utilizing Microsoft KinectTM technology can capture trunk and lower extremity kinematics. However, these systems are generally not automated, require significant post-assessment data processing, and are not commercially available. Objective: To validate sagittal and frontal plane trunk and lower extremity jump-landing kinematics reported by a commercially available markerless motion capture system. Design: Correlational. Setting: Biomechanics laboratory. Patients or **Other Participants:** Healthy, physically active participants (male = 10, female = 10; age = 20.50 ± 2.78 yrs; BMI = 23.50 \pm 2.40) were recruited from a university's general student body. Interventions: Participants completed 5 jump-landing assessments from a 30cm tall box to a target located 0.9m in front of the box. Data were simultaneously recorded with markerless (PhysimaxTM) and stereophotogrammetric (ViconTM) motion capture systems. Main Outcome Measures: Sagittal and frontal plane trunk, hip, and knee joint angles were identified at: initial ground contact (IC); maximum angle (MAX); and the displacement

between IC and maximum knee flexion (DSP). Kinematics were averaged across jump-landing trials. Statistical outliers were removed prior to analyses. Intraclass correlation coefficients (ICC(2,1)) assessed inter-system reliability and paired-samples t-test examined differences in mean values ($\alpha \le 0.05$). Results: Significant agreement exists between the systems (ICC_{range} = -1.515-0.963; ICC_{avg} = 0.580) with 75.00% of the measures being significantly validated ($p \le 0.05$). Agreement is better for sagittal plane $(ICC_{range} = 0.501 - 0.963; ICC_{avg} = 0.843)$ than frontal plane (ICC_{range} = -1.515-0.918; $ICC_{ave} = 0.349$) measures. Agreement is the best between MAX measures (ICC_{range} = 0.552-0.955; ICC_{avg} = 0.769) as com-pared to IC (ICC_{range} = -0.185-0.963; ICC_{avg} = 0.562) or DSP measures (ICC_{range}) = -1.515 - 0.952; ICC_{avg} = 0.409). Pairwise comparisons identified significant differences for 18.75% of the measures. Fewer differences were observed for sagittal plane (0.00%) than frontal plane (35.29%)measures and fewer differences were observed for MAX (18.18%) and DSP (18.18%) measures than for IC (20.00%) measures. In general the Physimax[™] system underestimated sagittal plane measures (86.67% of measures) and overestimated frontal plane measures (76.47%) of measures). No trends were observed for over/underestimating IC, MAX, or DSP measures. Conclusions: Moderate agreement exist between markerless and stereophotogrammetric motion capture systems. Better agreement exists between the systems for larger joint angles (e.g., sagittal; MAX) than smaller joint angles (e.g., frontal; IC). DSP angles had the worst agreement; this is likely because DSP measures are derived and not directly measured. The PhysimaxTM system can validly identify trunk and lower extremity jump-landing kinematics which can aid clinicians in identifying individuals at increased lower extremity injury risk.

A Critical Evaluation of the Landing Error Scoring System for Individuals With ACL Reconstruction

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Context: The Landing Error Scoring System (LESS) is a valid and reliable indicator of ACL injury risk. However, measurement properties of the LESS among individuals with ACL reconstruction (ACLR) have not been critically evaluated to maximize clinical benefit. **Objective:** To critically evaluate the sex-based differences in LESS performance and item-level measurement properties of the LESS when applied to individuals with ACLR. Design: Descriptive research study. Setting: Two university laboratories. Patients or Other Participants: One hundred sixty-eight individuals (41M/127F, age = 19.7 ± 2.7 yrs., time since surgery = 29.1 ± 17.7 mo.) with a history of primary, unilateral ACLR were enrolled in the study. Individuals with multi-ligamentous injury, significant surgical complications, or those who had not vet returned to unrestricted physical activity were excluded from this study. Interventions: None. Main Outcome Measures: Participants completed the International Knee Documentation Committee Subjective Knee Evaluation Form and the Tegner Activity Scale to assess patient-reported knee-related function and peak physical activity, respectively. Participants then completed a minimum of 3 trials of a drop vertical jump task which were scored using the LESS. Between sex difference in LESS score was assessed using an independent samples t-test while between sex differences in each LESS item were assessed using separate Fischer's exact tests. Cronbach's alpha (α) and corrected item-total correlations (CIC) were calculated to assess the internal consistency for the LESS among all participants, as well as in the male and female groups. Results: Female participants displayed a greater number of total landing errors (male = 4.6 ± 2.4 errors, female = 6.1 ± 2.3 errors, p <0.001) and were more likely to display errors for trunk flexion at initial contact (IC; male = 4.9%, female = 23.6%, p = 0.01), medial knee position at IC (male = 17.1%, female = 42.5%, p =0.01), medial knee displacement (male = 24.4%, female = 73.2%, p < 0.001), total joint displacement (male = 65.8%, female = 85.9%, p = 0.02), and overall impression (male = 78.0%, female = 94.5%, p = 0.01) when compared to male participants. The internal consistency of the LESS was $\alpha = 0.52$ among the total sample, $\alpha = 0.56$ among males, and $\alpha = 0.47$ among females. Knee flexion displacement [CIC = 0.42 - 0.44], hip flexion displacement [CIC = 0.26 -0.41], trunk flexion displacement [CIC = 0.45 - 0.51], total joint displacement [CIC = 0.44 - 0.48], and overall impression [CIC = 0.32 - 0.49] consistently displayed acceptable corrected item-total correlations among males and females with ACLR. Conclusions: The LESS may enable clinicians to assess kinematic patterns among individuals with ACLR but application of this outcome as an indicator of ACL injury risk after ACLR should be integrated with caution until supporting prospective evidence is available.

Influence of Maturation and Injury History on the Landing Error Scoring System

Saul NR, Nguyen A, Frank BS, Zuk EF, Boling MC, DiStefano LJ, Bailey J, Ford KR, Taylor JB, Trigsted SM: High Point University, High Point, NC; University of North Carolina, Chapel Hill, NC; University of Connecticut, Storrs, CT; University of North Florida, Jacksonville, FL; North Carolina Football Club, Cary, NC

Context: Poor landing mechanics increase risk of lower extremity injuries. Females tend to land in positions associated with higher risk of injury and diverge from males especially post-puberty. Previous injury could directly alter landing mechanics leading to increased risk of re-injury. The Landing Error Scoring System (LESS) has been used to assess landing mechanics and to identify those with increased injury risk. It is currently unknown whether previous injury results in altered landing mechanics in youth athletes. As knee and ankle injuries continue to rise in youth athletes, identifying how LESS scores differ between maturational stages is critical. Understanding whether LESS scores differ in youth athletes with previous injury and across stages of maturation can help develop effective targeted interventions. **Objective:** To examine if total LESS scores differ between youth soccer players with history of lower extremity injury and stage of maturation. Design: Cross-sectional study. Setting: Field setting. Patients or Other Participants: Three hundred and fourteen youth soccer players (M 163, F 151, age = 12.1 ± 1.1 yrs, height = 153.7 ± 14.0 cm, mass = 44.2± 8.8 kg) participated. Interventions: Participants reported history of lower extremity injury (INJ) and no injury (NOINJ) using a self-reported baseline questionnaire and maturation stage [pre-pubertal (PRE), pubertal (PUB), or post-pubertal (POST)] was determined using the Khamis-Roche method to estimate percent of adult stature (%AS). Two-dimensional kinematics were collected during three trials of a jump landing task from a 30cm high box and scored using a validated automated LESS scoring system (PhysiMax Technologies Ltd, Tel Aviv, Israel). Main Outcome Measures: Injury to the hip, knee, lower leg, or ankle discriminated the INJ (N = 114) and NOINJ (N = 200) groups. Based on evidence of peak height velocity estimates, participants were classified as PRE (N = 122) with less than 80% AS, PUB (N = 115) with 80-92% AS, and POST (N = 77) with greater than 92%AS. The dependent variable was total LESS score. A two (INJ vs NOINJ) by three (PRE vs PUB vs POST) ANOVA was used to compare total LESS scores. Post-hoc LSD comparisons were performed when appropriate. Results: There were no significant interaction effects between maturation and injury history (p = 0.065) and no main effect for injury group (p = 0.338). There was a significant main effect for the maturation group (p = 0.028). LESS scores in PRE (5.7 ± 2.1) were significantly higher than POST $(5.14 \pm 1.9, p = 0.044)$. Scores from PUB (6.0 ± 1.9) were also significantly higher than scores in POST $(5.14 \pm 1.9 \text{ p} = 0.002)$. <u>Conclusions:</u> While there were no significant differences between INJ and NOINJ, individuals who are pre-pubertal and pubertal scored higher on the LESS than those who were post-pubertal. Higher LESS scores indicate worse landing mechanics. Poor landing biomechanics are associated with future risk of injury. Clinicians should utilize interventions in pre-pubertal and pubertal athletes to address landing biomechanics that are associated with higher risk of injury.

Difference in Lower Extremity Injury Risk During Basic Combat Training Between Military Recruits With High and Low Quality Movement Patterns Cameron KL, Miraldi SFP, Peck KY, Posner MA, Eckard TG, DiStefano LJ, Marshall SW, Padua DA: Keller Army Hospital, United States Military Academy, West Point, NY; University of North Carolina, Chapel Hill, NC; University of Connecticut, Storrs, CT

Context: Lower-extremity (LE) injuries are common in military training environments. These injuries place a significant burden on military training populations and healthcare resources, and they negatively impact combat readiness. Developing technologies to efficiently screen large groups of incoming recruits for high risk movement patterns is a critical need in these populations. **Objective:** To prospectively examine the risk of LE injury during basic combat training between military recruits with high and low quality movement patterns based on Landing Error Scoring System (LESS) assessments upon entry to military service. Design: Prospective cohort. Setting: United

States Service Academy. Patients or Other Participants: 1,216 incoming cadets from the graduating class of 2021. Interventions: In their first week at the Academy in the summer of 2017, incoming cadets completed a baseline pre-injury movement screening with the LESS using a depth camera (Microsoft KinectTM, Microsoft Corp, Redmond, WA) and markerless motion capture software (PhysiMax Technologies Ltd, Tel Aviv, Israel). High quality movement patterns were defined as a LESS score <3 and low quality movement patterns were defined as a LESS score >7. Main Outcome Measures: The primary outcome measure was the incidence proportion for LE injury during basic combat training. Injury outcomes were documented via active surveillance during the follow-up period using injury data from the Cadet Illness and Injury Tracking System (CIITS) and the Armed Forces Health Longitudinal Technology Application (AHLTA). Incident LE injuries were defined as the first LE injury experienced by each participant from baseline LESS assessment through the duration of the follow-up period as documented in CIITS and/or AHLTA. The risk of LE injury was calculated along with risk ratios (RR) and 95% confidence intervals (CI)

to compare the risk between groups. Results: Of the 1,216 participants screened at baseline, 161 were identified as having high quality movement patterns and 62 were identified with low quality movement patterns (Table 1). The incidence proportion for LE injury during basic combat training was 35.5% in those with low quality movement at baseline compared to 11.7% in those with high quality movement at baseline. The incidence of LE injury during basic combat training was over three times higher in participants with low quality movement at baseline (RR = 3.01, 95% CI: 1.75-5.16, p < 0.001) when compared to those with high quality movement patterns. Conclusions: Participants with low quality movement patterns upon entry to military service were three times more likely to sustain a LE injury during basic combat training when compared to those with high quality movement. These preliminary data suggest that LESS scores, measured using a depth camera and markerless motion capture software, may have utility in efficiently screening large groups of military recruits for LE injury risk during basic combat training.

Injured	Low Quality	High Quality	Total	
	(LESS > 7)	(LESS < 3)		
Yes	22	19	41	
No	40	142	182	
Total	62	161	223	
Incidence	35.50%	11.70%	18.40%	

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Free Communications, Oral Presentations: Pediatric Wellness

Thursday, June 28, 2018, 7:00AM-8:00AM, Room 208–210; Moderator: Jennifer Medina McKeon, PhD, ATC, CSCS

The Effect of Sport Specialization, Overuse Injury, and Travel on Daytime Sleepiness in Youth Athletes Post EG, Trigsted SM, Schaefer DA, Cadmus-Bertram LA, Watson AM, McGuine TA, Brooks MA, Bell DR: University of Wisconsin, Madison, WI; High Point University, High Point, NC

Context: The increasing trend in early sport specialization and year-round sport participation has been shown to have physical consequences such as an increase in overuse injuries. However, the effect of sport specialization on important non-physical aspects of well-being in adolescents, such as sleep, has yet to be assessed. **Objective:** To examine the effect of sport specialization on daytime sleepiness in youth club sport athletes. A secondary purpose was to examine the potential independent effects of overuse injury and regular sport travel on daytime sleepiness. Design: Crosssectional survey. Setting: Club sport competitions and practices. Patients or Other Participants: 647 youth club sport athletes (63.5% female; 14.0 \pm 1.5 years) were recruited to complete an anonymous questionnaire. Subjects were between 12-18 years of age and active on a youth sports team in the past 12 months. Interventions: Youth sport athletes were invited to complete a self-administered and anonymous questionnaire that consisted of demographics, sport specialization status, and daytime sleepiness. Questions were developed utilizing the feedback of a panel of content-area experts and the University of Wisconsin Survey Center. Main Outcome Measures: Sport specialization status was determined using a widely-utilized 3-point specialization scale. Daytime sleepiness was assessed using the Pediatric Daytime Sleepiness Scale (PDSS), a reliable and previously-validated tool that provides a score of daytime sleepiness (0-32) with higher scores indicating increased sleepiness. Data were summarized by least-square means (LS-mean) and standard errors (SE). Multivariable regression analysis was used to examine the associations between the independent variables (specialization status, overuse injury, and regular travel) with PDSS score, adjusting for sex, age, and day of week (weekday vs. weekend). Post-hoc pairwise Tukey's HSD tests were used to compare least-squares means estimates of PDSS scores between specialization levels (p < .05). **Results:** Highly specialized athletes had significantly higher PDSS scores compared to low specialization athletes $(16.1 \pm 0.5 \text{ vs.})$ 14.6 ± 0.6 , p = .04), even after adjusting for several covariates. Athletes that had sustained an overuse injury in the previous year had significantly higher PDSS scores compared to non-injured athletes $(16.3 \pm 0.7 \text{ vs. } 14.2 \pm 0.4, \text{ p} < .01).$ Athletes that reported travelling regularly for their sport had higher PDSS scores than athletes that did not travel regularly $(16.0 \pm 0.5 \text{ vs. } 14.5 \pm 0.5, \text{ p})$ < .01). Conclusions: Highly specialized athletes displayed increased levels of daytime sleepiness, which has been previously shown to be associated with impaired academic performance and increased negative emotion, such as anger. Previous overuse injury and regular sport-related travel were also associated with increased davtime sleepiness. Parents, coaches, clinicians and athletic trainers involved in youth sports should be aware of the potential association between sport specialization and daytime sleepiness.

Examining Health-Related Quality of Life in Middle School Athletes

Pope J, Kelshaw P, Hallsmith K, Caswell AM, Ambegaonkar JP, Cortes N, Caswell SV: George Mason University, Manassas, VA

Context: Health-related quality of life (HRQOL) has emerged as an important patient-reported outcome measure in sports medicine. The Pediatric Quality of Life Inventory 4.0 (PedsOL is designed to measure four dimensions of HRQOL in children (physical, emotional, social, and school functioning). However, few studies have investigated PedsQL scores among a middle school athlete population. Objective: To examine PedsQL outcome scores by sex and grade in healthy middle school student-athletes. Design: Cross-sectional survey. Setting: Metropolitan public middle schools in Virginia. Patients or Other Participants: 1621 of 2221 middle school student-athletes (n=838 girls, 50.5%, 12.1 ± 0.9 years; n = 823boys, 49.5%, 12.3 ± 0.9 years) at 9 middle schools during the 2016-2017 academic year participated in this study (74.8% response rate). Interventions: Participants completed the written PedsQL generic core battery (GCB). The PedsQL was administered individually by each school's athletic trainer during pre-season. The GCB (23-items) consisted of 4 constructs of pediatric functioning: physical (8 items), emotional (5 items), social (5 items), and school (5 items). All items were anchored by a 5-point Likert-type scale ranging from never (0) to almost always (4). Main Outcome Measures: Scores for the GCB and each construct were calculated. Additionally, a composite psychosocial health summary (PHS) score was calculated from all 15-items comprising the emotional, social, and school functioning constructs. Descriptive statistics for PedsQL GCB, each individual construct, and the composite

PHS were calculated by sex and grade. **Results:** The PedsQL GCB (a = 0.88) and PHS (a = 0.85) items demonstrated acceptable reliability. Girls' GCB, PHS, physical, emotional, social, and school function scores by grade were as follows: grade 6 (86.6 ± 10.0 , 85.5± 11.7, 88.4 ± 10.4, 84.1 ± 16.6, 89.8 ± 12.3, 82.5 ± 14.0), grade 7 (87.8 ± 10.7 , $86.5 \pm 12.4, 89.2 \pm 10.6, 85.1 \pm 17.0,$ 92.1 ± 11.4 , 82.4 ± 15.4), and grade 8 $(88.3 \pm 9.4, 87.1 \pm 11.0, 89.6 \pm 10.7,$ $85.6 \pm 16.4, 92.8 \pm 9.7, 82.8 \pm 14.9$), respectively. Boys' GCB, PHS, physical, emotional, social, and school function scores were: grade 6 (89.0 ± 10.1 , 87.5 \pm 11.7, 91.2 \pm 9.3, 88.8 \pm 14.4, 89.9 \pm 14.0, 83.9 ± 15.0), grade 7 (91.9 ± 7.8, $91.1 \pm 8.8, 93.1 \pm 8.2, 92.8 \pm 10.6, 93.4$ $\pm 10.3, 87.1 \pm 12.8$), and grade 8 (93.1 \pm $8.3, 92.2 \pm 9.2, 94.1 \pm 9.0, 92.7 \pm 12.6,$ $95.6 \pm 8.8, 88.3 \pm 13.3$, respectively. Conclusions: Our findings provide insight regarding PedsQL scores among healthy male and female middle school student-athletes by grade level. In our sample, student-athletes scored higher on all PedsQL constructs compared with prior research examining non-athlete middle school students. However, the scores were lower compared to baseline values reported in previous studies with high school student-athletes. It is important for clinicians to recognize that baseline values may vary based upon grade level and participation in sport. Collecting annual PedsQL baseline values for middle school student-athletes is recommended and may enable clinicians to more accurately evaluate HRQOL and better manage pediatric athletes throughout recovery from injury. Future research using a larger and more geographically diverse sample should examine socioeconomic status, race, primary language spoken at home, and sport.

The Risk of Nonmedical Prescription Opioid Use (NMPOU) in High School Athletes

Robison HJ, Medina McKeon JM: Ithaca College, Ithaca, NY

Context: NMPOU has reached epidemic levels in the U.S. general population. The high risk of addiction warrants investigation on both prevalence and prevention of NMPOU in interscholastic sports. **Objective:** To quantify the risk of NMPOU in interscholastic athletes. Data Sources: PubMed was searched through 9/17. Search terms included iterations of "opioid", "abuse". "sport", "high school", and "athletics." Studies were limited to those published after 2012 and written in English. A hand search followed. Study Selection: Selection criteria required that studies investigated 1) high school students, 2) athletes and non-athletes, 3) epidemiological data regarding self-reported misuse or abuse of prescription opioids. Data Extraction: The independent variable was interscholastic sports participation(frequently [>1 per week] vs. infrequently/none). The outcome of interest was history of NMPOU (yes, no). Two investigators extracted frequencies for these variables. Extracted data were originally collected via large-scale survey administered nationally to high schools and middle schools. Odds ratios [99% CIs] were calculated for event and frequency data. A summary model was generated to determine the effect of sports participation on NMPOU. Studies were appraised for potential threats to internal validity utilizing the modified Downs and Black Checklist (mD&B) for non-randomized studies. Based on the designs of the included studies, 11 items were removed from the mD&B as irrelevant, reducing this tool from 27 to 16 items. Data Synthesis: Four studies met selection criteria; one study was removed for failure to report appropriate data. Three studies were analyzed. The summary model indicated a slightly protective effect for frequent sports participation

on NMPOU, however, CIs encompassed 1 (summary OR = 0.9 [0.2, 4.4], p = 0.8). Individually, 2 studies demonstrated deleterious effects of sports on NMPOU (summary OR = 1.5 [0.7, 3.1], p = 0.13), while the 3rd demonstrated a protective effect of sports on use (OR = 0.3 [0.3, 0.3], p < 0.001). All three studies scored 15/16 on the mD&B. The consistently missed item was failure to report p-values. Conclusions: There was inconclusive evidence for the risk of NMPOU associated with interscholastic sports participation. In 2 studies, there was about a 50% increase of NMPOU in athletes compared to non-athletes. However, the third study indicated about 70% protective effect of sports participation on NMPOU. Although not quantitatively assessed, a closer inspection of one study revealed a considerable increase of NMPOU in football and wrestling, while a neutral or protective effect for other sports. This discrepancy, based on sex and/or sport, likely nullified the effect in the summary analyses. Whether this was an effect of sex, or the high contact/collision nature of the sports (an increased risk of serious injury may result in more access to prescription narcotics), could not be discerned. Regardless, ATs working with football or wrestling should consider closely monitoring both narcotic prescription acquisition following moderate or severe injury, and also for potential signs of NMPOU.

Ankle Best Practices Forum: The Role of Muscle Function in Ankle Sprains and Instability

Thursday, June 28, 2018, 8:15AM-9:15AM, Room 208–210; Moderator: Kathryn Webster, PhD, ATC Discussants: Jay Hertel, PhD, ATC, FACSM, FNATA; Luke Donovan, PhD, ATC

Free Communications, Oral Presentations: Gait and Postural Constraints in Chronic Ankle Instability

Thursday, June 28, 2018, 9:30AM-11:15AM, Room 208-210; Moderator: Phillip Gribble, PhD, ATC, FNATA

Stride-to-Stride Gait Variability in Individuals With Chronic Ankle Instability, Copers, and Healthy Controls

Sugimoto YA, Kuznetsov NA, Rhea CK, Ross SE: The University of North Carolina, Greensboro, NC

Context: Decreased variability in the spatial and temporal characteristics of gait has been suggested to reflect a loss of adaptability due to the more robotic (stiff) movement patterns. While less spatial variability in walking has been noted in patients with chronic ankle instability (CAI), the temporal variability profile of patients with CAI is currently not documented. Understanding how temporal variability differs between individuals with CAI, copers (individuals who have sustained a sprain, but have no residual symptoms), and healthy controls (individuals with no history of a sprain) may help clinicians redevelop adaptive gait characteristics in individuals with CAI and reduce further ankle sprains. We hypothesized that individuals with CAI would exhibit less temporal variability during gait relative to copers and healthy individuals. **Objective:** To examine the variability in stride-to-stride timing during walking in individuals with CAI, copers, and healthy controls. Design: Case-control. Setting: Research Laboratory. Patients or Other Participants: Twenty-one physically active collegiate students with CAI (20.71 \pm 2.63 yr, 173.96 \pm $7.41 \text{ cm}, 74.93 \pm 12.16 \text{ kg}; 6 \text{ females},$ 1 males; N = 7), copers (22.00 ± 3.65 yr, 171.14 ± 8.36 cm, 63.79 ± 14.83 kg; 5 females, 4 males; N = 7), and healthy controls (21.29 ± 3.30 yr, 169.86 \pm 6.12 cm, 71.00 \pm 17.66 kg; 5 females, 2 males; N = 7). Interventions: Participants completed 12-minutes of walking at a self-selected speed. Lower extremity kinematics were recorded at 240Hz using a retroreflective marker 3D motion capture system. The limb with a history of ankle sprains was the

affected limb for copers and CAI, and the healthy participants were assigned an affected limb (matched by dominance to the injured groups). The unaffected limb was the contralateral limb. Main Outcome Measures: Stride-tostride timing was quantified as the duration from heel contact to the next heel contact of the same limb. Variability in stride-to-stride timing was quantified as the coefficient of variation (CV) of the stride-to-stride time series, which was separately calculated for affected and unaffected limbs. A Repeated Measures ANOVA (alpha=0.05) with one between factor (group: CAI, Copers, Healthy) and one within factor (limb: affected, unaffected) was used to analyze CV of stride time. Tukey HSD was used for post-hoc analysis. Results: No significant differences were found for the main effect for group $(F_{(2.18)} = 0.53, p)$ > .05) or the main effect for limb (F_(1.18)) = 0.15, p > .05). However, a significant limb by group interaction was found $(F_{(2.18)} = 3.89, p = .04)$. Tukey post-hoc testing indicated that the CAI group had less CV of stride timing (affected = 1.37 $\pm 0.33\%$, unaffected = $1.38 \pm 0.34\%$) than copers (affected = $1.56 \pm 0.50\%$, unaffected = $1.53 \pm 0.48\%$) and healthy controls (affected = $1.60 \pm 0.51\%$, unaffected = $1.63 \pm 0.53\%$) participants. Conclusions: Participants with CAI demonstrated less variability in strideto-stride time compared to copers and healthy controls. Decreased variability in this temporal characteristic of gait for individuals with CAI may have the benefit of added gait stability, but the consequence of less gait adaptability.

Influence of Optical Flow Perturbations on Gait Variability in Chronic Ankle Instability Patients

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Context: Individuals with chronic ankle instability (CAI) have known balance impairments. Research suggests these CAI-associated balance impairments are due to an inability to appropriately reweight sensory information. Indeed, CAI patients place a greater emphasis on visual information during single-limb stance than uninjured controls. However, this evidence is based on removing visual information during static conditions. **Objective:** To investigate the effect of perturbed optical flow on walking gait variability in those with CAI compared to healthy Design: individuals. Case-control. Setting: Laboratory. Patients or Other Participants: 15 CAI patients (age: 20.2 ± 1.6 years, height: 167.3 ± 7.7 cm, weight: 64.7 ± 7.2 kg) and 15 uninjured individuals (age: 21.6 ± 1.8 years, height: 165.8 ± 4.7 cm, weight: $66.4 \pm$ 10.5 kg) volunteered. Interventions: In counterbalanced order, participants walked on a split-belt treadmill while watching a speed-matched virtual hallway with and without continuous mediolateral (ML) visual perturbations while walking at 1.25 m/s for 3 minutes per trial. Three-dimensional pelvic and foot kinematics were recorded at 100 Hz using a motion capture system to track retroreflective markers placed on the sacrum and both heels. Kinematic data were low-pass filtered at 8 Hz using a 4th order Butterworth filter. We analyzed at least 300 consecutive steps for each 3-minute trial. Main Outcome Measures: Right-left and left-right step width (SW) values from consecutive ML heel positions averaged over a period from 12-25% of the gait cycle (corresponding to mid-stance prior to heelrise) were calculated. Step length (SL) was computed as the relative fore-aft position of successive heel markers at 20% of each gait cycle plus the treadmill translation over the duration of that step. Gait variability was characterized as the standard deviation of step width (SWV) and step length (SLV) over all steps performed within a 3-min trial. All mean and variability metrics were normalized to subject leg length (%LL). Repeated measure ANOVAs assessed the effects of group and condition on dependent variables and posthoc testing was used when appropriate. An alpha level of 0.05 was used for all analyses. Results: A significant group x condition interaction was observed for SWV. In normal walking, SWV did not differ between groups (CAI: 2.92 \pm 0.63% LL, control: 2.54 \pm 0.66% LL). However, the CAI group (5.06 \pm 1.68% LL) exhibited greater SWV than healthy controls $(3.73 \pm 0.67\% \text{ LL})$ walking with visual perturbations (p = 0.008). There were significant condition main effects for SW, SL, and SLV (p < 0.001). In both groups, SW and SL increased and SLV decreased in the perturbed condition compared to normal walking. Conclusions: Walking with ML visual perturbations to optical flow induced greater SWV in those with CAI relative to controls. When combined with the existing literature, this finding suggests that CAI individuals have a greater reliance on visual information in both static and dynamic (i.e. walking gait) conditions relative to healthy individuals. Novel interventions may be needed to address this specific CAI associated sensorimotor adaptation.

Walking Gait Mechanics and Gaze Fixation in Individuals With Chronic Ankle Instability

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Context: Many individuals who suffer a lateral ankle sprain will develop chronic ankle instability (CAI). Individuals with CAI demonstrate kinematic differences in walking gait, as well as somatosensory alterations when compared to healthy individuals. Therefore, CAI subjects may rely more on their vision to compensate for these somatosensory alterations while waking. However, the role of vision during walking gait in this population remains unclear. **Objective:** To evaluate ankle kinematics, gaze deviations, and gaze velocity between participants with chronic ankle instability (CAI) and healthy controls while walking on a treadmill during three separate visual conditions. Design: Casecontrol study. Setting: Laboratory. Patients or Other Participants: 10 CAI participants (4 men, 6 women;

age = 21.5 ± 1.4 years, FAAM Sport = $62.8 \pm 12.4\%$, # of previous sprains = 5.4 ± 7.4) and 10 healthy matched controls with no history of ankle sprain (4 men, 6 women; age = 21.5 ± 1.3 years, FAAM Sport = $100 \pm 0\%$) participated. Interventions: Participants walked shod on an instrumented treadmill while wearing a gaze tracking headset during three separate conditions (no visual target, fixed visual target, moving visual target). Participants were asked to look at the targets on the screen in front of them while walking normally at a self-selected pace. Main Outcome Measures: Ankle sagittal and frontal plane kinematics were collected using a 12-camera Vicon 3D motion capture system and were analyzed throughout the duration of the gait cycle. The gaze deviation was calculated as the absolute value of the target position minus the focal point position (m). Gaze velocity was obtained by taking the first derivative of the focal point (m/s). The mean and standard deviation (SD) of gaze deviation and gaze velocity were calculated in the horizontal (X) and vertical (Y) directions. In each condition, between group comparisons were made with

90% confidence intervals for kinematic measures and Mann-Whitney U tests (data was not normally distributed) for gaze measures. Results: No significant differences were found between the two groups for either ankle kinematics or gaze variables, however large effect sizes were found in the no target condition for average deviation of horizontal gaze (Healthy = 0.05 ± 0.02 m, CAI = $0.12 \pm$ 0.11 m; ES: 0.84). Additionally, moderate effect sizes were identified in the no target condition for SD of vertical gaze (Healthy = 0.04 ± 0.03 m, CAI = 0.11 \pm 0.15 m; ES: 0.61) and in the moving target condition for average velocity of horizontal (Healthy = 1.56 ± 0.73 m/s, $CAI = 2.27 \pm 1.15$ m/s; ES: 0.73) and vertical (Healthy = 1.07 ± 0.51 , CAI = 1.47 ± 0.52 ; ES: 0.76) directions (see Table). Conclusions: Although no significant differences were found between groups, the moderate and large effect sizes reveal that it is possible that the role of vision in individuals with CAI may be altered with a more difficult task. Further research with larger sample sizes and more variety of tasks are needed to better understand the role of vision in individuals with CAI.

Table. Averages (in meters), standard deviations, and average velocities (in meters per second) in the X and Y directions in three separate target conditions.

	No Target			Fixed Target		Moving Target			
	Healthy	CAI	Effect Size	Healthy	CAI	Effect Size	Healthy	CAI	Effect Size
Average Deviation of X	0.05 ± 0.02	0.12 ± 0.11	0.84	0.03 ± 0.02	0.04 ± 0.04	0.31	0.24 ± 0.06	0.25 ± 0.11	0.11
Average Deviation of Y	0.10 ± 0.07	0.15 ± 0.16	0.39	0.06 ± 0.02	0.06 ± 0.04	0	0.16 ± 0.05	0.17 ± 0.07	0.16
Standard Deviation of X	0.03 ± 0.02	0.06 ± 0.08	0.49	0.02 ± 0.01	0.02 ± 0.01	0	0.18 ± 0.06	0.20 ± 0.08	0.28
Standard Deviation of Y	0.04 ± 0.03	0.11 ± 0.15	0.61	0.03 ± 0.01	0.03 ± 0.01	0	0.11 ± 0.05	0.13 ± 0.05	0.40
Average Velocity of X	0.47 ± 0.19	0.53 ± 0.40	0.18	0.34 ± 0.18	0.39 ± 0.20	0.26	1.56 ± 0.73	2.27 ± 1.15	0.73
Average Velocity of Y	0.74 ± 0.32	0.75 ± 0.46	0.02	0.53 ± 0.32	0.56 ± 0.16	0.12	1.07 ± 0.51	1.47 ± 0.52	0.76

Decreased Dynamic Postural Control and Weight-Bearing Dorsiflexion in Young-Adults and Middle-Aged Adults With Chronic Ankle Instability Kosik KB, Johnson N, Thomas AC, Terada M, McCann RS, Gribble PA: University of Kentucky, Lexington, KY; University of North Carolina, Charlotte, NC; Ritusmeikan University, Kusatusu, Shiga-ken, Japan; Old Dominion University, Norfolk, VA

Context: Former middle-aged athletes with a previous musculoskeletal injury report having more limitations during daily activity and exercise, and more chronic injuries compared to non-athletes. Lateral ankle sprain is the most common lower extremity injury among young, physically active, adults. Majority of individuals are able to return to their normal activity quickly, however, a considerable proportion of these young adults experience lasting symptoms and develop CAI as a young-adult. Current research examining the mechanical and sensorimotor impairments associated with CAI has focused largely on young-adult populations. Specifically, young-adults with CAI have decreased dynamic postural control and weight-bearing dorsiflexion ROM. A dearth of studies has attempted to quantify these functional deficits in middle-aged adults with CAI. Understanding if these functional deficits persist, or even progress, into middle adulthood could help us identify a progressive time course of CAI. Objective: Compare dynamic postural control and weight-bearing dorsiflexion ROM between young- and middle-aged adults with and without CAI. Design: Case-Control. Setting: Research Laboratory. Patients or Other Participants: A total of 60 young-adults (age: 18-35) volunteered to participate and were assigned to the CAI (n = 31, 23.58 \pm 3.1 years, 167.59 ± 9.55 cm, 73.2 ± 15.4 kg) and healthy-control (HC) (n = 29, 23.45 \pm 2.5 years, 169.81 ± 9.2 , 67.47 ± 15.8 kg) group. A total of 35 middle-aged (age:

36-59) adults volunteered to participate and were assigned to the CAI (n = 24, 44.9 ± 8.4 years, 166.8 ± 11.7 cm, 80.66 \pm 18.1 kg) and HC (n = 11, 44.45 \pm 10.0 years, 170.41 ± 10.12 cm, 74.74 ± 12.0 kg) group. Interventions: Participants completed the anterior, posteromedial and posterolateral reach directions of the star excursion balance test (SEBT); and the Weight-Bearing Lunge Test (WBLT). Main Outcome Measures: The distanced reached across three trials in each direction of the SEBT was averaged and normalized as a percentage of stance leg length (%LL). The maximum distanced lunged from three trials was averaged for the WBLT (cm). Separate 2 x 2 Group (CAI & HC) by Age (Young & Middle) ANOVAs were used for each outcome variable. A Bonferroni post hoc analysis was used in the event of a significant interaction. Significance was set a priori at $P \le 0.05$. **Results:** Significant Group main effects were observed for all primary outcome variables. The CAI group demonstrated lower anterior excursion (CAI: 61.3 \pm 6.9% LL, HC: 65.4 \pm 4.9% LL, p = 0.007), posteromedial excursion (CAI: 75.25 ± 11.7% LL, HC: 83.18 ± 10.4% LL, p = 0.006), and posterolateral (CAI: $67.1 \pm 16.6\%$ LL, HC: $76.3 \pm 10.5\%$ LL, p = 0.013) excursion compared to the HC group. The CAI group also demonstrated decreased weight-bearing dorsiflexion ROM (CAI: 7.7 ± 3.4 cm, HC: 9.8 ± 3.8 cm, p = 0.013) compared to the HC group. There were no significant main effects for Age, or any significant interactions. Conclusions: Both young and middle-aged participants with CAI had decreased dynamic postural control and weight-bearing dorsiflexion ROM. Sustaining musculoskeletal injury as a young adult produces enduring, but stable, deficits in postural control and weight-bearing activities. Further research is needed to understand how these persistent deficits affect other health-related consequences in those with CAI.

Gender Differences in Non-Linear Postural Stability in Patients With Chronic Ankle Instability and Controls McGrath ML, Yentes JM, Rosen AB: University of Montana, Missoula, MT; University of Nebraska, Omaha, NE

Context: Chronic ankle instability (CAI) is a common consequence of ankle injury and may cause prolonged disability and pain in physically active patients. Patients with CAI often report impaired balance and stability, yet traditional measures of postural stability often do not detect differences between patients with CAI and healthy controls. Non-linear measures of postural stability have been proposed as more sensitive to the changes in motor control that may occur in patients with CAI. In addition, while males generally exhibit poorer static balance compared to females, gender-related differences in postural stability between patients with CAI and healthy controls are less clear. **Objective:** To assess gender-related differences in non-linear measures of postural stability between healthy participants and those with CAI. Design: Case-control. Setting: Biomechanics Laboratory. Patients or **Other Participants:** Sixty participants volunteered for this study: Thirty participants with CAI (13 M, 17 F, age = 22.3 \pm 2.7 yrs, mass = 76.9 \pm 19.2 kg, height = 170.9 ± 8.9 cm, Cumberland Ankle Instability Tool (CAIT) score = $17.6 \pm$ 4.5), and thirty healthy controls (14 M, 16 F, age = 22.1 ± 2.5 yrs, mass = $75.6 \pm$ 13.9 kg, height = 171.9 ± 9.6 cm, CAIT score = 29.9 ± 0.3). Interventions: Participants stood on a single leg on a force platform for 60sec with eyes open. The leg with CAI (defined as a CAIT score ≤ 24) was assessed in the CAI group. For Controls, the test leg was matched to the tested leg from the CAI group. Center of pressure (CoP) excursion in the anterior-posterior (AP) and medial-lateral (ML) directions was collected at 1000Hz. Main Outcome Measures: Sample entropy (SampEn), a non-linear method of assessing time-series regularity, was calculated from the CoP data. SampEn calculates the probability that a pattern will repeat within a time series of data. Higher values indicate less regularity and more randomness, while lower values indicate greater regularity and pattern repetition. 2 x 2 ANOVAs compared SampEn_{AP} and SampEn_{MI} between genders in both groups (p < 0.05). Cohen's d effect sizes were calculated for significant results. Results: A significant main effect for group ($F_{1.56} = 9.19, p =$ 0.004) was observed for $SampEn_{AP}$, $(CAI = 0.65 \pm 0.14, Control = 0.56 \pm$ 0.10, Cohen's d = 0.60). No differences in $\text{SampEn}_{\text{\tiny ML}}$ were observed between groups ($F_{156} = 0.27$, p = 0.605). A significant main effect for gender was observed for both SampEn_{AP} ($F_{1.56} = 6.43$, p = 0.014) and SampEn_{ML} (F_{1.56} = 6.13, p = 0.016). Females demonstrated lower SampEn values in both AP (Female $= 0.57 \pm 0.13$, Male $= 0.65 \pm 0.11$, Cohen's d = 0.57), and ML directions (Female = 0.63 ± 0.14 , Male = $0.72 \pm$ 0.11, Cohen's d = 0.62). Conclusions: Participants with CAI demonstrated more irregular AP CoP patterns compared to healthy controls, suggesting difficulty maintaining postural stability in the AP direction. Increasing irregularity may indicate impaired stability, and an inability to find a stable attractor state for single-leg balance in patients with CAI. This may help explain the compromised balance and postural stability often observed in patients with CAI. Males also exhibited a pattern of more irregularity than female participants, regardless of group assignment. However, there were no interactions that would suggest different responses to CAI between genders.

Free Communications, Oral Presentations: Laser, Light, and Electrical Stimulation

Thursday, June 28, 2018, 5:15PM-6:45PM, Room 208-210; Moderator: Noelle Selkow, PhD, ATC

Tissue Temperature Increases From a Red and Blue Combination Photobiomodulation Light Patch

Wells AM, Rigby JH, Castel JC, Draper DO: Brigham Young University, Provo, UT; Texas State University, San Marcos, TX; CareWear Corp, Reno, NV

Context: Photobiomodulation has been used to treat musculoskeletal injuries, reduce pain, and improve muscle performance and function. Many physiological effects of photobiomodulation therapy have been examined, but the thermal effects of photobiomodulation therapy have yet to be determined. Objective: To determine the superficial tissue heating characteristics of a red and blue combination photobiomodulation light patch. Design: Controlled laboratory study Setting: Research laboratory Patients or Other Participants: Ten healthy individuals $(M = 5, F = 5, age = 22.2 \pm 2.3, height =$ 170.3 ± 8.3 cm, mass = 76.8 ± 13.1 kg) Interventions: Participants were positioned prone on a treatment table and their posterior calf was cleansed before an IT-21 needle thermocouple was inserted 0.5 cm into the subcutaneous tissue. A PT-6 skin thermocouple was secured to the posterior calf adjacent to the needle thermocouple. A second PT-6 skin thermocouple was secured to the skin 3 cm away from the treatment location. All thermocouples interfaced with an Isothermex electrothermometer. A single Careware Firefly light patch was positioned over the subcutaneous and skin thermocouple within the treatment area. A 15 minute photobiomodulation therapy (wavelength = 640 and 450 nm, average irradiance = 3 mW/ cm^2 , peak power = 9 mW, continuous peak power = 3 mW, energy density = 5.4 J/cm², treatment area = 50 cm²) was administered to the posterior calf. After the treatment, a 5 minute post-treatment temperature decay was recorded. Main Outcome Measures: Tissue temperature measurements from the thermocouples were taken every 1 minute throughout the 15 minute treatment and for 5 minutes post-treatment. Absolute tissue temperature and change from baseline temperature were used during the data analysis. A repeated measures ANOVA was used to determine if tissue temperature increased between the

3 measurement sites over the treatment time. Results: The light patch increased subcutaneous tissue temperature 6.22 \pm 2.25° C to a peak absolute temperature of $37.71 \pm 1.78^{\circ}$ C. The light patch increased skin temperature 8.22 ± 2.62 °C to a peak absolute temperature of 38.90 \pm 2.24° C. The skin temperature 3 cm away from the treatment remained relatively constant throughout the treatment $(-0.11 \pm 0.30^{\circ} \text{ C})$. The subcutaneous and skin temperatures directly under the treatment area significantly heated compared to the reference 3 cm away from the treatment site (P < .001). During the 5 minutes post-treatment, tissue temperature decreased 2.68 ± 1.45 °C, 4.54 ± 1.93 °C, and 0.23 ± 0.12 ° C at the subcutaneous, treatment skin surface, and 3 cm away skin surface sites, respectively. Conclusions: The red and blue wavelength combination photobiomodulation light patch significantly increases superficial tissue temperature. Thermal physiological effects may be an added benefit to this type of photobiomodulation therapy.



The Effect of Pulsed Versus Continuous Photobiomodulation Therapy for Muscle Recovery After an Eccentric Exercise Protocol

Rigby JH, Thiriot K, Hyldahl RD, Draper DO: Texas State University, San Marcos, TX; Brigham Young University, Provo, UT

Context: Photobiomodulation therapy has previously improved muscle recovery when applied before strenuous exercise. However, several parameters have not been determined to maximize the effects of photobiomodulation therapy. **Objective:** To determine if pulsed or continuous photobiomodulation therapy is better at increasing muscle recovery and limiting muscle soreness after a strenuous eccentric exercise bout. Design: Randomized clinical trial. Setting: Research laboratory. Patients or Other Participants: Twenty-four healthy participants (M = 12 and F = 12, age = 23.3 ± 3.4 y, height $= 175.4 \pm 10.2$ cm, mass $= 80.34 \pm 18.1$ kg). Interventions: Participants were randomly assigned into a pulsed (N = 12) or continuous (N = 12) treatment group and were blinded to their group assignment. Four Carewear Firefly light patches (wavelength = 640 and 450 nm, average irradiance = 3 mW/cm^2 , pulsed peak power = 9 mW, continuous peak power = 3 mW, energy density = 5.4 J/cm^2 , treatment area = 200 cm²) provided 30 minutes of treatment over the quadriceps muscles before and for each of the 4 days following the eccentric exercise bout. Participants performed 3 bouts of 10 sets of 10 eccentric knee extension reps with a 1-minute rest between each set for a total of 30 sets and 300 reps. Main Outcome Measures: All dependent variables, except for serum creatine kinase, were measured at baseline and immediately, 24, 48, 72, and 96 h post-exercise bout. Strength deficits were measured via isometric peak torque using a Biodex dynamometer. Participant's perceived function and soreness was measured using the Lower Extremity Functional Scale (LEFS) and visual analog scale (VAS), respectively. Blood draws were collected at baseline, 48 and 96 h post-exercise bout for serum creatine kinase analysis. To normalize the data between participants, strength was analyzed as percent of baseline and subjective measures of LEFS and VAS were analyzed as change from baseline. A logarithmic transformation was used to normalized creatine kinase data. For each dependent variable, a repeated measures ANOVA was used to determine differences between treatment groups over time. Results: The pulsed treatment improved the rate of recovery over the continuous treatment for LEFS (P = .005), VAS (P = .023), and creatine kinase levels (P = 0.013), but did not alter isometric peak torque (P = 0.453). Isometric strength decreased to 84.1 ± 27.5 and $64.6 \pm 28.7\%$ of baseline immediately after the exercise for the pulsed and continuous treatment groups, respectively, but returned to near baseline values by 96 h (pulsed = 99.5 \pm 23.5, continuous = 95.3 \pm 27.7% of baseline). Across all time points, LEFS scores decreased 4.4 ± 10.0 and 14.1 ± 21.6 points and VAS scores increased 14.0 ± 24.9 and 30.4 \pm 31.2 mm for the pulsed and continuous groups, respectively. Creatine kinase levels were still elevated at 96h post-exercise in the continuous group $(9453.5 \pm 16823.2 \text{ U/L})$ compared to the pulsed group (444.4 \pm 990.0 U/L). Conclusions: Pulsed photobiomodulation therapy improved participants perceived function, soreness, and muscle recovery measured via serum creatine kinase, but this did not affect isometric strength between treatment groups.

The Effects of Transcutaneous Electrical Nerve Stimulation (TENS) on Postoperative Pain and Analgesic Usage: A Systematic Review Christie CM, Bell RA, Nicolai MA, Berry DC: Saginaw Valley State University, University Center, MI

Context: Opioid analgesics are prescribed to manage acute and chronic pain and following elective surgical procedures (i.e., knee arthroscopy). However, opioid usage has accompanying complications leading to an acquired dependence, addiction, or tolerance, reaching the level of a national public health. **Objective:** To answer the question, In adult postoperative patients (P), does the application of Transcutaneous Electrical Nerve Stimulation (TENS) (I) versus placebo-TENS (C) change pain levels and decrease opioid/nonopioid analgesic requirements during the first 6-weeks of recovery from surgical/invasive procedures (O)? Data Sources: Articles (n = 100) were identified from: PubMed, CINAHL, MEDLINE, ScienceDirect, Cochrane, Physical Therapy and Sports Medicine Collection and ProQuest using ["transcutaneous electrical nerve stimulation" AND postoperative AND "opioid use"] and ["transcutaneous electrical nerve stimulation" AND postoperative AND "analgesic requirement"] from 2007- 2017 (September). Study Selection: Following initial screening (duplicates = 18, title, abstract), 17 articles were reviewed. Seven articles met inclusion criteria: (1) peer-reviewed, randomized controlled trial (RCT), (2) compared TENS to placebo-TENS, (3) adults (age = 18-85) with postoperative pain, (4) English-language, (5) available abstract, (6) outcome measuring opioid/ nonopioid analgesic usage and pain (visual analog scale [VAS], numerical rating scale [NRS]). Data Extraction: Three reviewers independently assessed studies' level of evidence (LOE) and quality using the Oxford Center for Evidence-Based Medicine (2011) and Physiotherapy Evidence Database (PEDro) instruments. Data of interest: subjects, TENS

parameters, descriptive and inferential statistics, and effect sizes (ES) related to pain and opioid/nonopioid usage. Data Synthesis: Seven studies met the inclusion criteria (LOE = 2). PEDro scores ranged from 8-10 (maximum = 10; average = 9.34 ± 0.50). Pooled sample size = 690, patients underwent rotator cuff repair (n = 37), liposuction (n = 42), hip arthroplasty (n = 60), birth (vaginal = 100, caesarean = 100), inguinal herniorrhaphy (n =100), and knee arthroplasty (n = 251). All studies demonstrated a reduction in pain and analgesic usage following surgical/ invasive procedures using TENS. TENS compared to placebo-TENS demonstrate moderate-to-large effects at 2-hours (n =1, ES = 0.78), 4-hours (n = 1, ES = 0.79), 6-hours (n = 2, ES = 0.75), 8-hours (n = 2, ES = 0.58), 12-hours (n = 3, ES = 0.59), 24-hours (n = 4, ES = 0.72), 2-days (n = 2, ES = 0.89), 3-days (n = 1, ES = 0.74), 4-days (n = 1, ES = 0.83), 5-days (n = 1, ES = 0.79), and 7-days (n = 1, ES = 0.54) postoperatively. One study found significant differences in patients reporting "no pain" (P = 0.02) 30-days postoperatively. Opioid analgesic requirement were significantly less 6-hours to 24-hours postoperatively (P < 0.001), up to 48-hours postoperatively (P < 0.001) in two studies. Inguinal herniorrhaphy studies (n = 2)found significant reductions in nonopioid analgesic intake (P < 0.01). Limitations include: (1) sample size, (2) limited long-term data, (3) absence of electrode placement standardization, and (4) inconsistent clinical parameters (i.e., frequency, duration). Conclusions: TENS shows moderate-to-strong effectiveness in reducing pain (ES = 0.70) and opioid/ nonopioid analgesic requirements during the first 30-days following surgical/invasive procedures. Athletic trainers should consider integrating TENS applications in conjunction with other therapeutic interventions (i.e., cryotherapy) in athletes undergoing surgical procedures to control pain and limit exposure to opioid analgesics and their associated risks.

Comparison of Over-the-Counter Electrical Stimulation Treatments to Clinician Applied Treatments on a Pain Pressure Threshold Test in Healthy Individuals Ip WYV, Trowbridge C: University of Texas, Arlington, TX

Context: Transcutaneous electrical nerve stimulation (TENS) are commonly used to relieve pain. They are now available over-the-counter (OTC) and simply include a power button and intensity controls. The OTC TENS units are pre-programmed, whereas, therapeutic TENS units allow for manipulation of a variety of parameters. Therefore, it is important to know whether the pain relief provided by these OTC TENS equate to those therapeutic TENS operated by a trained professional. **Objective:** To compare the pain relief provided by OTC TENS and therapeutic TENS units. Design: Repeated measure double-blind randomized. Setting: Laboratory. Patients or Other Participants: Eighteen volunteers with no neurological pathology

and currently not taking any pain medications were recruited. Four subjects were excluded (n = 1; medical reasons,n = 3; inconsistencies in pain pressure threshold (PPT). Total subjects (males n = 9 and females n = 5) (age = 24 \pm 2.9 years, mass = 75.4 \pm 14.3 kg, height = 171.1 ± 10.5 cm) participated. Interventions: PPT was measured before, during 30 minutes of electrical stimulation, and during 20 minutes of passive recovery using a pressure algometer at the web space between first and second metacarpals of the dominant hand. Treatments were IcyHotO Smart relief with gate-control intensity set to "strong but comfortable" or a therapist adjusted TENS unit with central biasing setting using 150 Hz, 300msec, 30 sec ON/5 sec OFF, Ramp 5 sec with a "to tolerance" intensity setting. Main Outcome Measures: Means ± SD for pain pressure threshold (PPT) measured in newtons (N). Two way ANOVA (2 x 6) with two treatment groups and six levels of time (0, 10, 20, 30, 40, 50 mins) investigated PPT changes from baseline. Alpha was set apriori at 0.05.

Results: There was no interaction between treatment group and time (p =0.801), but there was a time main effect (p < 0.001). For both treatment groups, change in PPT at 10 (p < 0.001), 20 (p< 0.001), 30 (p < 0.001), and 40 (p =0.026) mins was different from baseline. Maximum change in PPT occurred at 30 mins $(4.75 \pm 3.5 \text{ N})$ which was the end of treatment. PPT values declined within 10 mins after treatment ended $(40 \text{ mins} = 1.9 \pm 2.8 \text{ N}; 50 \text{ mins} = 0.5$ ± 2.2 N). Conclusions: Based on pain control theories, we hypothesized that central biasing treatment would result in greater and longer lasting pain relief; however, there was no statistical significance between treatment groups. Pain was relieved as early as 10 mins and continued until treatment ended at 30 mins, but neither group demonstrated lasting pain relief post treatment. Two limitations included small sample size and increasing tenderness at the web space due to repeated measurements. Future research should include larger sample size and use less frequent PPT measure post-treatment.



Human In Vivo Dexamethasone Sodium Phosphate Concentration and Skin Perfusion During a 4 mA Iontophoresis Treatment Smith BM, Rigby JH, Hyldahl RD, Mack GW, Draper DO: Brigham Young University, Provo, UT; Texas State University, San Marcos, TX

Context: Previous research has determined the in vivo concentration of dexamethasone sodium phosphate (DEX-P) and related forms delivered to subcutaneous tissue during lower current intensity (1 and 2 mA) iontophoresis treatments in human participants. However, limited research methods have restricted the ability to know DEX-P concentrations in higher current intensity (4 mA) iontophoresis treatments. **Objective:** To determine the subcutaneous DEX-P concentration and skin perfusion during and after a 4 mA iontophoresis treatment using microdialysis. **Design:** Controlled laboratory study. Setting: Research Laboratory. Patients or Other Participants: Thirteen healthy individual participants (Male = 5, Female = 8, age = 25.6 ± 4.4 y, height = 172.0 ± 8.9 cm, mass = 69.6± 12.6 kg). Interventions: Participants received an 80 mA*min iontophoresis treatment of 4 mg/mL DEX-P using a 4 mA current intensity (treatment time = 20 minutes). Two hollow fiber (13 KD MWCO) microdialysis probes were placed in the ventral forearm at 3.2±0.9 mm below the surface of the skin. The microdialysis probes were perfused with sterile saline at 1.2 µL/min to assess DEX-P, dexamethasone (DEX), and its metabolite (DEX-MET) concentrations in the subcutaneous tissues. Skin perfusion was measured using laser Doppler flowmetry placed within the drug chamber of the iontophoresis patch. Main Outcome Measures: Microdialysis samples were collected at baseline, at the conclusion of the 20 minute treatment, and every 20 minutes post-treatment for 60 minutes. Samples were analyzed using high performance liquid chromatography to determine the concentration of DEX-P, DEX, and DEX-MET. The 3 forms of dexamethasone were summed to create dexamethasone total (DEX-TOTAL). Using the same data collection time points, skin perfusion was calculated as a percent change from baseline. One-way repeated measures ANOVAs were used to determine if DEX-TOTAL or skin perfusion changed during or after the treatment. Results: DEX-P was found in 7 out of 13 participants (53.8%), with a peak concentration occurring 20 minutes post-treatment (778.9 \pm 1541.7 ng/ mL). DEX-TOTAL was found in 12 out of 13 participants (92.3%) and showed a trend toward increasing over the course of the treatment and post-treatment time (P = .057). The peak concentration of DEX-TOTAL occurred at 40 minutes post-treatment (4536.2 ± 1903.1 ng/ mL). Skin perfusion significantly increased during and immediately after the treatment, but returned to near baseline values 60 minutes post-treatment (P < .001). Peak skin perfusion occurred 20 minutes post-treatment (194.1 ± 27.3% of baseline). Conclusions: Dexamethasone forms were found in almost all samples collected following a 4 mA iontophoresis treatment. The higher current intensity resulted in DEX-P concentrations in the subcutaneous tissues, when previous research using lower current intensities (1 and 2 mA) only found DEX and DEX-MET concentrations. Skin perfusion increased but not to levels which may have washed out the drug concentration.

Free Communications, Oral Presentations: Concussion Reporting

Friday, June 29, 2018, 7:00AM-7:45AM, Room 208–210; Moderator: Zachary Kerr, PhD, MPH

Influencing Factors and Role Expectations in Concussion Disclosure

Kay MC, Gildner P, Dorman AV, Marshall SW, Kerr ZY, Linnan LA, Hennink-Kaminski H, Cameron KL, Peck KY, Houston MN, Register-Mihalik JK: University of North Carolina at Chapel Hill, Chapel Hill, NC; Keller Army Community Hospital, West Point, NY

Context: Up to 50% of all concussions are not reported by athletes. Therefore, it is imperative to understand factors that may impact an athlete's disclosure of concussion-related symptoms, including their expectations of diagnosis and management. With discrepancies in what is expected versus what occurs, athletes may be less likely to report potential symptoms. **Objective:** To explore factors and expectations regarding concussion disclosure among National Collegiate Athletic Association (NCAA) varsity athletes in the context of the socioecological model. Design: Consensual qualitative research tradition/framework based in phenomenology. Setting: Individual in-person interviews were conducted in a University research lab. Patients or **Other Participants:** Twenty-five civilian Division 1 NCAA varsity athletes representing 15 sports (12 males; 13 females; age = 20.1 ± 0.8) were interviewed, to reach data saturation. Participants were recruited via convenience sampling. Data Collection and Analysis: A single semi-structured in-person interview (28 questions) was conducted with each participant and transcribed verbatim. A four-person research team consisting of novice and expert qualitative researchers (2 athletic trainers; 2 with a background in health behavior) individually coded the data into themes and categories, and then met to attain consensus on coding accuracy and comprehensiveness. An internal auditor reviewed results. Results: Participant interviews highlighted four factor levels influencing their current

disclosure behaviors: intrapersonal, interpersonal, environmental, and concussion perceptions. Intrapersonal factors included individual characteristics such as their previous medical history. Interpersonal factors included team/coach support and perceived pressure from peers or superiors. Environmental factors included the presence of medical professionals at the time of the event, which facilitated disclosure. Lastly, concussion perceptions included two primary findings: their knowledge and attitudes towards concussion disclosure and the perceptions of others' knowledge and attitudes, such as teammates or coaches. Interactions between these four domains were also described, specifically, previous medical history and witnessing a concussive event were discussed by participants as positively impacting both knowledge and attitudes. Athletes also mentioned concussion disclosure role expectations from four main groups: themselves, teammates, coaches, and medical personnel. A fifth, smaller group included parents, siblings, school personnel, and others. In general, participants described being relatively satisfied with all individuals, but felt more could be done to enhance the social environment to improve disclosure. For instance, they felt medical professionals should recognize the injury and remove athletes from participation, perhaps lessening the need for self-disclosure. Conclusions: Information from this study highlights the need for key social referents such as medical personnel and coaches to understand and improve athletes' expectations of the concussion management process in efforts to improve self-disclosure and overall identification of concussive injuries. Lastly, it is important to consider all aspects of an athlete's life including, mental, physical, and social factors that may impact their willingness to disclose concussion-related symptoms.

Examining Sex Differences of Self Efficacy Ratings in the Use of Concussion Assessment and Management Tools

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Context: Currently, sports-related concussion (SRC) assessment and management have taken a multifaceted approach with new SRC measures being developed yearly. However, to date no research has examined sex differences in certified athletic trainers (ATs) self-efficacy in the use of assessing and managing SRCs. **Objective:** To examine sex differences of self-efficacy ratings of ATs in SRC assessment and management tools. Design: Cross-Sectional Study. Setting: Webbased questionnaire. Patients or Other **Participants:** 114 [male n = 62; female n = 52] ATs had a mean age of $38.30 \pm$ 11.5 years old [male 40.85 ± 12.0 ; female 35.25 ± 10.3], and were certified as an athletic trainer for 14.08 ± 10.2 years [male 15.61 ± 11.0 ; female 12.25 ± 8.7]. The overall response rate was 11.2%. Interventions: The National Athletic Trainers Association randomly selected 1000 ATs to complete the questionnaire. The survey was a self-administered, one-time online survey through MSU Qualtrics. Participants completed a 30item survey evaluating their self-efficacy of the assessment and management tools of SRCs. Self-efficacy was rated on a likert scale between 0 (lower self-efficacy) and 100 (higher self-efficacy). Face and content validity and internal consistency were established before the distribution of the survey. Main Outcome Measures: The independent variable was sex. Dependent variables included the self-efficacy ratings of ATs for the SRC assessment and management tools. Separate multivariate analysis of variance was performed to determine if there were differences between male and female ATs in their self-efficacy ratings of SRC assessment

and management tools. The p value was set aprior at .05. Results: Females reported higher self-efficacy ratings in the SRC assessment tools when compared to males (p = .02). Female ATs had a higher self-efficacy rating of $89.9 \pm$ 20.6 in the assessment of baseline examination (p = .03), compared to males with an average self-efficacy rating 77.52 ± 37.1 . Female ATs had a higher self-efficacy rating of 77.83 ± 28.6 in the assessment of cranial nerve examination (p = .02), compared to males with an average self-efficacy rating 63.11 ± 38.2 . Female ATs had a higher self-efficacy rating of 84.19 ± 29.6 in the assessment of computerized neuropsychological test (p = .02), compared to males with an average self-efficacy rating 67.10 ± 43.4 . No differences were found when examining sex differences in overall self-efficacy ratings of SRC management (p = .49). <u>Conclusions:</u> Overall females had greater self-efficacy ratings for the assessment of SRCs when compared to males. However, when managing SRCs, no differences between males or females were found in self-efficacy ratings. Future research should replicate this study with a larger sample size and examine self-efficacy differences in level of education.

Reporting Skill: A Missing Ingredient in Concussion Reporting Behavior Assessment

Warmath D, Winterstein A: University of Wisconsin, Madison, WI

Context: Efforts to improve concussion reporting have relied on a model in which education produces improvements in concussion knowledge and, therefore, reporting. Numerous studies cast doubt on the knowledge-reporting behavior relationship. Some studies suggest that the process of deciding whether to report and then understanding how to report are overlooked components. Other domains, such as consumer finance, have recognized the importance of decision skill. No study, however, has taken up the call to fill this important gap in the concussion literature. Objective: The present study seeks to define a new construct, reporting skill, and develops a scale to measure it. Design: Secondary analysis of decision-making skill from other domains and qualitative interviews are used to define the construct. Exploratory and confirmatory factor analyses are conducted on three waves of data collection to identify and confirm the scale. Structural Equation Modeling is used to examine the relative contribution of reporting skill and concussion knowledge to intention to report a concussion. Setting: The setting involves three waves of an online survey with national samples. Patients or Other Participants: A national sample of 1,491 young-adult athletes (age 18 to 24) of various sports and levels of competitiveness from the Survey Sampling International (SSI) panel. Interventions: Eleven candidate survey items developed from a review of other literature employing a decision-skill construct were reviewed by experts and tested in cognitive interviews. The items were included in the online survey alongside established measures (e.g., concussion knowledge and reporting intention). Main Outcome Measures: In scale development, we examine factor loadings, variance explained, Cronbach's Alpha, Composite Reliability, and Average Variance Explained. In our regression, we used reporting intention as the primary outcome. Results: Concussion reporting skill involves knowing when I don't know enough or have the right perspective to decide whether to report a concussion, knowing where to get the advice/knowledge/perspective I need to help me decide, and being able to use that knowledge/advice/perspective to decide whether to report. Scale development produced one factor with six items explaining 60.2% of the variance. Factor loadings were all above .7 and reliability statistics exceeded minimum values. Confirmatory factor analysis showed reasonable fit of the scale (X2(5) = 11.669, RMSEA = .057, CFI =.991, TLI = .982). While there is a significant zero-order correlation between knowledge and reporting intentions, the best fitting reporting intentions model including reporting skill and not knowledge. Conclusions: Reporting skill is an important and, until now, missing ingredient in the concussion literature and practice. Incorporating reporting skill development in concussion education initiatives is likely to improve actual reporting.

Head Best Practices Forum: Inside the Athlete Brain: Why Do Athletes Delay or Fail to Report Their Concussions and How Can We Fix It?

Friday, June 29, 2018, 8:00AM-9:00AM, Room 208–210; Moderator: Michelle Weber, MS, ATC Discussants: Julianne Schmidt, PhD, LAT, ATC; Breton Asken, MS, ATC

Free Communications, Oral Presentations: Health and Well Being of Athletic Trainers

Friday, June 29, 2018, 10:45AM-11:45AM, Room 208-210; Moderator: Janet Simon, PhD, AT

Health Behaviors of Athletic Trainers

Shea ME, Eberman LE, Games KE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN

Context: Good health behaviors act as disease prevention measures to decrease prevalence of pathologies. Hours of sleep, substance use, nutritional intake, and physical activity are behaviors that may impact the health of athletic trainers (AT). Objective: To describe health behaviors of ATs in comparison to national norms. Design: Cross-sectional design. Setting: Web-based survey. Patients or **Other Participants:** Participants (n = 1306, access rate = 12.9%) were clinically practicing ATs recruited from the National Athletic Trainers' Association member database and representative of the membership (age = 34 ± 10 y; male = 505, 38.7%, female = 740, 56.7%; experience = 11 ± 9 y). **Interventions:** We used the Healthy Eating Vital Sign (HEVS) Questionnaire with physical activity items (13 items) and Center for Disease Control Annual Consensus Survey (5 items). The HEVS has been found to have moderate to high criterion validity and internal reliability through each individual item. We calculated statistics of central tendency (means, frequency, and mode) to describe the characteristics of the athletic training population represented by our sample. Main Outcome Measures: The main outcome measures were hours of sleep, frequency of alcohol consumption and number of drinks consumed while drinking, weekly consumption of fast food, daily consumption of vegetables, daily servings of caffeine, smoking behavior in the last month, and exercise in the last day and week. Results: We found that the majority of ATs sleep 5-8 hours per night, and 48.7% of participants consumed alcohol on a weekly

basis at a rate of three drinks per sitting. In addition, 66.3% eat fast food at least one time per week, 85.6% eat vegetables at least one time per day. Further, 62.7% consumed 1-3 portions of caffeine in a typical 24-hour period, and 98.2% have not smoked a cigarette in the last 30 days. Finally, 49.2% perform physical activity greater than or equal to 3 times per week where the heartbeat and breathing are elevated. Conclusions: Compared to national averages, ATs are sleeping the same amount as the general population. Alcohol consumption is at a level of low-risk behavior. Approximately 28% of Americans eat fast food about once per week, whereas 66.3% of ATs consume fast food weekly. In addition to consuming fast food. ATs and the general population alike are not consuming enough servings of vegetables per day. Both the athletic training and the general population drink a moderate amount of caffeine. Only 1.8% of athletic trainers report smoking. The number of ATs who smoke cigarettes is 13.3% less than the general population. Finally, the activity average falls short (1.9%) of the national average for adults exercising at least three times per week. Overall the health of ATs is similar to the general population except ATs consume fast food more frequently and fewer athletic trainers smoke compared to the general population.

Health Related Quality of Life and Workplace Behaviors of Athletic Trainers

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Context: Athletic Trainers (AT) report work-life imbalance related to job demands and staffing issues that create a 24/7 face-time expectation in the workplace. It is unknown how this sociocultural expectation impacts health related quality of life (HRQOL) in ATs. Objective: Explore ATs' patient scheduling practices and HRQOL in the college setting. Design: Cross-sectional. Setting: Online survey (Qualtrics®, Provo, UT). Patients or Other Participants: 7094 emails sent to NATA members in the college/university setting. 95 participants excluded (academic appointment, were not currently practicing). 707 participants started survey (access rate = 9.97%); 529 completed survey (74.82% completion rate); age $= 34 \pm y$; male = 220, 41.6%, female = 308, 58.2%; experience = 11 ± 15 y; Div 1 = 204, 28.6%, Div 2 = 96, 18.1%, Div 3 = 130, 24.6%, NAIA/Independent = 99,18.7%. Interventions: We developed a web-based questionnaire evaluated for content and face validity by three experts in the field. The survey was 51 items: demographics, scheduling practices, and HRQOL using the RAND-36 questionnaire. Main Outcome Measures: Variables of interest included patient scheduling practices (patient-centered, team-based, and "other") and AT HRQOL (RAND-36 normalized sub-scores related to emotional health: general health [GH], vitality [V]), social functioning [SF], role emotional [RE], and mental health [MH]). Individualized scheduling practices was individualized appointments. Teambased scheduling practices was treatment scheduling on a "walk-in" basis for specific patient populations (teams). We

calculated descriptive statistics and compared groups using a one-way ANOVA. **Results:** Participants predominantly indicated they use a team-based scheduling approach (282, 53.3%; individualized = 156, 29.5%; other = 90, 17.0%); However, they prefer the individualized approach (n = 336, 63.8%) over the team-based approach (n = 191, 36.1%). Participants demonstrated lower than population norm sub-scales for HRQOL: $GH = 43.8 \pm 9.8$, $V = 43.2 \pm 12.6$, $SF = 46.2 \pm 10.1$, RE = 18.0 ± 4.4 , MH = 50.3 ± 12.1). We identified a significant difference between scheduling practices on the GH subscore (F2, 527 = 4.393, p = 0.013), whereby those with individualized scheduling practices (mean = 44.4 ± 0.8) and teambased scheduling practices (44.3 \pm 0.7, p = 0.025) reported higher general HRQOL than those using other practices (41.0 \pm 1.1, p = 0.014). Upon review of the "other" approaches, the participants indicated they use a combination of scheduling including open scheduling practices (e.g. walk in clinic blocks [not specific to teams], open times spanning 4-15 hours per day). No other significant differences were identified for the HROOL subscales (p > 0.05). Participants also indicated they were largely satisfied with their current approach (mode = 4/5, n = 292, 55.2%) and the flexibility they have to decide (mode = 4/5, n = 213, 40.3%) their current approach to patient scheduling. Conclusions: ATs who are engaged in "other" scheduling practices such as combined scheduling practices or open clinic scheduling report lower general HRQOL. All HROOL sub-scales are below population norms. However, ATs indicate they are satisfied with their current scheduling practices and the flexibility they have. The perceived satisfaction and HRQOL measures appear to contradict one another, suggesting it is possible that ATs are unaware what informal workplace policies (including scheduling) are available to improve their HRQOL.

The Relationship Between Health-Related Quality of Life and Burnout in Athletic Trainers Allen DC, Winkelmann ZK, Shea ME, Eberman LE, Games KE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN

Context: Burnout is the negative response to chronic stress resulting in emotional and physical exhaustion. In athletic training, higher perceived levels of stress, specifically on the emotional exhaustion and depersonalization (EEDP) construct, affects burnout. Previous qualitative research has identified that athletic trainers (AT) were extremely concerned about the negative effects burnout may have on their health-related quality of life (HRQoL). However, there is a gap in the literature to support the relationship between the constructs of burnout and HRQoL in ATs. Objective: To investigate the relationship among the constructs of burnout and self-reported HRQoL in ATs. Design: Cross-sectional design. Design: Cross-sectional design. Setting: Web-based survey. Patients or **Other Participants:** Certified ATs from all job settings were recruited from the National Athletic Trainers' Association (n = 10911). Completed responses from 1,157 participants were used for the analysis (10.6% response rate, age = 34 ± 13 y, male = 458, 39.6%, female = 689, 59.6%; experience = 10 ± 12 y). Interventions: The survey contained 10 demographic items, and self-reported outcome tools for HROoL using the RAND-36 and indicators of burnout using the Athletic Training Burnout Inventory (ATBI). Main Outcome Measures: The means of the four constructs within the ATBI (EEDP, administrative responsibility [AR], time commitment [TC], and organizational support [OS]), as well as the means of each normalized subscales of the RAND-36 (physical functioning [PF], role-physical [RP], bodily pain [BP], general health [GH], vitality/

energy [VE], social functioning [SF], role-emotional [RE], mental health/ emotional wellbeing[MH]) were calculated. A follow-up correlation analysis (Pearson r) was completed on the mean emotional exhaustion and de*polarization* construct from the ATBI to the means of each subscale of the RAND-36. Results: HRQoL means were near the general population normative values (50 \pm 10) for PF (55.1 \pm 3.9), BP (51.2 \pm 7.3), GH (47.6 \pm 5.8), VT (45.6 ± 12.2), SF (47.0 ± 9.4), MH (52.2 ± 11.9) . RE (18.1 ± 4.3) and RP (26.7 ± 2.5) fell below the population normative values. On the ATBI, mean values were 3.0 ± 0.6 for EEDP, $3.6 \pm$ 1.1 for AR, 4.2 ± 1.1 for TC, and 3.5 \pm 0.4 for OS. There was a significant negative correlation between EEDP and the subscales of the RAND-36: PF r =-0.169; RP r = -0.282; BP r = -0.250; GH r = -0.331; VE r = -0.574; SF r =-0.480; RE r = -0.451; MH r = -0.564 with significance levels of P < 0.001. Conclusions: Our findings suggest that the role and job responsibilities of an AT leads to poor HRQoL outcomes. Additionally, EEDP is the construct of most concern within our sample of ATs. These results identify that physical and emotional aspects of ATs HRQoL play a substantial part in their EEDP. The significant negative correlations between each construct indicate the quantity and quality of interactions with others play an influential role in emotional hardening. The profession of athletic training should explore interventions focused on improving job and life satisfaction of ATs as a potential means to increase retention and mitigate attrition in the profession due to burnout.

Examination of Energy Availability, Energy Balance, and Psychosocial Constructs in Athletic Trainers

Lyles T, Torres-McGehee TM, Moore EM, Wakefield G, Walker S: University of South Carolina, Columbia, SC; Ball State University, Muncie, IN

Context: Athletic Trainers (ATs) experience occupational stressors that may lead to mental health challenges, poor dietary habits, and decreased physical activity levels; which may result in mental health disorders, and energy imbalance. **Objective:** Examine energy balance (EB) in ATs and estimate the prevalence of mental health risks (e.g., depression, anxiety, and risk for eating disorders [ED]) associated with energy imbalance. A secondary aim will examine differences of EB and mental health risks between gender and employment. Design: Cross-Sectional Study. Setting: Local traditional and non-traditional athletic training sites in the Southeast United States. Patients or Other Participants: Participants (n = 46) consisted of females (n = 23; age: 28.9 ± 7.9 yrs; height: 164.1 ± 6.3 cm; weight: 66.6 ± 10.7 kg) and males (n = 23; 29.1 \pm 7.9 yrs; height: 179.6 \pm 7.1 cm, weight: 88.3 ± 15.5 kg) employed through different occupational settings (e.g., secondary, collegiate/university, hospital/clinic, etc.); and represented both part-time (n = 23) and full-time (n = 23)= 23) employment status. Interventions: Independent variables are gender (female vs. male) and employment status (parttime vs. full-time). Participants completed a series of surveys related to mental health (depression, anxiety, and ED risk); anthropometric measures, dietary energy intake (DEI) via food-logs and total energy expenditure (TEE) via SenseWear Armbands were collected across 7-days. Main Outcome Measures: The Eating Disorder Inventory-3 and Symptoms Checklist measured ED risk. Depression was evaluated by the Center for Epidemiological Studies Depression Scale-Revised and anxiety was examined by State/Trait Anxiety Scale. A 7-day dietary log measured DEI. Energy balance, determined by DEI and TEE, was calculated using (DEI=TEE) and categorized as negative or positive balance. Crosstabulations and chi-square analyses examined the relationship and distribution of categorical variables (e.g., gender, employment status, ED, depression, and anxiety risks. Results: Negative (82.6%) and positive (17.4%) EB were found in ATs. Overall ED risk demonstrated 84.8% (n = 39) of ATs reported engaging in some form of pathogenic behavior (e.g., dieting, excessive exercise, etc.). No differences between gender and employment status to EB and ED overall risk were elicited, however there were significant differences between dieting among full-time and part-time ATs (45.7% vs. 32.6%). Depression Risk was found in 15.2% (n = 7) of ATs (males = 10.9%, females = 4.3%; Part-Time = 10.9%, Full-Time = 4.3%). All participants at risk for depression were also at risk for ED behaviors. Additional, 19.6% (n = 3) were above average and 78.3% (n = 36) were within normal ranges for gender and occupational status for State Anxiety. Trait Anxiety was 17.4% (n = 8) above the average and 71.7% (n = 33) within normal ranges for gender and occupational status for Trait Anxiety. Conclusions: Overall, high prevalence of energy imbalance were present for ATs, particularly negative EB. We also observed a high prevalence of ED risk. With these factors and awareness of previous literature, the risk for poor overall health observed in ATs may diminish their ability to provide peak professional performance and demonstrates potential increased risk of burnout.

Free Communications, Oral Presentations: Central Nervous System in Lower Extremity Function

Friday, June 29, 2018, 12:00PM-1:15PM, Room 208-210; Moderator: Alan Needle, PhD, ATC, CSCS

Negative Emotional Stimuli Increase Neurocognitive Processing In The Brain

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Context: Recent studies have suggested that anterior cruciate ligament injury and reconstruction (ACLR) may cause permanent neural adaptations in the brain. This neuroplasticity may play an important role in restoring patient function. However, growing evidence suggests that fear of re-injury/movement following an ACLR may be linked to functional joint instability because neural processing in the patient's prefrontal cortex is critical for both emotional regulation and the preparation of complex motor control strategies. It remains unclear if seeing negative emotional stimuli causes different brain activation patterns in ACLR patients compared to healthy controls. **Objective:** To examine cortical activity differences between ACLR patients and healthy controls in response to emotional evocative pictures. Design: Case-control study. Setting: Neuromechanics laboratory. Patients or Other Participants: Twenty ACLR patients $(21.9 \pm 3.5 \text{ yrs}, 71.8 \pm 25.2 \text{ kg},$ 165.9 ± 10.4 cm) with a unilateral ACLR and 20 healthy Controls $(23.9 \pm 4.8 \text{ yrs})$, 62.5 ± 12.5 kg, 166.6 ± 9.2 cm) with no history of knee injury volunteered. Interventions: Fronto-parietal electrocortical activations (Fz, Pz) in theta frequency band (4-8Hz) were quantified using EEG while viewing randomly selected three types of emotional evocative pictures (30 each of neutral, fearful, and knee injury-related pictures). The International Affective Picture System (IAPS) was used to induce targeted neutral and fearful emotions in addition

to preselected knee injury-related pictures. Main Outcome Measures: Event-related synchronization (ERS: % increased power relative to a non-active baseline) during the first second of picture presentations were compared across picture types (3-levels) and group (2-levels). Results: Significant type main effects (Fz; $F_{2.64} = 7.181$, p =0.002, Pz; $F_{1.819,65.499} = 20.654$, p < 0.001) revealed that fearful pictures produced greater theta powers in the fronto-parietal regions (Fz; $36.81 \pm 30.3\%$, Pz; $81.11 \pm 66.71\%$), when compared to neutral pictures (Fz; $26.60 \pm 29.27\%$, Pz; $68.06 \pm 57.16\%$). Further, knee injury-related pictures also showed greater theta power in the parietal region (Pz; $118.83 \pm 84.56\%$), when compared to the fearful (Pz; $81.11 \pm 66.71\%$) and neutral pictures (Pz; $68.06 \pm 57.16\%$). No significant type by group interaction effects were observed for the fronto-parietal cortex regions (Fz;_{2.64} = 2.041, p = 0.138, Pz; $F_{1.819.65.499} = 0.738, p = 0.470$). Conclusions: Fearful pictures from the IAPS provoked greater theta power in the fronto-parietal regions compared to neutral pictures. The heightened frontal theta power implies increased cognitive processing required to sufficiently regulate fearful stimuli. Knee injury-related pictures also increased theta power in the parietal cortex compared to both neutral and fearful pictures, which indicates increased cognitive processing associated with situational awareness of visual cues. Because the fronto-parietal cortex areas are crucial for muscle coordination, this increased neural demand may disrupt normal cognitive motor processing needed for neuromuscular control and joint stiffness regulation. While this heightened brain activity was observed in all subjects, ACLR patients may be more vulnerable to episodes of functional joint instability, due in part to the higher fear of re-injury/movement.

Disrupted White Matter Connectivity in the Motor Cortex and Corticospinal Tract After Anterior Cruciate Ligament Reconstruction Grooms DR, Onate JA: Ohio University, Athens, OH; Ohio State University, Columbus, OH

Context: Anterior cruciate ligament (ACL) injury and reconstruction leads to deficits in motor coordination and changes in brain region activity and excitability for motor control. This injury related neuroplasticity may cause changes in the structural connectivity between brain regions and neural projections to the associated lower extremity musculature. Objective: To determine if those with ACL reconstruction (ACLR) have altered brain white matter connectivity within the motor cortex and corticospinal tract compared to healthy matched controls. Design: Cohort. Setting: Neuroimaging center. Patients or Other Participants: Fifteen left ACLR (25.5 \pm 1.37 years, 1.70 ± 0.13 m, 75.6 ± 19.2 kg, Tegner activity level 6.0 ± 1.5 , 23 ± 18 months post-surgery) and fifteen healthy controls matched on height, mass, extremity dominance and physical activity level participated $(23.6 \pm 3.14 \text{ years})$ 1.75 ± 0.05 m, 73.5 ± 12.24 kg, Tegner activity level 6.0 ± 1.5). Interventions: Diffusion tensor imaging data were collected while the participants laid supine in a Siemens 3T MRI scanner. Image acquisition consisted of 64 gradient directions, 2.03 voxel size, 65 axial slices with a 8.6 TR. Data processing and analyses were completed with the FMRIB Software Library (FSL) with standard parameters, including eddy current distortion and movement correction, followed by estimation of diffusion parameters for each participant and tractography within the right motor cortex and corticospinal tract as regions of interest. Main Outcome Measures: Independent variable was group (ACLR vs. control) and the dependent variables were fractional anisotropy (directional diffusion measure: 0 - no anisotropy, 1 - maximum anisotropy) and mean diffusivity (general diffusion measure) of the motor cortex and corticospinal tract. An independent samples t-test was completed between groups with threshold-free cluster enhancement for multiple-comparison correction. **Results:** Those with ACLR history had relative increased fractional anisotropy $(0.12 \pm 0.14; \text{ maximum: } 0.48, \text{ mini-}$ mum: 0.002; p < .01; 437 voxel cluster) indicating potentially greater white matter connectivity in the superior longitudinal fasciculus tract whereas those without ACLR history had relative increased fractional anisotropy (0.11 \pm 0.16; maximum: 0.54, minimum: 0.004; p < .01, 1175 voxel cluster) in the corticospinal tract. No significant differences were noted in mean diffusivity (p >0.05). Conclusions: The longitudinal fasciculus tract connects the motor cortex with frontal (cognitive) and parietal (sensory) regions, while the corticospinal tract connects the motor cortex to the muscles via the spinal cord. The increased structural connectivity within the superior longitudinal fasciculus and decrease in the corticospinal tract after ACLR may indicate increased co-activation and utilization of cortical processes to engage in motor coordination relative to direct connectivity from the motor cortex to the muscles. Clinicians can impact this neuroplasticity by incorporating dual-tasking, unanticipated reactions and perturbation or proprioceptive facilitation during neuromuscular training.

Changes in Brain Function During Knee Extension Exercise Following 8 Weeks of Attentionally Focused Neuromuscular Training Schmitz RJ, Park K, Raisbeck LD, Wilkins RW, Grooms DR, Rhea CK, Shultz SJ: The University of North Carolina at Greensboro, Greensboro, NC; Ohio University, Athens, OH

Context: Motor training with an external relative to an internal focus of attention is documented to enhance the acquisition and retention of the newly acquired behavior. However, the neurologic adaptations allowing for this skill development accompanying orthopedic preventative exercise delivered with external and internal foci are unknown. **Objective:** To determine changes in brain function during knee extension exercise after 8 weeks of attentionally focused neuromuscular training. Design: Prospective controlled trial. Setting: Neuroimaging center and biomechanics laboratory. Patients or Other Participants: 10 Healthy, recreationally active participants (4 males, 6 females; age = 21.0 ± 1.5 yrs, height $= 1.63 \pm .05$ m, mass $= 67.4 \pm 15.9$ kg). Interventions: Participants were randomly assigned to a no training control group (n = 4) or externally-focused (n = 3) or internally-focused (n = 3) neuromuscular training groups. The neuromuscular training groups performed lower extremity body-weight strength and stabilization exercises 3x/ week for 8 weeks; approximately 20 minutes per session. For the training groups, attentional focus was directed either externally or internally each session by a research team member. Sets/ repetitions were equal across groups. Brain functional magnetic resonance imaging (fMRI) was performed at baseline and following 8 weeks of training. With no attentional focus directions, participants completed unilateral left 45° knee extension/flexion movements at a rate of 1.2 Hz laying supine in a MRI scanner for 4 blocks of 30 seconds

interspersed with 30 second rest blocks. Main Outcome Measures: First level analyses of fMRI data contrasted brain activity between contraction and rest blocks. Baseline to post-training changes within each group were then contrasted using a mixed-effects general linear model with an a priori cluster threshold of Z > 2.3 and p < .05. Results: In the external group lobule VIIII of the left cerebellum decreased activation from baseline to post-training (cluster size = 460 voxels, $Z_{min-max}$ = 2.3-2.8, Z_{mean} = 2.7, P \leq .001). In the internal group, the left somatosensory cortex (BA3a/b) decreased activation from baseline to post-training (cluster size = 258 voxels, $Z_{min-max}$ = 2.3-2.6, Z_{mean} = 2.5, P \leq .001). There was no baseline to post-training change in the control group. Conclusions: Preliminary results indicate that manipulating the attentional focus in healthy participants during training has differential effects on changes in brain function during lower extremity exercise. Specifically, training with an external focus of attention for 8 weeks resulted in decreases in activation in areas of the brain associated with motor error correction which we suspect align with theories of external focus being associated with more automatic error correction. Training with an internal attentional focus resulted in decreases in activation in areas of the brain associated with somatosensation. Future work should continue to investigate prevention program instructional strategies with the goals of increasing learning, retention, and transference of skills.

Patients With Chronic Ankle Instability Demonstrate Deficits in Neurocognitive Function Compared to Control and Copers Rosen AB, McGrath ML: University of Nebraska at Omaha, Omaha, NE; University of Montana, Missoula, MT

Context: Ankle sprains often lead to chronic ankle instability (CAI), which has a significant impact on patient function and quality of life. CAI likely has mechanical and neuromuscular causes, and recent literature has found central nervous system adaptions in those with CAI. However, while poor neurocognitive function has been identified as a potential factor in other ligamentous injuries such as non-contact anterior cruciate ligament tears, little is known regarding its influence on individuals with CAI. Objective: To assess neurocognitive function in males with CAI compared to controls and ankle sprain copers. Design: Cross-sectional. Setting: Biomechanics Laboratory Patients or Other Participants: Forty-one males divided into healthy controls without history of ankle injury and Cumberland Ankle Instability Tool (CAIT) ≥ 28 (n = 14, age $= 22.6 \pm 2.4$ years, height $= 179.1 \pm 7.6$ cm, mass = 85.1 ± 12.3 kg, CAIT = 30.0 \pm 0.0), copers with history of ankle injury but no self-reported instability and CAIT ≥ 28 (n = 13, age = 22.2 ± 2.4 years, height = 179.5 ± 8.5 cm, mass = $81.1 \pm$ 9.8 kg, CAIT = 29.3 ± 0.8) and participants with self-reported CAI and CAIT ≤ 24 (n = 13, (age = 22.1 ± 2.7 years, height = 178.1 ± 6.4 cm, mass = $84.0 \pm$ $12.5 \text{ kg}, \text{CAIT} = 16.3 \pm 5.8)$ participated. Interventions: Participants completed the CNS Vital Signs (CNSVS) on a laptop computer. The CNSVS is a battery of valid and reliable computer-based neurocognitive tests consisting of multiple individual components to assess neurocognitive ability. These tests include the Verbal Memory, Visual Memory, Finger Tapping, Symbol Digit Coding, Stroop, Shifting Attention, and Continuous Performance Tests. Main Outcome Measures: Variables

assessed from the CNS vital signs included an overall neurocognitive index (NCI) as well as standardized individual domains of composite memory, verbal memory, visual memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, executive function, simple attention, and motor speed. The differences between the CNSVS domain scores across the Control, Coper and CAI groups were assessed via Analysis of Variance ($p \le 0.05$), follow-up Tukey's post-hoc testing and Cohen's d effect sizes. Results: Significant differences across groups were present for composite memory (p = 0.030), visual memory (p = 0.016) and simple attention (p =0.013). Follow-up tests revealed that those with CAI had worse composite memory (Control: 112.5 ± 14.5 ; CAI: 96.7 ± 15.2 ; p = 0.027, d = 1.06), visual memory (Control: 115.0 ± 11.8 ; CAI: 101.4 ± 12.2 ; p = 0.036, d = 1.13), and simple attention (Control: 104.1 \pm 7.6; CAI: 90.1 \pm 12.5; p = 0.010, d = 1.35) compared to controls. Copers also demonstrated worse visual memory $(100.1 \pm 16.1, p = 0.026, d = 1.06)$ compared to controls. Conclusions: In males with CAI large deficits in neurocognitive function, particularly related to memory and attention, were found relative to healthy control participants. Poor neurocognition may contribute to uncontrolled episodes of giving way through deficits in spatial awareness and/or an inability to identify environmental obstacles. Additionally, the ability to integrate sensory information properly may be inhibited by lower attentional capacities and potentially expose those with CAI to further injury. Clinicians may want to explore ways to provide additional stimuli through innovative rehabilitation protocols aimed at improving neurocognitive function in patients with CAI.

Free Communications, Oral Presentations: Changing Rules and Injury Risk

Friday, June 29, 2018, 1:30PM-2:45PM, Room 208-210; Moderator: Erik Swartz, PhD, ATC, FNATA

Pre-Season Injury Rates in a Division-II Football Team Before and After NCAA Pre-Season Practice Rule Changes

Smith JJ, Baer DJ: West Chester University of Pennsylvania, West Chester, PA

Context: In 2017, the National Collegiate Athletic Association (NCAA) implemented rule changes to reduce risk and enhance safety for college football athletes during preseason, in-season, and post-season participation. However, it remains unclear what effect these rule changes had on injury rates and time loss. Objective: The purpose of this study was to compare the number of injuries reported and time lost during two consecutive football pre-seasons before and after the rule changes impacting pre-season. We hypothesized that, following implementation of the NCAA rule changes, there would be a reduction in overall injury rate per practice session, time-loss injuries (missed ≥ 1 practice session) per practice session, lower extremity muscle strains per practice session, and time-loss lower extremity muscle strains (missed ≥ 1 practice session) per practice session. **Design:** Descriptive epidemiology study. Setting: Field study. Patients or Other Participants: NCAA Division-II football players at the same Pennsylvania State Athletic Conference university during the 2016 and 2017 pre-seasons. Interventions: Athletic trainers maintained daily injury reports and medical documentation throughout each pre-season. We calculated the rate of each hypothesized injury category per pre-season practice session. Main Outcome Measures: We compared the number of injuries reported during the 2016 football pre-season to injuries reported during the 2017 football pre-season at an NCAA Division-II institution. Variables of interest included: total number of injuries, number of time-loss injuries, number of lower extremity muscle strains, and number of time-loss lower extremity muscle strains. Results: Prior to the first game of the season, 25 practice sessions occurred in 2016 (4 two-adays) and 20 practice sessions occurred in 2017 (no two-a-days). In 2016, we recorded 79 total pre-season injuries (3.16/session), with 32 of those injuries resulting in at least one day missed from practice (1.28/session). In 2017, we recorded 63 total pre-season injuries (3.15/session), with 22 resulting in at least one day missed (1.10/session). For lower extremity muscle strains, we recorded 25 injuries in 2016 (1.00/ session) with 13 resulting in time lost (0.52/session). In 2017, we recorded 11 lower extremity muscle strains (0.55/ session) with 4 resulting in time lost (0.20/session). Conclusions: To our knowledge, this is the first report on NCAA Division-II football pre-season injury rates after the NCAA rule changes. As hypothesized, we observed fewer time-loss injuries per session (14.06% decrease), and a decrease in the number of acute lower extremity strains (45.00% decrease) and time-loss strains (61.54% decrease) per practice session following implementation of the NCAA rule changes. However, we did not observe a meaningful difference in total number of injuries per session (0.32% decrease) following the rule changes. These preliminary findings suggest that the rule changes may be effective in reducing both the number and severity of lower extremity muscle strains during pre-season football.

Evaluating the Effectiveness of a Safe Playing Techniques Program on Head Impact Biomechanics in High School Football Players

Campbell KR, Ranapurwala SI, Ford CB, Combs PR, Cabell GH, Nocera MA, Guskiewicz KM, Marshall SW, Register-Mihalik JK, Mihalik JP: The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Teaching players safe tackling and blocking techniques at an early age could limit unnecessary helmet-to-helmet contact to reduce severe head impacts and concussion risk. We deployed the Behavior Modification (BeMod) Program designed to reduce concussion risk using safe tackling and blocking videos with selected players also completing personalized mentoring sessions to promote safe playing techniques in high school football players and reduce head impact magnitudes. **Objective:** To determine the BeMod program's influence on head impact frequency and severity in a US high school football team. Design: Secondary data analysis. Setting: Field study. Patients or Other Participants: A convenience sample (n = 101) of players participated over six seasons. Interventions: All players wore an in-helmet accelerometer that measured head impact peak linear and rotational acceleration during all games and practices. Players (n =50) in seasons 1 through 3 did not view any instructional videos prior to starting their season and did not participate in any personalized mentoring sessions (pre-BeMod). During seasons 4 through 6, all players (n = 51) participated in the BeMod program and viewed safe tackling and blocking instructional videos once prior to participating in any games or practices. Eleven players, identified through video and head impact biomechanical measures, participated in personalized mentoring sessions. Main **Outcome Measures:** We computed the team's weekly average peak linear head acceleration (PLHA), peak rotational head acceleration (PRHA), and impact rate per 100 athletic-exposures throughout the six seasons. We used an interrupted time series analysis to calculate the pre-BeMod weekly trend, the absolute change in the week after BeMod implementation, and the change in weekly trend after BeMod implementation for all three outcome measures. **Results:** There were 79,126 impacts (31,234 during BeMod program) collected in six years from 82 games (31 BeMod games), and 330 practices (168 BeMod practices). The team's weekly average PLHA increased significantly during pre-BeMod seasons (trend = 0.09; 95% CI: 0.05, 0.13). After starting BeMod in the fourth season, the team's weekly average PLHA declined by 4.42 g of PLHA (95% CI: -5.99, -2.86). The team's post-BeMod weekly average PLHA continued to decline thereafter (trend = -0.08; 95% CI: -0.143, -0.02).This corresponds to a 22% reduction in the post-BeMod PLHA. Similarly, we observed a 24% reduction in post-Be-Mod PRHA and 25% reduction in the post-BeMod weekly impact rate per 100 athletic-exposures. Conclusions: Players viewing safe tackling and blocking instructional videos prior to participating in high school football seasons at a school involved in a personalized playing behavior mentorship program lead to overall team decreases in the weekly average PLHA, PRHA, and head impact frequency. This preliminary evidence suggests that using video-based instructional material in the context of a larger behavior modification intervention could reduce head impact magnitudes and potentially mitigate concussion risk among high school football athletes.

The Association Between Playing Surface and Lower Extremity Injuries in National Collegiate Athletic Association Football

Wasserman EB, Morris SN, Collins CL: Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Artificial playing surfaces are often used in collegiate American football. These surfaces have different properties compared to natural grass and may lead to increased risk of lower extremity injury. **Objective:** Compare the rate of lower extremity injury in National Collegiate Athletic Association (NCAA) football between natural grass and artificial playing surfaces. Design: Retrospective cohort study. Setting: NCAA Injury Surveillance Program (2009/10-2016/17). Patients or Other Participants: Collegiate football student-athletes from 68 football programs providing 204 team-seasons of data. Interventions: Athletic trainers (ATs) reported deidentified data on injuries and athlete-exposures (AEs) through electronic medical records with a common data element standard. Main Outcome Measures: Unweighted AEs and injury counts were reported using frequencies and percentages. National estimates of lower extremity (at and distal to the hip joint) injury rates per 1,000 AEs by playing surface were calculated. Rate ratios (RR) were reported with 95% confidence intervals (CI) to compare rates on artificial playing surfaces (artificial turf, other turf, and synthetic) to natural grass. This was done overall and by mechanism of injury (surface contact and noncontact). Results: Of 17,020 reported AEs, 9,181 (53.9%) were on artificial surface and 7,155 (42.0%) were on natural grass. Of 7,507 lower extremity injuries, 4081 (54.4%) were on artificial surface and 3,354 (44.7%) were on natural grass. Overall, there was no difference in injury rates by surface type (artificial surface:4.83/1,000 AEs, 95% CI: 4.68-4.98; natural grass:4.69, 95% CI:

4.52-4.86; RR = 1.03, 95%CI: 1.00-1.06). However, when restricting to surface contact injuries, the lower extremity injury rate was higher on artificial surface (1.04, 95% CI: 0.97-1.11) compared to natural grass (0.92, 95% CI: 0.85-1.00; RR = 1.13, 95% CI: 1.06-1.21). When restricting to noncontact injuries, the rate was lower on artificial surface (1.71, 95% CI: 1.61-1.80) than natural grass (2.04, 95% CI: 1.93-2.15; RR = 0.84, 95% CI: 0.79-0.88). Conclusions: While there was no difference overall in lower extremity injury rates between artificial surface and natural grass, the risk of surface contact lower extremity injury was higher on artificial surface than natural grass. However, the risk of noncontact lower extremity injury was lower on artificial surface than natural grass. Clinicians and athletics decision makers must weigh the risks of injury when choosing surfaces for practices and competitions. Further research is needed to explore the risk of specific injuries by playing surface, as well as possible reasons for differences in the association with playing surface based on mechanism of injury.

Lumbar Multifidus Cross Sectional Area as a Possible Predictor of Injury Among College Football Players Colston MA, Wilkerson GB, Mize K, Winkle C, Farris J: University of Tennessee, Chattanooga, TN

Context: Lumbar multifidus cross-sectional area (LM-CSA), Body Mass Index (BMI), and exposure to games (Starter status) may partially explain the substantial number of core and lower extremity (CLE) sprains and strains in college football players. Refinement of pre-participation screening methods are needed to identify players who possess an elevated injury risk **Objective:** To assess a possible association between LM-CSA derived from diagnostic ultrasound images (DxUS) with subsequent occurrence of CLE sprain or strain among college football players. Design: Descriptive prospective cohort study design. Setting: Athletic facilities. Patients or Other Participants: 67 college football players (20.1 \pm 1.3 years, 187.48 ± 5.74 cm, 105.12 ± 20.90 kg,). Interventions: Pre-participation injury risk screening. Main Outcome Measures: Injury was defined as any CLE sprain or strain that interrupted participation and required evaluation and treatment. Measures of LM-CSA were derived from right and left DxUS scans. Two-trial averages of right and left sides failed to demonstrate a significant difference. Therefore, 4-trial averages of the measures were used for analysis. Measures of height and weight acquired during the pre-participation examination were used to calculate BMI. Starter status was defined as \geq 1 game during the 13-game season. Receiver operating characteristic analyses identified cut-points for binary risk classifications. Univariable associations with CLE injury were derived from cross-tabulation analyses and multivariable injury risk models were derived from logistic regression analyses. Results: Good-quality DxUS scans were acquired for 47 cases (BMI: 27.54

 ± 3.24). A 3-factor prediction model for CLE injury for these 47 cases included Starter status (Adj OR = 4.17), BMI \geq 29 (Adj OR = 3.59), and CSA \leq 11.33 (Adj OR = 3.42). The odds for previous CLE injury were 8.6 times greater among players who exhibited any 2 or 3 risk factors (90% CI: 2.03, 36.41). Subcutaneous adiposity interfered with image clarity for 20 cases (BMI: 34.98 ± 4.35). A 2-factor model for CLE injurv for all 67 cases included Starter status (Adj OR = 4.23) and BMI \geq 29 (Adj OR = 1.88). The odds for a CLE sprain or strain was 8 times greater among players who exhibited any 1 or 2 risk factors (90% CI: 1.29, 49.59). An alternative 2-factor model for CLE injury included Starter status (Adj OR = 3.54) and High Torso Mass Effect, which was defined as BMI \ge 29 or CSA \le 11.33 (Adj OR = 4.40). The odds for a CLE sprain or strain was 9.8 times greater among players who exhibited both risk factors (90% CI: 2.30, 41.84). Conclusions: Risk for CLE sprain or strain is clearly elevated by suboptimal LM-CSA and high BMI. Targeted LM strengthening should be implemented for athletes which exhibit a high-risk profile.

Relative Value of Dual-Task Screening Tests for College Football Injury Risk Assessment Acocello S, Greene MA, Ormond KE, Wilkerson GB: The University of Tennessee at Chattanooga, Chattanooga, TN

Context: Emerging evidence suggests neurocognitive factors play a key role in maintenance of dynamic segmental stability. Dual-task screening tests that impose simultaneous cognitive and motor challenges may be useful for identification of subtle deficiencies that elevate injury risk. Objective: To assess the potential value of dual-task screening for estimation of core and lower extremity injury risk among college football players. Design: Prospective cohort study. Setting: Athletic Facility. Patients or Other Participants: 66 Division I-FCS football players (20.1 \pm 1.3 yrs; 105.54 \pm 20.77 kg; 187.65 \pm 5.59 cm) were assessed. Interventions: Prior to preseason training, visuomotor reaction time (VMRT) was measured using the Dynavision® D2 system, with 3 test modes: Proactive (buttons illuminated until pressed), remain Reactive (buttons illuminated for 750ms, simultaneous oral recitation of scrolling text), and Proactive+Flanker ('Proactive' mode with concurrent verbal response to 20 750ms Erikson flanker trials). Unilateral postural sway was assessed using 30-s single-leg balance tests performed with and without a concurrent flanker test. Core and lower extremity (Core/LE) injury data was collected prospectively throughout the following preseason and 12-game season. Main **Outcome Measures: VMRT measures** included average reaction time (RT), number of hits, and a peripheral-to-central performance ratio (O/I Ratio). For the Proactive+Flanker, peripheral RT was also assessed by adjusting for flanker performance (termed outer efficiency index, or OEI). Postural sway measures included center-of-pressure (COP) average velocity, medial-to-lateral movement standard deviation (COP M-L Std Dev), max deviation, and path length. Receiver operating characteristic and logistic regression analyses were used to develop models that provided maximum discrimination between those who did and did not sustain Core/LE injury. The odds ratio (OR) and its 95% credible lower limit (CLL_{95}) were calculated. Results: VMRT performance demonstrated good discriminatory power under dual- and single-task conditions (Proactive O/I RT Ratio ≥ 1.44 , OR = 4.39, $CLL_{95} = 1.59$; Proactive+Flanker $OEI \ge 1013 \text{ ms}, \text{ OR} = 2.80, \text{ CLL}_{95} =$ 0.88). Sway values were slightly improved or unchanged in dual-task condtion (With flanker: COP M-L Std Dev \geq 0.271, OR = 3.33, CLL₉₅ = 1.14; COP average velocity ≥ 1.41 m/s, OR = 2.06, $CLL_{95} = 0.75$; COP path length ≥ 39.57 m, OR = 1.98, $CLL_{95} = 0.74$; Without flanker: COP average velocity ≥ 1.48 m/s, OR = 3.18, CLL₉₅ = 1.15; COP path length \ge 40.87 m, OR = 1.77, CLL₉₅ = 0.67). The addition of starter versus non-starter status further improved predictive power. Starters with an OEI of \geq 1013 ms were 2.8 times more likely to sustain an injury than those with an OEI ≤ 1013 ms ($\chi^2(2) = 12.13$; p = .002; Hosmer & Lemeshow $\chi^2(2) =$ 0.62; p = .734; Nagelkerke $R^2 = .255$). Conclusions: High exposure to game conditions demonstrated strongest association with Core/LE injury. With an adjustment for starter status, dual-task OEI demonstrated the strongest predictive power among the measures used. Further research is needed to assess the potential benefit of dual-task training for injury risk reduction among college football players who demonstrate suboptimal postural balance, visuomotor reaction time, and/or neurocognition test results.

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Free Communications, Oral Presentations: Injury Epidemiology in High School Athletes

Friday, June 29, 2018, 3:00PM-4:00PM, Room 208-210; Moderator: Kenneth Lam, ScD, ATC

The Effect of Protective Soccer Head Gear on the Incidence and Severity of Non-Concussive Injuries in Female High School Soccer Players

Schwarz A, McDonald C, Gallenberger M, Pfaller A, McGuine TA: University of Wisconsin, Madison, WI

Context: There is an increased awareness regarding the incidence of sport related concussions sustained by female high school soccer players. As a result, there is a growing call to have females wear protective headgear (HG) to prevent these injuries. Critics of HG use have stated that players using HG may engage in more aggressive play, potentially increasing the incidence or severity of acute onset, non-concussive injuries (ANCI). To date, no prospective research has examined the link between the use of HG and incidence of ANCI in female high school soccer players. Objective: To assess associations between use of HG and ANCI in female high school soccer players. Design: Prospective cohort study. Setting: Data were collected at 52 high schools in Minnesota and Wisconsin during 2016 and 2017. Patients or Other Participants: A convenience sample of 1,312 female high school (Grades 9 -12, Age = 15.8 + 1.2 yrs.) soccer players enrolled and participated in 61,073 soccer (practice or competition) exposures. A total of n = 787 (60%) wore headgear (HG) while n = 525 (40%) did not wear (NoHG). Interventions: Athletic trainers at each school recorded the onset and days lost for each ANCI (abrasions, contusions, fractures, lacerations, ligament sprains, muscle or tendon strains) sustained during the season. Main Outcome Measures: The main outcome variable is the incidence of ANCI. Analyses included frequencies, proportions and median days lost due to injury (Median: [IQR 25th,75th]. Odds Ratios OR: [95%] were used to compare the incidence of ANCI between the HG and NoHG group. Wilcoxon Rank Sum tests were used to determine if there were differences in the severity (days lost) of ANCI [Median: 25th, 75th IQR] for the two groups. Results: A total of n = 219 (16.6%) subjects sustained a total of n = 235 ANCI causing them to miss a median of 6:[2.0,13.5] days from soccer. ANCI occurred most often to the ankle (28%), upper leg (19%), knee (16%) or Hip (9%) and included ligament sprains (41%), muscle/tendon strains (32%) and contusions (19%). Of these injuries, 73% occurred in competition. There was no difference (OR = 0.811:[0.6050 - 1.0895], p = 0.811)in the incidence of ANCI for the HG (15.3%) and the NoHG (18.2%) groups. There was no difference (p = 0.249), in the severity ANCI for subjects in the HG [5.0: 2.0,11.5] and NoHG [6.0: 2.0,14.0] groups. Conclusions: Female high school soccer players who wore HG did not sustain more ANCI than the NoHG players. There was no difference in the severity of ANCI between the HG and NoHG groups. Sports medicine providers should understand that female soccer players who wear protective HG do not sustain ANCI at a higher rate or severity than those who do not wear HG.

Epidemiology of Gymnastic Injuries Sustained by Female Secondary School Athletes: A Report From the National Athletic Treatment, Injury, and Outcomes Network Ritter KG, Richter SD, Williams RM, Thatcher A, Huxel Bliven KC, Wasserman EB, Snyder Valier AR: A.T. Still University, Mesa, AZ; AZ Sports Center Physical Therapy and Conditioning Inc, Chandler, AZ; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Gymnastics is highly competitive with intense practices and competitions that increase likelihood for injury. Few studies have reported on injuries sustained in female secondary school gymnastic athletes, and little is known about what injuries result in participation time loss (TL) or non-time loss (NTL). Knowledge of gymnastic injury patterns may help inform prevention and treatment strategies aimed at maintaining injury-free participation. Objective: To describe the epidemiology of TL and NTL practice and competition injuries sustained by secondary school girls' gymnasts. Descriptive epidemiology. Setting: Twenty-five unique schools contributed data resulting in 52 team-seasons. Patients or Other Participants: Female athletes participating in gymnastics at the secondary school level during the 2011/2012 through 2013/2014 academic years. Interventions: Gymnastics data from the National Athletic Treatment, Injury, and Outcomes Network (NATION) were analyzed. Athletic Trainers reported injuries and athlete-exposures (AEs). Main Outcome Measures: Injury counts, rates (IR) per 1,000 AEs, and rate ratios (IRR) were reported with 95% confidence intervals (CI). Results: NATION captured a total of 278 gymnastic injuries over 30,073 AEs, producing an overall IR of 9.24/1000 AE

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(95% CI: 8.16, 10.33). Of these, 84.1% (n = 233/277) were NTL injuries and 15.9% (n = 44/277) were TL injuries, and 1 was missing time-loss designation. Overall injury rates were higher in competition (IR: 14.07, 95% CI: 10.28,17.85) than practice (IR: 8.55, 95% CI: 7.44, 9.67). For competition, 44 (83.0%) injuries were NTL and 9 (17.0%) injuries were TL, resulting in a NTL injury rate of 11.68/1,000 AE (95% CI: 8.23, 15.13) and a TL injury rate of 2.39/1,000 AE (95% CI: 0.83, 3.95). For practices, 189 (84.3%) injuries were NTL and 35 (15.6%) injuries were TL, producing a NTL injury rate of 7.18/1,000 AE (95% CI: 6.16, 8.21) and TL injury rate of 1.33/1,000 AE (95% CI: 0.89, 1.77). The IRR for NTL to TL for competition was 4.89 (95% CI: 2.39, 10.01) and the IRR for NTL to TL for practice was 5.40 (95% CI: 3.76,7.75). Contusions/abrasions (36.8%, n = 102) were the most common injury sustained (competition: 17.6%, n = 18; practice: 82.4%, n = 84). All contusions/abrasions were classified as NTL. Sprains/strains accounted for 30.7% (n = 85) of injuries (competition: 17.6%, n = 15; practice: 82.4%, n = 70). Most sprains/strains were classified as NTL (80%, n = 68). Ankle injuries were most frequent in both competition (28.3%, n = 15/53) and practice (19.2%, n = 43/224), and the majority were NTL (competition NTL: 80%, n = 12/15; practice NTL: 86.0%, n =37/43). While arm/elbow injuries were uncommon (10.1%, n = 28/277), they accounted for the highest frequency of TL practice injuries (22.8%, n = 8/35). Conclusions: Rates of injury were highest during gymnastic competitions, with most injuries not removing the gymnast from participation. The high frequency of contusions/abrasions and strains/sprains along with differences in practice and competition injuries, warrants further study. Exploration into the apparatus at the time of injury may provide insight into injury prevention strategies.

Epidemiology of Secondary School Girls' Volleyball Injuries: A Report From the National Athletic Treatment, Injury, and Outcomes Network Huxel Bliven KC, Snyder Valier AR, Wasserman EB, Williams RM: A.T. Still University, Mesa, AZ; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: As a highly popular sport world-wide, volleyball athletes are prone to both upper and lower extremity injuries. The majority of volleyball-related injuries reported are classified as time loss (TL), and little is known about non-time loss (NTL) injuries, particularly in the secondary school setting. Insight into NTL injury patterns will inform prevention and management strategies for these injuries by Athletic Trainers. **Objective:** To describe the epidemiology of TL and NTL injuries sustained by girls' secondary school volleyball athletes during competitions and practices. Design: Descriptive epidemiology. Setting: Eighty-one unique schools provided data, representing 143 team-seasons. Patients or Other Participants: Female athletes participating in secondary school-sponsored volleyball during the 2011/2012 through 2013/2014 academic years. Interventions: Girls' vollevball data from the National Athletic Treatment, Injury, and Outcomes Network (NATION) injury surveillance program from the 2011/2012 through 2013/2014 years were analyzed. Athletic Trainers reported all injuries and exposures. Main Outcome Measures: Injury counts, rates (IR) per 1,000 athlete-exposures (AEs), and rate ratios (IRR), were reported with 95% confidence intervals (CI). Results: NATION captured a total of 2,161 injuries over 295,735 AEs for girls' volleyball, producing rates of 7.31/1,000 AEs (95% CI: 7.00, 7.62). The overall injury rates were similar between competition (IR: 7.32, 95% CI: 6.67, 7.88) and practice (IR: 7.32, 95% CI: 6.96, 7.68). For competition, 105 (18.9%) injuries were TL and 448 (80.9%) were

NTL, producing a TL injury rate of 1.38/1,000 AE (95% CI: 1.11, 1.64) and NTL injury rate of 5.88/1,000 AE (95% CI: 5.34, 6.42). The IRR for NTL to TL competition injuries was 4.27 (95% CI: 3.45, 5.28). For practice, 194 (12.1%) injuries were TL and 1,413 (87.9%) were NTL, producing a TL injury rate of 0.88/1,000 AE (95% CI: 0.76, 1.01) and NTL injury rate of 6.77/1,000 AE (95% CI: 6.10, 6.77). The IRR for NTL to TL practice injuries was 7.28 (95% CI: 6.27, 8.46). The most common body location for NTL injuries in competition and practice were to the hand/wrist (competition: n = 154, 34.4% NTL; practice: n = 400, 28.3% NTL), ankle (competition: n = 61, 13.6% NTL; practice: n = 185, 13.1% NTL), knee (competition: n = 52, 11.6% NTL; practice: n = 192, 13.6% NTL), and shoulder (competition: n = 46, 10.3% NTL; practice: n = 152, 10.7% NTL). The majority of all injuries in competition and practice were contusions/abrasions (competition: n=190, 34.3%; practice: n = 673, 41.9%) and sprains/strains (competition: n = 214, 37.8%; practice: n =558, 34.7%), most of which were classified as NTL (competition: contusions/ abrasions = 95.8%, sprains/strains = 86.0%; practice: contusions/abrasions = 98.8%, sprains/strains = 85.7%). Conclusions: The NTL to TL IRR is 1.7 times (7.28/4.27) as great for practice compared to competition, which highlights the large number of NTL injuries suffered by volleyball athletes in preparation for their sport. While contusions and abrasions may be unavoidable, the large number of non-time loss sprain/strain injuries warrants study to explore injury prevention strategies to keep athletes playing injury-free.

Clinical Presentation of Patients Following Sport-Related Elbow Injuries: A Report From the Athletic Training Practice-Based Research Network

Richter SD, Marshall AN, Lam KC, Huxel Bliven KC: A.T. Still University, Mesa, AZ

Context: Diagnosis of sport-related elbow pathologies can be challenging for athletic trainers (ATs) due to their infrequent occurrence. Understanding clinical presentation of elbow injuries may provide insight into the diagnosis process. **Objective:** Describe clinical presentation patterns of common sport-related elbow injuries. Design: Retrospective analysis of electronic medical records (EMRs). Setting: Seventy-two athletic training facilities (high school = 57, collegiate = 13, other = 2) across 17 states within the Athletic Training Practice-Based Research Network. Patients or Other Participants: One hundred ninety-one ATs (female = 59.2%, age = 28.7 ± 7.9 years, years certified = 4.5 ± 5.9 , years employed at site = 1.9 ± 4.2) practicing in athletic training facilities during the study period. Interventions: Patient records, created by ATs in a web-based EMR, with complete evaluation forms for an elbow injury between October 2009-October 2017 were analyzed. Elbow injuries were identified using ICD-9 diagnostic codes (eg, 841.1: ulnar collateral ligament sprain [UCL], 841.9: "other" sprain/strain). Main Outcome Measures: Summary statistics (percentages and frequencies) were calculated to describe clinical presentation at initial evaluation, including diagnosis, sex, sport, mechanism of injury (MOI), manual muscle test (MMT), orthopedic special tests (OST), and neurological tests. Results: ATs evaluated 124 elbow injuries during the study period. The most common diagnoses were UCL sprain (29.8%, n = 37/124) and "other" sprain/strain (25.8%, n = 32/124). Injuries were most frequently reported in males (63.7%, n = 79/124), in football (26.6%, n = 33/124), and

during in-season practice (47.5%, n = 59/124). The common MOIs were non-contact (33.0%, n = 41/124), contact (22.5%, n = 28/124), and falls (22.5%, n = 28/124). ATs reported using OST during 79.8% (n = 99/124) of evaluations, with an average of $2.8 \pm$ 1.2 OST performed. Valgus stress test was the most commonly used OST for UCL sprains (n = 24/73; results: positive = 16, negative = 2, inconclusive = 6), and "other" sprain/strains (n = 17/62; results: positive = 4, negative = 12, inconclusive = 1). MMTs were performed in 73.4% (n = 91/124) of the evaluations. Elbow flexion strength was assessed in 56.7% (n = 21/37) of UCL sprains and 59.3% (n = 19/32) of "other" sprains/strains, whereas elbow extension strength was assessed in 48.6% (n = 18/37) of UCL sprains and in 50.0% (n = 16/32) of "other" sprains/ strains. While the majority of MMTs were assessed to be within normal limits, "other" sprain/strain injuries most commonly displayed elbow flexion weakness (3-4/5). Neurological status was assessed in 71.8% (n = 89/124) of evaluations. Deficits (diminished light touch sensation) were reported in only one UCL sprain (5.8%, n = 1/17). Following injury diagnosis, the majority of patients were able to participate with no to minimal restrictions (95.1%, n = 118/124). Conclusions: ATs most commonly evaluate and diagnose UCL and "other" strain/sprain elbow injuries. Differences in valgus stress test results suggest this OST may be used to rule-in UCL sprains and rule-out "other" sprains/strains. MMTs may be more beneficial in ruling-in "other" sprains/strains, which may more specifically target muscle strain injuries over sprains. Further research is warranted to determine if ATs are following best evidence when evaluating and diagnosing elbow pathologies.

Free Communications, Oral Presentations: Master's Oral Awards

Wednesday, June 27, 2018, 8:00AM-9:00AM, Room 217–219; Moderator: Alison Snyder Valier, PhD, ATC, FNATA

The Relationship Between Depression Symptoms, Pain and Athletic Identity in Division II NCAA Athletes at Preseason Bodine LE, Keenan LC, Bear DJ, Daltry RM: West Chester University of Pennsylvania, West Chester, PA

Context: Most individuals diagnosed with depression first experience symptoms in their young adult years, putting college students at an increased risk. Pain has also been found to be related to depression symptoms; however, the experience of pain and depression symptoms may be unique in the athletic population and has not yet been studied. There has been a positive relationship found between depression symptoms and athletic identity; however, the literature is limited. The relationship between depression symptoms, pain and athletic identity has yet to be studied. **Objective:** To examine the relationship between depression symptoms, pain, and athletic identity in collegiate student-athletes. Design: Cross-sectional study. Setting: NCAA Division II public university. Patients or Other Participants: Ninety-one male (n = 49, 53.8%) and female (n =42, 46.2%) student-athletes across 4 sports including Women's Volleyball (n = 18, 19.8%), Women's Rugby (n = 24, 26.4%), Men's Swimming and Diving (n = 22, 24.2%), and Men's Soccer (n =27, 29.7%). Interventions: Participants completed three surveys on electronic tablets during preseason physicals. Measures included the Patient Health Questionnaire-9 (PHQ-9), a previously validated, brief depression symptom screen, the Numeric Rating Scale (NRS) measuring self-reported pain on a 0-10 scale, and the Athletic Identity Measurement Scale (AIMS), a seven-item Likert-scale quantifying the extent to which participants identified as athletes. Main Outcome Measures: Dependent variables included total PHQ-9 scores, AIMS scores and NRS

scores. Descriptive statistics (mean ± SD) were calculated and Pearson's correlation coefficients were used to examine relationships between dependent variables. A priori alpha level was set at p < 0.05. Results: The mean PHQ-9 score was 2.43 ± 3.138 , the mean NRS score was 0.81 ± 2.113 , and the mean AIMS score was 38.52 ± 7.644 . A significant but weak positive correlation was found between depression symptoms and pain (r = .304, p = .003) and between athletic identity and depression symptoms (r = .258, p = .013). No significant association was found between athletic identity and pain (r =.018, p = .867). Conclusions: Our data supports that student-athletes experiencing pain may experience more depression symptoms. Those student-athletes with a high athletic identity may also experience more depression symptoms. Ultimately, athletic training and sports medicine professionals should observe or screen student-athletes for depression symptoms, especially those expressing pain and who identify highly with the athletic role.

Association of Perception-Action Coupling With Concussion History and Self-Rated Function Odum EM, Fabries B, Vickers MA, Wilkerson GB, Acocello SN: The University of Tennessee, Chattanooga, TN

Context: Emerging research strongly suggests that musculoskeletal injury risk may be higher following concussion. Delayed response to environmental stimuli, termed perception-action coupling, may explain the elevation of injury risk. Reactive agility testing involves a whole-body movement in response to a visual stimulus, which may identify athletes who possess elevated injury risk. **Objective:** To assess the potential association of reactive agility test performance with self-reported concussion history, as well as self-rated functional performance capabilities, among college football players. Design: Cohort study. Setting: Athletic facility. Patients or Other Participants: 71 male collegiate football players (19.5 \pm 1.1 years, 103.49 ± 21.53 kg, $186.45 \pm$ 6.35 cm) were assessed 2 months after the end of the season. Interventions: All participants completed the Sport Fitness Index (SFI). The TRAZER Sports Simulator® (Traq Global Ltd.) was used to quantify side-shuffling responses to 20 visual targets that appeared on a large monitor in a random sequence of right and left positions. Main Outcome Measures: The SFI generates a 0-100 score, with higher scores indicating better self-reported functional performance. Variables derived from the side-shuffling task included speed, acceleration, deceleration, and reaction time, along with right-left asymmetry (% difference) for each. Receiver-operating characteristic (ROC) analyses and logistic regression were used to develop models that provided maximum discrimination between those with and without concussion history, and between those
with high versus low self-reported SFI scores. The odds ratio (OR) and its 95% credible lower limit (CLL_{os}) were calculated. Results: 49 players self-reported a history of concussion. Rightleft asymmetry in reaction time ($\geq 16\%$ difference; OR = 3.26, $CLL_{95} = 1.04$), speed ($\geq 6\%$ difference; OR = 3.01, $CLL_{95} = 1.20$), and deceleration ($\geq 7\%$ difference; OR = 3.67, $CLL_{95} = 1.32$) discriminated between players with and without a history of concussion. Having 2 of 3 of these factors demonstrated 86% sensitivity and 61% sensitivity (OR = 10.00, CLL₉₅ = 3.23; $\chi^2(3)$ = 14.86; p = .002). No variables successfully discriminated between those with high versus low self-reported functional performance capabilities. However, asymmetries in reaction time ($\geq 15\%$; OR = 2.55, $CLL_{95} = 1.12$), speed ($\geq 6\%$; OR = 5.56, $CLL_{95} = 2.22$), and deceleration ($\geq 18\%$; OR = 3.28, CLL₉₅ = 1.16) were able to discriminate high versus low self-rated functional performance when the SFI was limited to items 3-7 (cut-off: ≤ 22 out of 25). Conclusions: Performance values derived from the reactive agility test effectively discriminated between participants with and without concussion history, as well as those with high versus low self-reported function. Our findings suggest that asymmetries in right-left reaction time, speed, and deceleration may contribute to elevated risk for musculoskeletal injury.

Clinical Decision-Making: Investigating the Students' Process

Paver SR, Frank EM, Potteiger K, Pitney WA: Northern Illinois University, DeKalb, IL; Lebanon Valley College, Annville, PA

Context: As athletic training students' progress through a professional education program they develop and refine their clinical knowledge and skills in the classroom and clinical settings under the direction of faculty and preceptors. These experts should offer cognitive scaffolding to help the students further develop and refine their clinical decision-making skills. Upon graduation, students should have attained the ability to engage in the clinical decision-making process; however, the literature suggests a disconnect between formal education, professional practice, and the students' ability to make sound clinical decisions. **Objective:** Identify the clinical decision-making processes employed by athletic training students. Design: Qualitative design with stimulated recall interviews. Setting: Educational institution. Patients or Other Participants: Fourteen second year athletic training students enrolled in a baccalaureate athletic training program in the Midwest. Data Collection and Analysis: We collected data through direct observations and semi-structured interviews. We video recorded and directly observed each student's evaluation of a standardized orthopedic injury. The purpose of this was to take notes on each individuals' behaviors, reactions, interaction, think aloud process and clinical evaluation process. Furthermore, we formulated additional interview questions to better understand the cognitive process of each student. We conducted the semi-structured interviews immediately after the evaluation. We followed a script with added probing questions which, in part, came from the direct observations. During the interview, stimulated recall was employed while we watched the recorded video with each student

after they completed their evaluation. We audio recorded and transcribed all interviews verbatim. Inductive content analysis was employed to analyze the data we gathered. We each read the transcripts before the process of coding began and through conversations and modifications of the coding method, we identified categories and split those into themes that aid in understanding the students' clinical decision-making process. We ensured trustworthiness in three ways: (1) member checking; (2) engagement in data collection to ensure saturation; (3) peer debriefing regarding the process, findings, and interpretations. Results: Four preliminary themes emerged: a) Students engage in anchoring bias; b) Students use their own personal past experiences to form clinical impressions; c) Students model preceptors; and d) Students perceive incongruity between the didactic and clinical environment. Conclusions: Based on these findings, students would benefit from preceptors modeling their consideration of multiple pieces of evidence when making decisions. Under the direction of faculty and preceptors, athletic training students develop and refined their clinical decision-making skills. Before we can further identify how faculty and preceptors can best help develop the clinical decision-making skills in students, we must understand the process which students already employ. Gaining insight into this process has educational implications as curricular changes can be implemented to address shortcomings or foster advances in the students' cognitive thinking process.

The Risk of Ankle Sprains Based on Arthrometer Measurements: A Longitudinal Study

Perry M, Liu K, McConnell W, Gustavsen G, Kaminski TW: University of Evansville, Evansville, IN; University of Delaware, Newark, DE

Context: Ankle sprains are one of the most common injuries found in in the collegiate athletic setting. It is essential for athletic trainers to be knowledgeable about the injury risk to better incorporate treatment plans and prevention programs. **Objective:** To take baseline measurements of ankle joint laxity and document ankle sprains over the course of the athlete's collegiate career. Design: Longitudinal prospective study. Setting: Athletic Training Laboratory. Patients or Other Participants: 41 NCAA Division I male football players athletes (age = 18.6 ± 1.2 years, height = 186.4 ± 7.3 cm, weight = $103.2 \pm$ 20.3 kg) were recruited for this study. Interventions: Ankle joint laxities in the anterior, inversion, and eversion directions were measured using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL). Each athlete's preseason measurements were recorded and the sports medicine staff documented each ankle sprain that occurred thereafter. Main Outcome Measures: The primary outcome of interest was incidence of ankle sprain at the end of a collegiate career, treated dichotomously. The primary independent variables were baseline measurements of ankle laxities in the three directions, divided into quartile ranges. Logistic regressions were used to estimate the odds of an ankle sprain, controlling for BMI, based on quartile ranges of laxity in three directions. Average marginal effects were also calculated to estimate the probability of an ankle sprain for the quartiles of ankle laxity. Results: 11 participants sustained an ankle sprain over the course of this study with 7 participants sustaining unilateral sprains and 4 spraining both ankles. Laxities in the anterior and eversion directions were not associated with injury risk. However, those in the second quartile of laxity in the inversion direction had increased odds of 14.96 (95% CI 1.27-175.24, P = 0.031) for an ankle sprain in the same ankle with an increased probability of 37% compared to those in the first quartile. Further, laxity in the inversion direction in the third and fourth quartiles had increased odds of 15.89 (95% CI 1.11-225.74, P = 0.041) and 21.62 (95% CI 1.06-438.39, P = 0.045) and 37% and 42% increased probability, respectively, compared to those in the first quartile for a contralateral ankle injury. Those in the third and fourth quartiles of laxity of inversion in the ankle had increased odds of 24.63 (95% CI 1.66-365.32, P = 0.020) and 72.77 (95% CI 3.04-1741.21, P = 0.008) with 45% and 64% increased probability, respectively, for all ankle sprains. Conclusions: Not only does an increase in laxity increase the odds of sustaining an ankle sprain in the same ankle, it also increases the odds of a contralateral ankle sprain. Although longitudinal injury risk studies are a large time commitment, they can help to better identify true risk factors. After ascertaining the risk factors, interventions can then be determined to decrease the overall incidence of injuries.

Free Communications, Oral Presentations: Doctoral Oral Awards

Wednesday, June 27, 2018, 9:15AM-10:15AM, Room 217-219; Moderator: Eric Sauers, PhD, ATC, FNATA

Impact of Protein or Carbohydrate Supplementation on Musculoskeletal Injury Rates in Initial Army Training

McGinnis KD, McAdam JS, Roberts MD, Lockwood CM, Sefton JM: Warrior Research Center, Auburn University, Auburn, AL; Molecular and Applied Sciences Laboratory, Auburn University, Auburn, AL; Lockwood LLC, Draper, UT

Context: Musculoskeletal injury (MSI) contribute to high costs during Army initial entry training (IET). Objective: Determine if improved fueling can result in decreased MSI. Design: This study implemented a randomized placebo controlled, double blinded study, and subjects were compared with unit historical MSI data collected by our laboratory. Setting: Military training post, Army initial entry training Patients or Other Participants: Male Army IET Soldiers were divided into once or twice daily protein or carbohydrate groups: protein 1 shake (n = 50, age 21.3 ± 3.2 , 76.8 kg ± 12.8 , 173.2 cm \pm 7.8); carbohydrate 1 shake (n = 50, age 22.9 ± 3.8, 77.8 kg ± 15.3, 175.1 $cm \pm 7.8$); protein 2 shakes (n = 56, age 18.6 ± 0.9 , 73.4 kg ± 2.7 , 173.1 cm \pm 6.1); or carbohydrate 2 shakes (n = 56, age 18.6 ± 1.2 , $72.3 \text{ kg} \pm 10.9$, 173.2 $cm \pm 5.1$). Historical data was analyzed from the same unit, same months for 2015/2016. Non-matched pairs group averages were used for comparison. Interventions: Each participant consumed either a protein (38.6g Protein, 19g Carbs, 7.5g Fat) or carbohydrate shake (0.5g Protein, 63.4g Carbs, 3.9g Fat) twice or once a day immediately following physical training and prior to bed or prior to bed only. Main Outcome Measures: MSI data were recorded by the unit's Athletic Trainer using a customized injury data collection system. Odds Ratio (OR) and Chi square (χ^2) was calculated for each group to compare consumption of supplementation versus no supplementation, one versus two supplementation shakes per day, and carbohydrate versus protein supplementation. Results: There was a significant difference in MSI between participants who consumed two shakes a day and participants that consumed no shakes ($\chi^2 = 60.12$, CI = 3.40-8.39,

p < 0.001). Soldiers who were not supplemented were 5x (OR = 5.34) more likely to incur an MSI than those consuming two shakes. Participants who consumed two shakes a day were also significantly less likely to incur an MSI than participants that consumed one shake a day ($\chi^2 = 10.60$, CI = 1.53-6.05, p = 0.001). Participants who consumed one shake were 3x more likely to incur an MSI than participants who consumed two shakes a day. However there was no significant difference between participants who consumed one shake and Soldiers who were not supplemented ($\chi^2 = 1.59$, CI = 0.86-2.03, p = 0.208). There was no significant difference between protein or carbohydrate supplementation for one ($\gamma^2 =$ 0.059, CI = 0.74-4.09, p = 0.809) or two daily shakes ($\chi^2 = 1.65$, CI=0.34-2.30, p = 0.198). Conclusions: Intake of either protein or carbohydrate shakes resulted in decreased MSI in IET soldiers. Twice daily shakes of either supplement were more beneficial than one daily shake. IET soldiers not supplementing with protein or carbohydrate presented the highest rate of MSI.



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Quadriceps Function in ACL Reconstructed Patients: A Principal Component Analysis Norte GE, Hertel J, Saliba SA, Diduch DR, Hart JM: University of Virginia, Charlottesville, VA;

University of Toledo, Toledo, OH

Context: Context: Assessment of physical function for patients after ACL reconstruction (ACLR) is complex and warrants the use of diverse evaluation strategies. To maximize the efficiency of assessment and improve clinical outcomes, there is a need to identify tests that provide the most meaningful information. By establishing the diagnostic and predictive abilities of assessment tools to discriminate between patients with and without ACLR, clinicians can begin to evaluate the utility of each, and work towards an evidence-based assessment paradigm. **Objective:** To (1) investigate underlying constructs of quadriceps muscle function that uniquely describe patients after ACLR, (2) establish clinical thresholds for measures able to discriminate between patients with and without ACLR, and (3) identify a preliminary prediction model for patient status. Design: Cross-sectional. Setting: Laboratory. Patients or Other Participants: 72 patients with a primary, unilateral ACLR $(32 \text{ males}/40 \text{ females}, \text{ age} = 26.0 \pm 9.3$ years, height = 172.6 ± 11.2 cm, mass = 75.6 ± 17.7 kg, time since surgery = 46.5 ± 58.0 months), and 30 healthy individuals (12 males/18 females, age = 22.7 ± 4.6 years, height = 174.8 ± 11.8 cm, mass = 75.1 ± 16.2 kg) volunteered. Interventions: Quadriceps function was assessed bilaterally during one session. Main Outcome Measures: Isokinetic strength (peak torque [Nm/ kg], total work [J/kg], average power [W/kg]) at 90°/second, maximal voluntary isometric contraction (MVIC) torque (Nm/kg), central activation ratio (CAR,%), Hoffmann reflex (H/M ratio), and active motor threshold (AMT,%) were measured. Separate principal component analyses were conducted for the involved limb, contralateral limb, and limb symmetry indices. Receiver operating characteristic curve analyses were used to establish clinical thresholds that maximized the ability of retained variables within each component to discriminate patient status (ACLR vs. healthy). Binary logistic regression was used to predict patient status using the final combination of variables with the greatest discriminatory value from each retained component. Accuracy of classification, sensitivity, specificity, positive likelihood (LR+) and negative likelihood (LR-) ratios were calculated. Results: Three principal components of peripheral, central, and combined (peripheral and central) muscle function were identified, explaining 70.7-80.5% of cumulative variance among measures of quadriceps function. Involved limb total knee extensor work at 90°/ second (≥18.4 J/kg), CAR (≥94.7%), and AMT (≥40.0%) were the strongest predictors of patient status, and correctly classified 83.5% of patients with ACLR (sensitivity = 91.4, specificity = 57.1, LR += 2.13, LR = 0.15, P < .001). Conclusions: Individual constructs of peripheral, central, and combined quadriceps muscle function uniquely describe patients after ACLR. Measures recorded from the involved limb yielded the highest LR+ and lowest LR-. Total knee extensor work at 90°/second, CAR, and AMT consistently explained a significant portion of variance in measures of quadriceps function, demonstrated acceptable to excellent discriminatory value, and predicted patient status with 72.8-83.5% accuracy. The presented tests and clinical thresholds appear to provide a sensitive test battery for patient status and produce a moderate effect on decreasing the probability of being classified as having an ACLR.

Manipulating Peak Vertical Ground Reaction Force During Walking Influences Cartilage Oligomeric Matrix Protein in Individuals With Anterior Cruciate Ligament Reconstruction

Luc-Harkey BA, Franz JR, Hackney AC, Blackburn JT, Padua DA, Schwartz TA, Pietrosimone B: Brigham and Women's Hospital, Boston, MA; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: The complex interaction between aberrant mechanical loading and altered tissue metabolism that occurs following anterior cruciate ligament reconstruction (ACLR) is hypothesized to contribute to the development of posttraumatic knee osteoarthritis. It is currently unknown if acutely manipulating mechanical loading during walking is capable of influencing tissue metabolism in individuals with ACLR. Assessing changes in serum cartilage oligomeric matrix protein (COMP), a biomarker of cartilage breakdown, following the acute manipulation of peak vertical ground reaction force (vGRF) during walking may identify therapeutic targets that maintain homeostatic tissue metabolism following ACLR. Objective: To compare $\text{COMP}_{\text{CHANGE}}$ following 20 minutes of walking while using visual real-time biofeedback (RTBF) to elicit bouts of high-loading (increased vGRF), low-loading (decreased vGRF), and symmetrical loading (symmetric vGRF between limbs) compared to control loading (participant's usual loading) in individuals with ACLR. Design: Cross-over study. Setting: Research laboratory. Patients or **Other Participants:** Thirty individuals with primary, unilateral ACLR (70% female; age = 20.4 ± 2.9 years; BMI = 24.4 \pm 4.3 kg/m²; 47.8 \pm 26.9 months following ACLR). Interventions: Participants completed four separate sessions involving 20 minutes of walking on a force-measuring treadmill during one of four loading conditions. Loading conditions consisted of a control (participant's usual loading) followed by a randomized sequence of 3 experimental loading conditions prescribed using visual RTBF. Experimental loading conditions consisted of 1) walking with a 5% increase in vGRF (high-loading), 2) walking with a 5% decrease in vGRF (low-loading), and 3) walking with symmetric vGRF between the ACLR and contralateral limbs (symmetrical loading). Main Outcome Measures: Whole blood samples were collected immediately prior to (COMP_{PRE}) and following (COMP_{POST}) each 20-minute loading condition, and serum COMP was analyzed using a commercially available enzyme linked immunosorbent assay. COMP_{CHANGE} (COMP_{POST} - COMP_{PRE}) was calculated within each loading condition for analysis. One subgroup was identified from our entire cohort, which included only participants demonstrating an increase in serum COMP following the control condition (COMP_{CHANGE} >0ng/mL). A general linear mixed model was used to compare $\mathrm{COMP}_{\mathrm{CHANGE}}$ between each experimental loading condition (symmetrical loading, high-loading, low-loading) with control loading while adjusting for COMP_{PRE} . Post hoc comparisons were performed with the Dunnett-Hsu adjustment ($\alpha \leq 0.05$). Statistical analyses were conducted for the entire cohort and for the subgroup. Results: In the entire cohort, COMP_{CHANGE} was not different across experimental loading conditions compared to control loading $(n = 30; F_{329} = 1.34, P = 0.282)$. Within the subgroup demonstrating an increase in COMP following control loading (n =22), COMP_{CHANGE} was significantly less during high-loading (mean \pm SD; 1.95 \pm 24.22ng/mL, $t_{21} = -3.53$, P = 0.005) and symmetrical loading (9.93 ± 21.45ng/ mL; $t_{21} = -2.86$, P = 0.025) compared to control loading (25.79 \pm 21.40ng/mL). **Conclusions:** Increasing vGRF during walking results in less serum COMP response in individuals with ACLR, suggesting that higher loading may be beneficial for joint tissue metabolism in those who demonstrate an increase in serum COMP with usual walking.

Negative Emotional Stimuli Increase Neurocognitive Processing in the Brain An YW, DiTrani Lobacz A, Baumeister J, Swanik CB: New Mexico State University, Las Cruces, NM; Neumann University, Aston, PA; University of Paderborn, Paderborn, Germany; University of Delaware, Newark, DE

Context: Recent studies have suggested that anterior cruciate ligament injury and reconstruction (ACLR) may cause permanent neural adaptations in the brain. This neuroplasticity may play an important role in restoring patient function. However, growing evidence suggests that fear of re-injury/movement following an ACLR may be linked to functional joint instability because neural processing in the patient's prefrontal cortex is critical for both emotional regulation and the preparation of complex motor control strategies. It remains unclear if seeing negative emotional stimuli causes different brain activation patterns in ACLR patients compared to healthy controls. **Objective:** To examine cortical activity differences between ACLR patients and healthy controls in response to emotional evocative pictures. Design: Case-control study. Setting: Neuromechanics laboratory. **Patients** or Other Participants: Twenty ACLR patients $(21.9 \pm 3.5 \text{ yrs}, 71.8 \pm 25.2 \text{ kg})$ 165.9 ± 10.4 cm) with a unilateral ACLR and 20 healthy Controls $(23.9 \pm 4.8 \text{ yrs},$ 62.5 ± 12.5 kg, 166.6 ± 9.2 cm) with no history of knee injury volunteered. Interventions: Fronto-parietal electrocortical activations (Fz, Pz) in theta frequency band (4-8Hz) were quantified using EEG while viewing randomly selected three types of emotional evocative pictures (30 each of neutral, fearful, and knee injury-related pictures). The International Affective Picture System (IAPS) was used to induce targeted neutral and fearful emotions in addition to preselected knee injury-related pictures. Main Outcome Measures: Event-related synchronization (ERS:

% increased power relative to a non-active baseline) during the first second of picture presentations were compared across picture types (3-levels) and group (2-levels). Results: Significant type main effects (Fz; $F_{2.64} = 7.181$, p = $0.002, Pz; F_{1.819,65,499} = 20.654, p < 0.001)$ revealed that fearful pictures produced greater theta powers in the fronto-parietal regions (Fz; $36.81 \pm 30.3\%$, Pz; $81.11 \pm 66.71\%$), when compared to neutral pictures (Fz; $26.60 \pm 29.27\%$, Pz; $68.06 \pm 57.16\%$). Further, knee injury-related pictures also showed greater theta power in the parietal region (Pz; $118.83 \pm 84.56\%$), when compared to the fearful (Pz; $81.11 \pm 66.71\%$) and neutral pictures (Pz; $68.06 \pm 57.16\%$). No significant type by group interaction effects were observed for the fronto-parietal cortex regions (Fz; $_{264}$ = 2.041, p = 0.138, Pz; $F_{1.819,65.499} = 0.738, p = 0.470$). **Conclusions:** Fearful pictures from the IAPS provoked greater theta power in the fronto-parietal regions compared to neutral pictures. The heightened frontal theta power implies increased cognitive processing required to sufficiently regulate fearful stimuli. Knee injury-related pictures also increased theta power in the parietal cortex compared to both neutral and fearful pictures, which indicates increased cognitive processing associated with situational awareness of visual cues. Because the fronto-parietal cortex areas are crucial for muscle coordination, this increased neural demand may disrupt normal cognitive motor processing needed for neuromuscular control and joint stiffness regulation. While this heightened brain activity was observed in all subjects, ACLR patients may be more vulnerable to episodes of functional joint instability, due in part to the higher fear of re-injury/movement.

Education Best Practices Forum: Creating a Student-Centered Environment: Strategies for Faculty and Preceptors

Wednesday, June 27, 2018, 10:30AM-11:30AM, Room 2; Moderator: Angela Beisner, MA, BS Discussants: Jessica Rager, MS, ATC; Laura Harris, PhD, ATC

Free Communications, Rapid Fire Oral Presentations: Preceptors: Perspectives on Athletic Training Education

Wednesday, June 27, 2018, 11:45AM-12:30PM, Room 217-219; Moderator: Jessica Edler, PhD, ATC

Professional Masters Level Athletic Training Program Administrators' Experiences With the Preparation and Development of Preceptors Rager JL, Cavallario JM, Hankemeier DA, Welch Bacon CE, Walker SE: Ball State University, Muncie, IN; Old Dominion University, Norfolk, VA; A.T. Still University, Mesa, AZ

Context: As athletic training programs transition to the master's level, administrators will be preparing preceptors to teach advanced learners. Currently, preceptor development is variable between programs and ideal content vet to be identified. Exploring the development of preceptors teaching masters level learners can lead to an understanding of effective precepting practices. Objective: To explore masters level athletic training professional program administrators' (i.e. program director, clinical education coordinator) experiences preparing and implementing preceptor development. **Design:** This qualitative study was guided by the consensual qualitative research approach. Setting: Individual phone interviews. Patients or Other Participants: 18 program administrators (11 females, 7 males; 5.92 ± 4.19 years of experience; 17 clinical education coordinators, 1 program director) participated in this study. Participants were recruited and interviewed until data saturation was achieved. Data Collection and Analysis: A semi-structured interview guide was used to conduct interviews, which were recorded and transcribed verbatim. Data were analyzed by a four-person research team and coded into themes and categories based on a consensus process. Researchers independently coded the data and discussed emergent themes and categories to formulate a consensus codebook that appropriately represented the data. Credibility was established by utilizing multiple researchers, an external auditor,

and member checks. Results: Participants reported that the delivery of preceptor development content occurs both formally (e.g., in-person, online) and informally (e.g., phone calls, e-mail). Type of content delivered is adapted depending on many factors including the experience level of the preceptor, the years precepting with a specific program, and geographical location to the program. The content of preceptor development typically includes programmatic policies and procedures, expectations of preceptors, evolving accreditation and educational requirements of the program, effective precepting methods, and new knowledge and/or skills which have been recently added to the curriculum. Participants also described reading available evidence on effective precepting to inform their decisions on preceptor development. Feedback from program faculty, preceptors, learners, and other program administrators is also used when planning future preceptor development. Furthermore, participants use specific feedback from students regarding preceptors to promote individualized growth and development amongst preceptors. Lastly, the offering of tangible (e.g., money, CEUs) and intangible (e.g., personal growth, professional service) incentives to reward preceptors for their time engaging in both preceptorship and participation in preceptor development were reported. Conclusions: Findings suggest complex decision making occurs when planning preceptor development. Considerations include the years precepting with a program, expectations of the program, stakeholder feedback, and other sources of evidence. Furthermore, the content of preceptor development is modified based on programmatic needs, stakeholder feedback, and the evolution of professional education. Future research should explore the challenges associated with developing preceptors, and which aspects of preceptor development are effective at facilitating student learning and readiness for clinical practice.

Preceptor Perceptions of Student Integration in an Immersive Clinical Education Model Dougal ZD, Edler JE, Walker SE, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN; Grand View University, Des Moines, IA; Ball State University, Muncie, IN

Context: As more professional athletic training programs begin to offer immersive experiences during clinical education, a better understanding of how preceptors plan to engage students is imperative. **Objective:** To explore the preceptor's perceptions on how their role will differ during in an immersive clinical experience model verses a traditional clinical experience model. Design: Consensual qualitative research. Setting: Individual phone interview. Patients or Other Participants: 9 clinical preceptors (4 male, 5 female) with at least 1 year of experience as a preceptor (age = 31.4 ± 7.1 y, work experience = 8.6 ± 6.3 y, preceptor experience = 7.1 ± 5.0 y). **Data Collection** and Analysis: Phone interviews were audio-recorded and transcribed verbatim. A 3-person data analysis team identified codes and themes independently and then met to develop a consensus codebook. Each researcher then independently coded the data, and met to reach a final consensus ensuring accuracy and representativeness of the data. Trustworthiness was established by the use of multiple researchers and an external auditor. Results: Two themes emerged relating to preceptors' perceptions of how their role would differ in an immersive clinical experience model: student experiences and lack of awareness. Participants discussed their current clinical environments, which surrounded sport "coverage": pre-event (practice/competition), event, and postevent clean-up or patient follow-up as

a means to engage students. Plans to change the environment in the future included expanding student integration into administrative duties and communication with stakeholders. Participants had an overall lack of awareness regarding immersive clinical experiences and stated they thought the experience would not change at all indicating a misconception about the intention of immersion. Participants also had assumptions regarding the immersive clinical experiences in that they felt students would be more engaged due to not being preoccupied with coursework (the practice-intensive experience suggested in future standards does not require that students are not engaged in other coursework). Additionally, participants appeared inadequately informed regarding clinical immersion. When program administrators communicated information contrary to the current or future standards, preceptors demonstrated uninformed clinical teaching behaviors about student integration in clinical education. For example, one participant disclosed that they had not been informed about the hours expectation of students in their traditional clinical experience model, so it was difficult to imagine translating their experiences to an immersive clinical experience model. Conclusions: Preceptors are generally uninformed about how they would educate an adult learner in an immersive clinical experience model. Further insight is needed for preceptors by the academic programs and informed scholarship on changes that will occur during an immersive clinical experience. Preceptors should receive ongoing preceptor development that is focused on the intricacies of clinical teaching, including and how to maximize their site's strengths, minimize challenges, and focus on the specific needs of the adult learner, specifically in an immersion clinical experience model

An Investigation of Undergraduate and Graduate Professional Athletic Training Students' Perceptions of Preceptor Mentorship Maginnis SF, Clemmer BP: University of Iowa, Iowa City, IA; Wingate University, Wingate, NC

Context: The role of mentorship in professional socialization has been explored in various health care professions, but the differences between perceptions of mentorship between undergraduate and graduate level athletic training students in professional programs represents a gap in athletic training literature. Since mentorship has been associated with increased critical thinking, socialization, and retention, an investigation of these perceptions may provide insight into clinical education needs. Adult learner theory provides the framework for this mixed method investigation of preceptor mentorship. **Objective:** The purpose of this study was to investigate the differences between undergraduate and graduate athletic training students' perceptions of preceptor mentorship. Design: Cross-sectional. Explanatory sequential mixed-method design. Setting: Population-based. Patients or Other Participants: To capture perceptions of students at the end of their professional program, all participants were candidates for the BOC examination or had taken the exam within 4 months. Survey was distributed by the BOC email blast service on behalf of the researchers. 307 participants responded (269 undergraduate, 38 graduate). Overall response rate was 11% of the 2700 candidates who received the invitaiton. Interventions: Researcher-developed online survey consisting of demographic items and 25 Likert-type items measured students' perceptions of mentoring traits of their most influential preceptor. Delphi technique was used to establish content validity and to prepare survey items for pilot testing prior to data collection. Cronbach's alpha was calculated for each of the Likert-type item subscales - student-centered support (a = .955), approachabilty (a = .944), professional preparation (a = .831), mutuality (a = .926), and overall (a = .980). Main Outcome Measures: The survey tool

collected athletic training students' demographic data, identification of a preceptor as a mentor, and perceptions of mentoring traits in the students' most influential preceptor. The 25 Likert-type mentoring traits items were grouped into 4 sub-scales - student-centered support (60 points possible), approachability (30 points possible), professional preparation (15 points possible), and mutuality (20 points possible). Chi-square tests assessed the association between mentor recognition of undergraduate and graduate students. t-Tests compared means of Likert-type subscales between undergraduate and graduate level students. A focus group interview followed data analvsis in the explanatory sequential method. **Results:** Undergraduate students recognize their most influential preceptor as a mentor more frequently than graduate students (77% of undergraduate students, 62% of graduate students). This represents a significant difference (x^2 (1, N = 306) = 4.45, p = .035). No statistical difference was found between undergraduate and graduate students' perceptions of mentoring traits on the student-centered support Likert-type subscale [undergrad (M = 50.77, SD = 10.39), grad (M = 51.45, SD = 9.66); t(305) = -.403,p = .609], on the approachability subscale [undergrad (M = 26.12, SD = 5.32), grad (M = 27.11, SD = 5.07); t(305) = -1.075,p = .283], on the professional preparation subscale [undergrad (M = 12.55, SD = 2.86), grad (M = 12.58, SD = 2.74); t(305)= -.058, p = .953], on the mutuality subscale [undergrad (M = 17.40, SD = 3.73), grad (M = 17.79, SD = 3.51); t(305) = -.610,p = .542], or on the Likert-type total scale [undergrad (M = 106.83, SD = 21.57), grad (M = 109.92, SD = 20.30); t(305) = -.563,p = .574]. Conclusions: Undergraduate and graduate level athletic training students enrolled in professional programs recognize mentoring traits in their most influential preceptors similarly, but undergraduate athletic training students are more likely to identify their most influential preceptor as their mentor. Mentoring characteristics are very similar to desirable characteristics of effective athletic training preceptors so selecting and preparing preceptors to recognize and meet the individual educational needs of students may be important in the future.

Newly Credentialed Athletic Trainers' Perceptions on How Preceptors Impacted Learning and Transition to Practice Thrasher AB, Cavallario JM, Walker SE, Weidner TG: Western Carolina University, Cullowhee, NC; Old Dominion University, Norfolk, VA; Ball State University, Muncie, IN

Context: Preceptors are vital to learning in the clinical setting; yet it is not well established what preceptor characteristics and clinical teaching behaviors enhance learning and transition to practice. Understanding these qualities and behaviors can better inform preceptors of their role and guide preceptor development. **Objective:** Determine preceptor characteristics and behaviors that impacted learning during professional preparation and facilitated transition to practice. Design: Consensual Qualitative Review. Setting: Individual phone interviews. Patients or Other Participants: 17 newly credentialed athletic trainers in their first three months of employment participated in this study (10 female, 7 male; 23.6±3 years; work settings included college, secondary school, clinic, and health/fitness). Data saturation guided the number of participants. Data Collection and Analysis: Participants were interviewed via phone using a semi-structured interview guide. All interviews were recorded and transcribed verbatim. Data were analyzed through consensual qualitative review, with data coded for common themes and subthemes. Trustworthiness was established via peer review and multianalyst triangulation. **Results:** Three themes emerged: 1) characteristics of preceptors, 2) high impact practices, and 3) resulting behaviors implemented in practice transition. Characteristics of preceptors described characteristics that contributed to effective or ineffective precepting. Effective precepting is described as providing a realistic view of the athletic trainers' role, understanding the students' role, providing feedback on performance, and exhibiting model behaviors which included being approachable, professional, engaged, compassionate, and passionate. Ineffective precepting included being unapproachable or rude, failing to provide an active role in the clinical setting, and not including students in patient care decisions. High impact practices included providing students with opportunities to evaluate, decide on, and plan patient care based on their skill level. Specific learning opportunities such as requiring students to explain patient care decisions, using downtime effectively, and providing opportunities to communicate with stakeholders contributed to learning and transition to autonomous practice. Participants felt preceptors who provided independence while maintaining supervision enhanced their decision-making abilities and confidence. Resulting behaviors implemented in practice transition occurred during participants' transition to practice in response to precepting during professional education. These included modeling effective preceptors' behavior such as communication practices, emulating clinical practices, and providing rationales for all decisions. Participants also learned what not to do in response to ineffective precepting. Conclusions: Both effective and ineffective precepting impacts learning in the clinical setting as well as practice behaviors during the transition to practice. Preceptors are encouraged to continue modeling effective clinical practice, challenge students at the appropriate level, and provide active patient care opportunities. Ineffective precepting provides examples of behaviors to avoid during transition to practice. Potential topics to include during preceptor development are effective ways to provide feedback and ways to implement high impact practices such as providing opportunities to make decisions and instilling confidence.

Critically Appraising Evidence Within the Literature: Perceptions of Athletic Training Preceptors

Stokes LI, Hankemeier DA, Welch Bacon CE, Martin M: Longwood University, Farmville, VA; Ball State University, Muncie, IN; A.T. Still University, Mesa, AZ; Rocky Mountain University of Health Professions, Provo, UT

Context: Understanding athletic training (AT) preceptors' familiarity with critical appraisal (CA) may provide further insight to current use of best research evidence and CA. Identifying perceptions of preceptors affiliated with professional athletic training programs regarding critical appraisal of evidence may provide additional information related to their perceived level of knowledge of evidence-based practice (EBP), ability to appraise evidence within literature, and influence on clinical practice. **Objective:** To investigate AT preceptors' perceived ability to critically appraise high quality evidence within the literature to provide further understanding of how preceptors' perceived abilities influence clinical practice methods. Design: Qualitative study following the consensual qualitative research tradition Setting: Individual telephone interviews. Patients or Other Participants: Sixteen preceptors (7 males, 9 females; 36 ± 9.18 years of age) affiliated with CAATE-accredited professional AT programs were recruited to participate in the study using a purposeful sampling with snowball/chain sampling methods. Data saturation guided the total number of participants selected for the study. Data Collection and Analysis: One phone interview was conducted per participant using semi-structured interview guide to explore understanding, familiarity, and use of CA. Data was transcribed, reviewed, analyzed, and coded into common theme, categories, and sub-categories following the consensual qualitative research method. Triangulation of data occurred by use of multiple researchers and member

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checking to confirm accuracy of the data. **Results:** A single theme emerged from the data during the analysis process; understanding of CA. Within this single theme, three categories were developed: 1) understanding of CA, 2) barriers and factors negatively influencing the use of CA, and 3) awareness of available resources for CA. Conclusions: It is unknown which of the CA strategies are used by preceptors and to what effect the implementation of evidence has within clinical practice. Due to the shallow responses, additional research is needed to fully affect change in the athletic training profession. Although educational programming is available for EBP and CA, preceptors expressed uncertainty regarding CA. To gain further understanding of athletic trainers' use of CA in clinical practice, future research is recommended to understand current knowledge of CA and ability to implement CA into clinical practice. Additionally, future research is encouraged to explore modifications to didactic and clinical education opportunities for educators, students, and preceptors to collectively work toward further integrating the EBP principles, CA, and pre-appraised evidence into practice.

The Ways of the Preceptor: Facilitating the Students' Clinical Decision-Making Process

Frank EM, Paver SR, Pitney WA: Lebanon Valley College, Annville, PA; Northern Illinois University, DeKalb, IL

Context: Athletic training students are expected to make sound clinical decisions upon graduating from a professional education program. The literature suggests a disconnect between formal education, professional practice, and the students' ability to make appropriate clinical decisions. To get students to be competent in making clinical decisions, faculty and preceptors are responsible for teaching and providing experiences for the students to develop this skill. Clinical rotations are an ideal environment for students to identify and practice their clinical decision-making skills. In this setting, preceptors are responsible for fostering students' decision-making and, therefore, the ways in which preceptors facilitate the clinical decision-making process of athletic training students should be further investigated. **Objective:** Identify the ways in which preceptors facilitate athletic training students' clinical decision-making skills. Design: Qualitative study design. Setting: Educational institution. Patients or Other Participants: 17 preceptors affiliated with baccalaureate or graduate athletic training programs in the Midwest and Southeast. Data Collection and Analysis: We collected data using a semi-structured interview guide. All interviews were audio recorded and transcribed verbatim. An inductive content analysis was used to analyze the data and findings were organized in emergent themes describing the ways preceptors facilitate the students' clinical decision-making process. Trustworthiness of the research was ensured in three ways: (1) member checking; (2) engagement in data collection to ensure saturation; and (3) peer debriefing of the process, findings, and interpretations. Results: Four

themes have emerged: a) Preceptors want students to ask critical questions to help clarify their personal understanding; b) Preceptors teach students in the same ways in which they were taught as students; c) Preceptors seek strategies to stimulate student engagement in the clinical environment; and d) Preceptors identify cognitive anchors as the biggest challenge to students developing their clinical decision-making skills. Conclusions: Preceptors must realize that students will follow what is modeled to them; thus, it is incumbent on the preceptors to model questioning to gain deeper understanding. Furthermore, preceptor must recognize that their process of making clinical decisions may not be obvious to the student; therefore, the dialogue and cognitive scaffolding between preceptors and student is critical to explore the accuracies and errors of making a decision. Students would benefit from preceptors learning new pedagogical strategies to more effectively involve students in the decision-making process and facilitate students moving beyond anchoring bias during decision-making. The preceptor is responsible for helping the students develop and refine their clinical decision-making skills. Identifying how preceptors facilitate this process in the clinical environment can shed light on which methods exist and how well they work. Results from this study have curricular implications as they will inform what cognitive scaffolding process preceptors implement to teach students a very critical skill.

Free Communications, Oral Presentations: Effects of Dual Task and Cognitive Demand on Movement Mechanics

Thursday, June 28, 2018, 7:00AM-8:00AM, Room 217-219; Moderator: Dustin Grooms, PhD, ATC, CSCS

The Effects of Multiple Modalities of Cognitive Demand on Dynamic Balance in Patients With Chronic Ankle Instability Needle AR, Watson EL, Bearden AC, Doughton JH: Appalachian State University, Boone, NC

Context: Emerging evidence has implicated cognitive demand as a contributing factor to injury recurrence among patients with chronic ankle instability (CAI). Currently, studies describing effects of cognitive load on balance among these populations appear equivocal; however, these studies utilize static measures of balance and/or only a single cognitive task. **Objective:** This study aimed to determine differences in dynamic balance between patients with CAI and healthy controls under 3 different cognitive loads. Design: Case-control. Setting: Clinical laboratory. Patients or Other Participants: Thirty-two participants were stratified into control or CAI groups based on history of injury and Identification of Functional Ankle Instability questionnaires (Control: $n = 16, 21.8 \pm 3.2$ yrs; 171.1 ± 9.6 cm; 69.4 ± 14.8 kg; CAI: n = $16, 21.4 \pm 3.1$ yrs; 174.2 ± 8.5 cm; 73.7± 12.9 kg). Interventions: Participants reported for a single session where they were first tested for performance on 3 cognitive tasks: Benton's Judgement of Line Orientation (JLO), Symbol Digit Modalities Test (SDM), and Serial Sevens (SVN) to assess visuospatial, verbal-memory, and quantitative cognition, respectively. This was followed by performance of 20 forward hop-to-stabilization tasks. Participants were instructed to take a 2-step approach, jump over a 10cm hurdle located leg length from a force plate, and land and maintain balance on the force plate for 15 seconds. These hops were performed 5 times each as participants simultaneously verbally responded to JLO and SDMT tasks (presented on a projector), SVN, or performed no cognitive task.

The order of testing was randomized for each participant. Main Outcome Measures: Time-to-stabilization (TTS. s) was assessed as time sequential means of anteroposterior, mediolateral, or vertical components of the ground reaction force (GRF) fell within ±0.25 standard deviations of quiet stance. Additionally, vertical GRF was further assessed as the time for vertical GRF to fall within 5% of body weight. Factorial analyses of variance assessed differences between task and GRF-component between control and CAI groups ($\alpha =$ 0.05). Results: A significant task-by-direction interaction effect was observed for TTS values (F = 16.973, p < 0.001); however, no significant effect of group was observed (F = 2.199, p = 0.148). Post hoc testing revealed TTS in SVN (5.584 ± 0.110) was significantly greater than JLO (5.342 ± 0.119) ; however, no other differences were observed between tasks. For the vertical force, a significant main effect of group was observed (F = 17.814; p < 0.001), indicating higher TTS in the CAI group (control: 3.42 ± 0.78 s; CAI: 8.11 ± 0.79 s), but no effect of task was observed (F = 1.034, p = 0.382). Conclusions: Contrary to pre-existing hypotheses, cognitive load did not affect dynamic balance in CAI patients differently than uninjured controls. However, higher vertical TTS values in CAI indicate these patients used a different landing strategy than controls. Furthermore, cognitive load that did not require a visual component (SVN) increased TTS when compared to a visuospatial task (JLO). It remains unclear whether these adaptations are trainable to minimize the impact of cognitive demand on dynamic balance.

Dual Task Capability After Anterior Cruciate Ligament Reconstruction: Motor Task Verse Cognitive Task Miko SC, Simon JE, Starkey C, Grooms DR: Ohio University, Athens, OH

Context: Patients who experience anterior cruciate ligament (ACL) ruptures have poor functional outcomes including high re-injury risk, decreased quality of life, low rates of return to activity, and deficits in their cognitive (attentional) process due to changes in motor control. However, assessments of integrated cognitive-motor function related to athletic performance are limited. **Objective:** Determine the effect of motor versus cognitive dual tasking on postural control in those with ACL reconstruction (ACL-R). Design: Cohort Study. Setting: Laboratory. Patients or Other Participants: Twenty-eight volunteers (18 women, 10 men) from a local university community were recruited; 14 with ACL-R (20.7 \pm 2.0 years, 170.3 ± 13.5 cm, 76.9 ± 19.1 kg) along with 14 healthy matched individuals $(21.2 \pm 1.4 \text{ years}, 170.4 \pm 14.7 \text{ })$ cm, 75.4 ± 15.3 kg). Healthy controls were matched to ACL-R participants based on age, weight, sex, and activity level (Tegner and Marx). The participants in the ACL-R group were six months to seven years post-operative and cleared to return to full function by their physician. Participants in the control group were excluded if there was a history of significant musculoskeletal conditions including fractures, sprains, strains or surgery that resulted in time lost or referral to physician. Interventions: Participants performed a total of four single-leg balance tasks (eves open, eves closed, cognitive, and motor) for each leg. For the motor task, to add sport specificity the participants were asked to catch a ball from a pitching machine. The cognitive task asked participants to repeat a string of

numbers in reverse order after viewing them on a screen. Main Outcome Measures: Independent variables were group (ACL-R and CON), condition (eyes open, eyes closed, cognitive task, and motor task) and side (dominant and injured) while the dependent variables were medial-lateral CoP and anterior-posterior CoP. One multivariate repeated measures ANOVA was calculated with one between subjects factor group (ACL-R and healthy) and two within subjects factors condition (eyes open, eyes closed, cognitive task, and motor task) and side (dominant and injured). Alpha level was set at p < 0.05for all analyses. Results: The multivariate ANOVA was not significant for side or group (p > 0.05). A significant difference was seen for condition (p < 0.05), center of pressure (CoP) excursion with eyes open having the lowest (ML: 0.77 \pm .02; AP: 0.87 \pm .02) followed by dual cognitive (ML: $0.84 \pm .02$; AP: $0.97 \pm$.02), eyes closed (ML: $1.49 \pm .06$; AP: $1.49 \pm .05$) and dual motor (ML: $1.72 \pm$.058; AP: $1.8 \pm .06$) having the greatest CoP excursion. Conclusions: Center of pressure changes minimally or not at all from eyes open to dual cognitive but increases greatly from eyes open to eyes closed or dual motor. The use of eyes closed training to train visual-motor ability after injury maybe insufficient because the addition of a sports-specific motor task is more challenging.

The Effects of a Cognitive Dual Task on Jump-Landing Mechanics

Schnittjer AJ, Simon JE, Yom J, Starkey C, Grooms DR: Ohio University, Athens, OH

Context: Athletic injuries typically occur within a dynamic sporting environment with many distracting factors. However, limited clinical assessments exist to quantify motor control under cognitive distraction. **Objective:** Examine the effects of an easy and difficult dual task on jump-landing mechanics. Design: Cross sectional. Setting: Laboratory. Patients or Other **<u>Participants</u>**: Twenty male (n = 10)and female (n = 10) participants (22.4) \pm 1.31 years; 1.71 \pm 0.10 m, 71.75 \pm 11.96 kg) who participated in exercise at least three hours a week, had experience jumping, were not suffering from lower extremity or back injury within the three months prior to participation, had no history of anterior cruciate ligament reconstruction or lower extremity surgery, had no history of neurocognitive disorder, concussion within one year of participation, or psychological distress were recruited. Interventions: All participants completed a series of tuck-jumps under three conditions (control, easy, and difficult cognitive task) on a force platform. The participant carried out a series of tuck-jumps for 10 seconds for each trial (three trials per condition). Two minutes of rest were given between trials to account for fatigue. The control task consisted of no cognitive load, the easy task consisted of a simple recall of a string of digits, and the difficult task consisted of serial addition of a string of digits. Two cameras were utilized to record the participants during their tuck-jump trials. The cameras recorded the participant in both the frontal and sagittal plane. Analysis of the tuck-jump performance was based on established criteria (ligament dominance, quadriceps dominance, leg dominance or residual injury deficits, trunk dominance, and technique perfection on a 0 (error not present) to 1 (error

present) scale) with scores ranging from 0-9. Main Outcome Measures: The independent variable was condition (control, easy, and difficult cognitive task) the dependent variables were (average tuck-jump score and average vGRF). Descriptive statistics were calculated for all dependent variables. Separate repeated measures ANOVA were conducted for each dependent variable. Each repeated measures ANOVA had one within-subjects factor condition (control, easy, and difficult cognitive task). Alpha level was set at p < 0.05for all analyses. Results: There were significant differences in overall tuckjump score from baseline to easy cognitive task and baseline to difficult cognitive task (p < 0.05), with no difference between cognitive conditions. The cognitive dual task increased tuckjump score from 3.52 ± 1.64 baseline, p < .001 relative to 4.37 ± 1.25 with the easy cognitive task to 4.67 ± 1.24 with the difficult cognitive task, p < .001. No significant differences were found in vGRF across the three conditions, p=.323. Conclusions: The dual-task conditions affected jump-landing mechanics as measured by the tuck-jump score indicating potential increased injury risk kinematics with no change in kinetics. Clinicians may consider cognitive dual tasks during functional testing to increase difficulty and assess potential on the field injury risk.

Creating a Dynamic Dual-Task Paradigm: The Effects of a Cognitive Task on Jump-Landing Performance

Biese KM, Stanley LE, Andrejchak M, Lynall RC, Wikstrom EA, Padua DA: University of North Carolina, Chapel Hill, NC; University of Wisconsin, Madison, WI; University of Georgia, Athens, GA

Context: Movement during sport is highly dynamic, consisting of both high cognitive and motor demands. Despite the relevance to athletics, most dual-task research has focused on motor tasks such as gait and postural control - mainly in elderly or impaired cohorts. **Objective:** Therefore, the objective was to determine the effects of cognition on jump-landing movement patterns in healthy individuals. Design: Controlled intervention trials. Setting: University biomechanics laboratory. Patients or **Other Participants:** Recreationally active athletes. Recreationally active defined as participating in sport at least once/week for more than one hour, in one of five sports: basketball, football, rugby, soccer or lacrosse. Twenty participants (male = 11, female = 9; age = 21.1 ± 1.5 years, height = $176.5 \pm$ 9.9 cm, weight = 71.9 ± 11.5 kg) volunteered for this study. Interventions: Participants completed cognitive baseline testing for three different cognitive tests (Stroop Color Word Test-SCWT, Symbol Digit Modalities Test-SDMT, Brooks Visuospatial Task-BVT). After baseline testing, participants performed twelve jump-landing trials, nine jump-landing trials with a concurrent cognitive test (three SCWT, three BVT, three SDMT), and three jump-landing trials with no concurrent cognitive test. The twelve trials were randomly ordered a priori. For the dual-task condition trials, the participant began the cognitive task. After the participant provided two responses, regardless of accuracy, the principal investigator could give the verbal cue "jump" at any time during the remainder of the cognitive test, which signaled the participant to

start the jump-landing task. To be considered a successful trial, participants were required to continue with the cognitive test during the jump-landing task, which was operationally defined a priori as, "completing two or more responses (colors, numbers, or directions) during the jump-landing task." Main Outcome Measures: The Landing Error Scoring System (LESS) was used to evaluate movement patterns, and participant's gross reaction time of the jump-landing task was recorded. Cognitive test time to completion and test errors were recorded. Results: LESS scores were not different between the single-task jump-landing (5.5 ± 1.66) to dual-task conditions (DT $SCWT = 5.4 \pm 2.03$, DT $SDMT = 5.2 \pm$ $1.89, DT \pm BVT = 5.9 \ 1.92)[F_{3.17} = 1.77,$ p = 0.16]). Reaction time was different between trials (DT SCWT reaction time = 1.21 0.17 sec, DT SDMT reaction time = 1.27 ± 0.32 sec, DT BVT reaction time = 1.13 ± 0.33 sec, single-task reaction time = 1.10 ± 0.13 sec [F_{3.17} = 3.30, p = 0.027) and post hoc analysis found that DT SCWT and DT SDMT were slower than the single-task trials ($T_{19} = 5.06$, p < 0.001; $T_{19} = 2.93$, p = 0.007). <u>Conclusions</u>: These results demonstrate that individuals may sacrifice RT to create an appropriate jump-landing motor plan. The novelty of this study's methodology provides a basis for future research to investigate the utility of incorporating cognition into clinical movement pattern evaluations and return to sport assessments.

Free Communications, Rapid Fire Oral Presentations: What's in Your Past? Influence of Injury History on Neuromuscular and Functional Measurements

Thursday, June 28, 2018, 8:15AM-9:15AM, Room 217–219; Moderator: Thomas Kaminski, PhD, ATC, FNATA

Association of Previous Concussion to Decrements in Perception-Action Coupling Behavior in College-Aged Athletes

Eagle SR, Nindl BC, Johnson CD, Kontost AP, Connaboy C: Neuromuscular Research Laboratory/Warrior Human Performance Research Center, University of Pittsburgh, Pittsburgh, PA; UPMC Sports Medicine Concussion Program/Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA

Context: Following a concussion, athletes are at higher risk for another concussion and musculoskeletal injuries. Altered perception of action boundaries, or the limits of one's action capabilities, is one possible mechanism for this increase in injury risk following concussion. **Objective:** To evaluate differences in physical and emotional symptoms, neurocognitive performance, and action boundary behavior between subjects with no concussion history (NoHx) and concussion history (ConcHX). Design: Cross-sectional Setting: Research laboratory Patients or Other Participants: ConcHx (n = 22; age: 21.8 ± 3.0 years, height: 174.0 ± 8.3 cm, mass: $77.8 \pm$ 14.8 kg) and NoHx athletes (n = 24; age: 21.6 ± 2.0 years, height: 176.0 ± 10.0 cm, mass: 72.0 ± 15.3 kg) participated. Interventions: Participants completed the Patient Health Questionnaire-9 (PHQ-9), General Anxiety Disorder-7 (GAD-7), Vestibular-Ocular Motor Screen (VOMS), Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), Post-Concussion Symptom Score (PCSS) and the Perception Action Coupling Task (PACT). The PACT presents pairs of 'virtual' balls and holes of differing sizes, to assess the ability to accurately and quickly determine if a ball will fit inside a hole on an iPad. Eight "ballto-hole" aperture ratios are presented

from 0.2 (ball is much smaller than the hole) to 1.8 (hole is much smaller than the ball). Main Outcome Measures: The PHQ-9 measures depression, the GAD-7 measures anxiety, VOMS assesses vestibular/oculomotor symptoms and impairment, and ImPACT assesses cognitive performance, which includes the PCSS to assess total symptom severity. Reaction time (period from stimulus presentation to removing finger from home button), movement time (period between home button finger removal and placing finger on the joystick), initiation time (period between finger touching the joystick and moving in the intended direction), and accuracy percentage are the PACT outcomes. Appropriate parametric/nonparametric independent-samples tests were used to assess significant differences (p < 0.05, a priori). Results: ConcHx reported 2.7 \pm 1.5 previous concussions and 263.8 \pm 228.9 days since last concussion at time of testing. ConcHx reported higher symptom severity (ConcHx: 12.1 ± 14.0, NoHx: 3.7 ± 5.2 ; p = 0.013), depression (ConcHx: 4.2 ± 4.2 , NoHx: 1.4 \pm 1.7; p < 0.001) and anxiety (ConcHx: 3.7 ± 3.9 , NoHx: 1.7 ± 2.2 ; p = 0.03) scores than NoHx. ConcHx also reported more symptoms in response to vertical saccades (ConcHx: 0.9 ± 1.7 , NoHx: 0.2 ± 0.4 ; p = 0.048), vertical vestibular-ocular reflex (ConcHx: 0.9 ± 1.2 , NoHx: 0.2 ± 0.4 ; p = 0.019), and visual motion sensitivity (ConcHx: 1.1 ± 1.5 , NoHx: 0.2 ± 0.5 ; p = 0.013). Average PACT movement time (ConcHx: $0.32 \pm$ 0.10 msecs, NoHx: 0.25 ± 0.07 msecs; p = 0.02) and reaction time (ConcHx: 0.13 ± 0.03 msecs, NoHx: $0.11 \pm$ 0.01 msecs; p = 0.01) were longer in ConcHx, while ConcHx were also less accurate at aperture ratios 0.4 (-2.6%), 0.6 (-2.7%) and 0.8 (-5.6%). No differences were observed on ImPACT. Conclusions: This study indicates that athletes with previous concussion experience impaired action boundary perception. However, further study is

needed to determine cause and effect in this population. If dysregulated action boundary perception is confirmed as a concussion consequence, it could be a viable mechanism for increased musculoskeletal injury risk following concussion and inform subsequent treatments strategies to mitigate injury risk following concussion.

Association of Perception-Action Coupling With Concussion History and Self-Rated Function Odum EM, Fabries B, Vickers MA, Wilkerson GB, Acceptio SN: The

Wilkerson GB, Acocello SN: The University of Tennessee at Chattanooga, Chattanooga, TN

Context: Emerging research strongly suggests that musculoskeletal injury risk may be higher following concussion. Delayed response to environmental stimuli, termed perception-action coupling, may explain the elevation of injury risk. Reactive agility testing involves a whole-body movement in response to a visual stimulus, which may identify athletes who possess elevated injury risk. **Objective:** To assess the potential association of reactive agility test performance with self-reported concussion history, as well as self-rated functional performance capabilities, among college football players. Design: Cohort study. Setting: Athletic facility. Patients or Other Participants: 71 male collegiate football players (19.5 \pm 1.1 years, 103.49 ± 21.53 kg, $186.45 \pm$ 6.35 cm) were assessed 2 months after the end of the season. Interventions: All participants completed the Sport Fitness Index (SFI). The TRAZER Sports Simulator® (Traq Global Ltd.) was used to quantify side-shuffling responses to 20 visual targets that appeared on a large monitor in a random sequence of right and left positions. Main Outcome Measures: The SFI generates a 0-100 score, with higher scores indicating better self-reported functional performance. Variables derived from the side-shuffling task included speed, acceleration, deceleration, and reaction time, along with right-left asymmetry (% difference) for each. Receiver-operating characteristic (ROC) analyses and logistic regression were used to develop models that provided maximum discrimination between those with and without concussion history, and between those with high versus low self-reported SFI scores. The odds ratio (OR) and its 95% credible lower limit (CLL_{os}) were

calculated. Results: 49 players self-reported a history of concussion. Rightleft asymmetry in reaction time (≥16% difference; OR = 3.26, $CLL_{05} = 1.04$), speed ($\geq 6\%$ difference; OR = 3.01, $CLL_{95} = 1.20$), and deceleration ($\geq 7\%$ difference; OR = 3.67, $CLL_{95} = 1.32$) discriminated between players with and without a history of concussion. Having 2 of 3 of these factors demonstrated 86% sensitivity and 61% sensitivity $(OR = 10.00, CLL_{95} = 3.23; \chi^2 (3) =$ 14.86; p = .002). No variables successfully discriminated between those with high versus low self-reported functional performance capabilities. However, asymmetries in reaction time ($\geq 15\%$; OR = 2.55, CLL₉₅ = 1.12), speed ($\geq 6\%$; OR = 5.56, CLL₉₅ = 2.22), and deceleration ($\geq 18\%$; OR = 3.28, CLL₉₅ = 1.16) were able to discriminate high versus low self-rated functional performance when the SFI was limited to items 3-7 (cut-off: ≤22 out of 25). Conclusions: Performance values derived from the reactive agility test effectively discriminated between participants with and without concussion history, as well as those with high versus low self-reported function. Our findings suggest that asymmetries in right-left reaction time, speed, and deceleration may contribute to elevated risk for musculoskeletal injury.

Proprioceptive Function is Impaired and Associated With Poor Patient-Reported Outcomes Following Hamstring Strain Injury DiTrani Lobacz A, An YW, Jaric S, Silbernagel KG, Swanik CB: Neumann University, Aston, PA; New Mexico State University, Las Cruces, NM; University of Delaware, Newark, DE

Context: Hamstring strain injury (HSI) continues to rank as a highly re-occurring medical problem in sport. Proprioceptive function has been largely overlooked in hamstring rehabilitation and research. Straining mechanisms during HSI may induce trauma to mechanoreceptors (spindles and GTOs), which would lead to inaccurate force regulation or limb positioning. It remains unknown if such deafferentation occurs with HSI, which could explain prolonged symptoms and poor outcomes known to persist following injury despite lengthy rehabilitation periods. **Objective:** To assess hamstring proprioceptive function and determine its relationship with patient-reported outcomes (PRO). It is hypothesized that deficits in force sense and joint position sense (JPS) occur following HSI and may be associated with poor outcomes, which could explain high re-injury rates. Design: Cross-sectional study. Setting: Neuromechanics research laboratory. Patients or Other Participants: Fifty-five participants (INJ: n = 28; 20.4 ± 1.2 yrs, 70.7 ± 14.1 kg, $172.5 \pm$ 9.9 cm) with a previous history of HSI and limb-matched controls (CON: n = 27; 20.7 ± 1.6 yrs, 70.9 ± 11.7 kg, 172.6 \pm 9.1 cm) volunteered for this study. Interventions: To examine force sense, participants held a target force (20%, 40% MVIC) by using the hamstrings to pull against the lever of a modified isokinetic dynamometer for 5 seconds with visual feedback provided. The participant then attempted to reproduce the same force without visual feedback. Joint position sense was measured blindfolded as the participant aimed to reproduce a knee flexion target angle (15° less than maximum flexibility) in the 90-90 position. PRO were quantified using the VISA-H, which examines function, pain, and activity. Main Outcome Measures: Force sense (Nm/ kg) and JPS (3 trial average,°) were recorded as absolute error (AE). VISA-H scores were based on a calculated total of 100. Paired samples and independent t-tests were employed to examine inter-limb and group differences. Pearson correlation coefficients were calculated

to examine relationships between dependent variables. Results: Force sense AE was significantly greater in the HSI limb (.319 \pm 23 Nm/kg) compared to the matched CON limb (.219 \pm .12 Nm/ kg) at 20% MVIC (P = .049). JPE AE was significantly greater in INJ (4.88 \pm 3.2°) compared to CON matched limbs $(2.15 \pm 1.7, \circ P < .001)$, as well as compared to the uninjured limb (2.64 ± 2.2) , $^{\circ}P$ < .001). VISA-H scores were significantly lower in INJ (82.86 ± 15.5 , P = .001) compared to CON (94.5 ± 6.3). VISA-H scores were significantly correlated with JPS AE in the injured/ matched limbs (r = -.41, P = .002). Conclusions: This was the first study to identify proprioceptive deficits in previously injured hamstrings and establish a relationship with PRO. Impaired mechanoreceptor function may alter neuromuscular function, leading to an over-stretching or inappropriate loading of the hamstrings during high-speed activity. Results may suggest evidence of ineffective binding of sensory input in the brain following HSI. Clinicians should consider assessments of force sense and JPS during HSI rehabilitation and future research exploring intervention strategies for hamstring proprioception and its relationship with re-injury is warranted.

Joint Position Sense Between Limbs and Groups



Changes in Lower Extremity Musculoskeletal and Neuromuscular Characteristics Are Associated With History of Lower Extremity Musculoskeletal Injury in Intercollegiate Athletes Faherty M, Csonka J, Salesi K, Moore T, Zarzour R, Sell T: Duke University, Michael W. Krzyzewski Human Performance Laboratory, Durham, NC; Department of Athletics, University of Pittsburgh, Pittsburgh, PA; Duke University, Department of Athletic Medicine, Durham, NC

Context: Lower extremity musculoskeletal injuries (LEMSI) continue to be a serious medical concern for intercollegiate athletes. LEMSI lead to changes in proprioception, strength, compromised functional joint stability, and re-injury. Examining the effect of history (HX) of LEMSI on musculoskeletal and neuromuscular characteristics will assist in the development of secondary injury prevention and rehabilitation programs. **Objective:** To determine differences in musculoskeletal and neuromuscular characteristics between intercollegiate athletes with and without a HX of LEMSI. Design: Cross-sectional study. Setting: Athletic Training Room. Patients or Other Participants: 158 intercollegiate male and female athletes participated. 116 with no history (NHX) of LEMSI (Age: 19.5 ± 1.4 years, Height: 180.5 ± 9.6 cm, Weight: 78.1 ± 14.1 kg) and 42 with HX of LEMSI (Age: 19.7 ± 1.1 years, Height: 180.7 ± 10.9 cm, Weight: 83.6 ± 23.6 kg). Interventions: LE flexibility tests included standing ankle dorsiflexion (SAD), active ankle dorsiflexion (AAD), active knee extension (AKE), and straight leg raise (SLR). Strength tests included ankle dorsiflexion/plantarflexion and inversion/eversion, hip abduction/adduction and internal/external rotation, and knee flexion/extension. Single-leg static balance (SB) and dynamic postural stability (DPS) were assessed using a force plate. Single-leg SB was assessed under eyes-open and eyes-closed conditions. Subjects stood on a single-leg, hands-on-hips, and maintained balance for ten-seconds. DPS was assessed as subjects jumped over 30.48cm hurdle from 40% of their height and landed on a single-leg. Main Outcome Measures: Flexibility tests including, AAD, AKE, and SLR were expressed as a mean value in degrees. Mean value in centimeters was analyzed for SAD. Isometric strength was expressed as mean peak force normalized to body weight (%BW). SB was expressed as the standard deviation of GRF composite score (SBC) and DPS was expressed as the dynamic postural stability index composite score (DPSIC). Component scores in the anterior/posterior (APSB, APSI), medial/lateral (MLSB, MLSI), and vertical (VSB, VSI) directions were calculated for SB and DPS. Data were assessed for normality. If normally distributed, between-group differences were assessed using independent samples T-tests; if normality was violated, Mann-Whitney U tests were utilized. Significance of <0.050 was established a priori. Results: Betweengroup (NHX of LE MSI vs. HX of LE MSI) differences yielded significant results for APSI (p = 0.012); athletes with HX of LE MSI demonstrated worse APSI. No between-group differences were noted for LE flexibility, strength, or SB. Conclusions: The observed between-group differences may indicate that changes in DPS persist after an athlete has returned to play (RTP). This difference may indicate a need for continued neuromuscular rehabilitation following RTP. Future research should determine the appropriate neuromuscular rehabilitation program to mitigate continued deficits in DPS.

Association of Neuromechanical Responsiveness With Time-Loss Lower Extremity Injury History Among Olympic Athletes Sowers DR, Rubingh SL, Wilkerson GB, Acocello S: University of Tennessee, Chattanooga, TN

Context: Data acquired from previous risk screening studies suggest that musculoskeletal injury risk may be elevated among athletes with suboptimal neuromechanical responsiveness. Reactive agility testing, which involves whole-body movement responses to visual stimuli, and dual-task assessment, which involves simultaneous imposition of cognitive and motor demands, may identify athletes who possess elevated injury risk. Objective: To assess the association between previously sustained time-loss lower extremity injuries and neuromechanical responsiveness among Olympic athletes. Design: Retrospective cohort study. Setting: Sports medicine clinic. Patients or Other Participants: 48 Olympic athletes (34 males, 14 females; 24.25 ± 4.45 years) representing a variety of sports. Interventions: Athletes completed 3 different 60-second visuomotor reaction time (VMRT) tests using the Dynavision® D2 system: a single-task mode (buttons illuminated until manually contacted), a dual-task mode that included verbal responses to 20 Eriksen flanker test 250-ms arrow displays (VMRT + FT), and a dualtask mode that included oral recitation of scrolling text (VMRT + ST). The TRAZER Sports Simulator® (Traq Global Ltd.) was used to quantify whole-body reactive agility (WBRA) performance in response to 10 left and 10 right visual targets that appeared in random order on a large monitor. The Sports Fitness Index was used to document injury history for the 12-month period prior to testing. Main Outcome Measures: Average VMRT and outer-peripheral to inner-central VMRT ratio (O/I) were assessed for each of the 3 VMRT test modes. Reactive agility measures included average and right-toleft asymmetries in speed, reaction time, acceleration and deceleration. Receiver operating characteristic, cross-tabulation, and logistic regression analyses were used to assess exposure-outcome associations. The odds ratio (OR) and associated 90% confidence interval (CI) were calculated to quantify both univariable and multivariable associations. **Results:** Strongest univariable associations with injury history were found for VMRT + ST $O/I \ge 1.28$ (OR = 5.25, CI: 1.72-16.03), VMRT + FT ≥825 ms (OR = 5.25; CI: 1.72-16.03) and WBRA deceleration $\leq 2.74 \text{ m/s}^2$ (OR = 4.00, CI: 1.41-11.32). Backward stepwise logistic regression analysis retained all 3 factors (model χ^2 [3] = 23.09; P<.001; Nagelkerke $R^2 = .510$), with ≥ 2 positive factors providing greatest discriminatory power (OR = 14.25, CI: 4.13, 49.15). Conclusions: Metrics derived from dual-task VMRT tests and the WBRA test provided strong collective discriminatory power to differentiate Olympic athletes who sustained a time-loss lower extremity injury in the past year from those who did not report such a history. Our findings may provide a mechanism to identify athletes who may derive greatest benefit from a risk-reduction intervention designed to address suboptimal neuromechanical responsiveness.

Associations of Neuromechanical and Behavioral Factors With Musculoskeletal Injury History

Guida E, Heidt D, Wilkerson GB, Acocello S: The University of Tennessee, Chattanooga, TN

Context: Sport-related concussion can affect visuomotor reaction time (VMRT), as well as psychoemotional status and sleep quality, which may elevate risk for musculoskeletal injury. Prior studies have demonstrated associations between concussion, sleep quality, slow VMRT, and suboptimal psychoemotional status, but the possible cumulative effect of these factors on musculoskeletal injury risk is not known. Objective: To examine associations between concussion history, psychoemotional status, neuromechanical performance, sleep quality, self-rated functional performance, and musculoskeletal injury history. Design: Cohort study. Setting: Exercise science laboratory. Patients or Other Participants: 204 college students (78 males/126 females; 21.9 ± 3.3 yrs, 172.3 ± 7.4 cm, $73.0 \pm$ 13.6 kg) participated. Interventions: All participants completed the Sport Fitness Index (SFI), the Pittsburgh Sleep Quality Index (PSQI), and the Depression, Anxiety and Stress Scale (DASS). VMRT was quantified by the Dynavision D2® system in two test modes: Proactive (buttons illuminated until manually pressed) and Reactive (buttons illuminated for 1 s with simultaneous oral recitation of scrolling text). A unilateral reactive hop test (URHT) was used to assess reactive agility performance. Participants were asked to hop in the direction indicated by a specified color pattern displayed by an array of 5 lights; 6 trials were performed per extremity. Main Outcome Measures: The SFI yields a 0-100 score, with higher scores indicating better self-rated functional performance. For both the PSQI and DASS, a higher score indicates more severe symptoms. VMRT performance was quantified using average reaction time (RT) and number of hits, as well as a peripheral-to-central performance ratio for both test modes. For the URHT, the time (ms) that elapsed between the 5 lights appearing and the participant completing a hop in the correct direction represented RT. Receiver operating characteristic and logistic regression analyses were performed to identify models that best discriminated those who had sustained a core or lower extremity sprain or strain within the previous 12 months from those who had not, using sleep quality, pschoemotional status, concussion history, and neuromechanical performance as predictors. The odds ratio (OR), its associated credible lower limit (CLL_{os}), and the risk ratio (RR) were calculated. Results: A 5-factor model included $PSQI \ge 8$, Reactive peripheral-to-central hit ratio ≤ 0.41 , positive concussion history, URHT RT of ≥ 1260 ms, female sex, and SFI ≤ 80 (≥ 2 factors: OR 6.50; $CLL_{95} = 2.56$, RR = 5.35; ≥ 3 factors: OR = 11.38; $CLL_{95} = 5.23$, RR = 6.84). Poor sleep quality (PSQI \geq 6) was associated with DASS subscores: depression ≥ 8 , OR = 7.94; anxiety ≥ 6 , OR = 5.02; stress ≥ 12 , OR = 4.87 (≥ 2 of 3 factors: OR = 8.00). Conclusions: Our findings support the use of screening procedures to quantify psychoemotional status, sleep quality, and neuromechanical performance for injury risk assessment. Psychoemtional dand sleep disturbances may adversely influence neuromechanical capabilities required for injury avoidance.

Free Communications, Oral Presentations: Transition to Clinical Practice

Thursday, June 28, 2018, 9:30AM-10:15AM, Room 217-219; Moderator: Jessica Barrett, PhD, ATC

Examining Initial Perceptions of Transition to Clinical Practice From the Perspective of Professional Master's Students Bowman TG, Mazerolle SM, Kilbourne BF, Barrett JL: Lynchburg College, Lynchburg, VA; University of Connecticut, Storrs, CT; Emory & Henry College, Emory, VA

Context: Newly credentialed athletic trainers are expected to be independent practitioners capable of making their own clinical decisions. Transition to practice can be stressful and present challenges for graduates who are not accustomed to practicing independently. Clinical education requires direct supervision, which can limit the chances for independent decision-making by students thus limiting skill development and increasing stress as they transition to practice. No studies to date have examined transition to practice in professional master's students. **Objective:** Examine perceptions of transition to clinical practice from current students in their last semester of a professional master's program. Design: Qualitative study. Setting: 9 higher education institutions. Patients or Other Participants: 14 athletic training students (7 male, 7 female, age = $25.6 \pm$ 3.7 years) participated from 9 different professional master's programs. At the time of the interview, participants were in the last month of their respective professional master's program or had graduated within the three weeks prior. 12 had passed the BOC exam at the time of the interview while 2 participants were scheduled to take the exam for the first time during a later exam window. Data Collection and Analysis: Participants completed a semi-structured interview over the phone. The interview guide was focused on the perception of preparedness for professional master's students to enter clinical practice, was developed based upon the literature and purpose of the study, and was pilot

tested prior to the start of data collection. All transcribed interviews were analyzed using a general inductive approach. Multiple analyst triangulation and peer review were used to ensure trustworthiness. Results: We found themes for facilitators and challenges to transition to autonomous clinical practice. Students felt prepared for independent practice due to 1) mentoring networks they had developed, 2) exposure to the breadth of clinical practice, and the 3) autonomy they experienced during clinical education. Participants noted preceptors, peers, and faculty as primary mentors they planned to contact for guidance during transition. Experiencing multiple patient cases and appropriate levels of autonomy during clinical education fostered readiness for transition. Potential challenges included making 1) timely difficult clinical decisions and 2) building confidence by practicing autonomously. Participants noted that making decisions while in stressful moments did cause them some anxiety and that building confidence would be something they would need to work at due to being solely responsible for clinical decisions after transitioning. Conclusions: Our findings suggest graduates from professional master's programs, although ready for clinical practice, may need support networks in place to assist in confidence building. Professional master's program administrators should work to provide clinical education experiences that expose students to a wide variety of clinical situations (patients, settings, preceptors) with appropriate professional role models while providing decision making autonomy within accreditation standards.

Mentorship Relationships: The Developmental Process for the Newly Credentialed Athletic Trainer and Mentor

Mazerolle SM, Walker SE: University of Connecticut, Storrs, CT; Ball State University, Muncie, IN

Context: Despite the documented evidence of the presence of mentoring relationships in athletic training, and the value perceived by the mentor relationship, we have little understanding about the process of development. Mentoring relationships are classified as dynamic, and evolving over time as the mentor and protégé matriculate through the phases of relationship development. **Objective:** Explore how mentoring relationships develop between the newly credentialed athletic trainer and their mentor. Specifically, we wanted to better understand the formality of the relationship, and the process in which it develops for the newly credentialed athletic trainer Design: Grounded theory Setting: Individual, semi-structured phone interviews Patients or Other Participants: 13 athletic trainers who graduated from a professional master's program, were certified between February and July of 2016, and obtained employment between July to August of 2016 participated in this study (6 female, 7 male, 26 ± 3 years; work settings included professional sports, college, secondary and middle school, and clinic). Data saturation guided the number of participants. Data Collection and Analysis: Phone interviews using a semi-structured interview guide were conducted at 3, 8 and twelve months of work experience. All interviews were audio recorded and transcribed verbatim. Data were analyzed using a constant comparative approach that was inductively grounded. Data were coded for common themes and subthemes. Credibility was established investigator through triangulation.

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peer debriefing, and member checks. Results: Participants identified a mentor who was an athletic trainer and could help increase their confidence, as their mentors had past experiences and/ or had served in the role they were beginning. Mentors were also sought due to the need for continued support and growth during the first year. The development of this relationship as described by our participants was done intentionally. Participants wanted a mentor who was available and willing to respond to questions as a means to ease their transition into clinical practice. The relationships between the mentor and mentee was informal in nature, and often initiated by participants but reciprocated by their mentor. The relationshop was not structured with planned meetings and goals and objectives. In the beginning 3 to 6 months of the relationship, participants reported communicating via various means (text, email, phone call, in person) with their mentor. As the participants gained role continuance, they communicated less frequently with their mentor due an increase in their perceived confidence and a better understanding of their role. Conclusions: Mentoring was identified as part of the transition process for the newly credentialed athletic trainer. As confidence and role understanding developed, the frequency and need for interactions between the mentor and mentee decreases. Results suggest that mentors facilitate transition to practice, as a means for continued reassurance and the relationship is evolving, and informal.

The Role Mentoring Plays in the Transition to Practice of Newly Credentialed Athletic Trainers Walker SE, Mazerolle SM, Rager, JL: Ball State University, Muncie, IN; University of Connecticut, Storrs, CT

Context: Mentoring has been identified as an important method to support newly credentialed athletic trainers during their transition to practice. It is, however, unclear how the mentor/mentee relationship develops and influences the transition. Gaining a better understanding of this relationship will provide valuable insights that may assist employers and professional programs to develop a plan, which could better facilitate the transition. **Objective:** To examine how the relationship between a newly credentialed athletic trainer and their mentor influences transition to practice. Design: Grounded theory. Setting: Individual phone interviews. Patients or Other Participants: 13 athletic trainers who graduated from a professional master's program, were certified between February and July of 2016, and obtained employment between July to August of 2016 participated in this study (6 female, 7 male, 26±3 years; work settings included professional sports, college, secondary and middle school, and clinic). Data saturation guided the number of participants. Data Collection and Analysis: Phone interviews using a semi-structured interview guide were conducted at 3, 8 and twelve months of work experience. All interviews were audio recorded and transcribed verbatim. Data were analyzed independently by two co-investigators using a constant comparative approach that was inductively grounded. Data were coded for common themes and subthemes. Credibility was established through investigator triangulation, peer debriefing, and member checks. Results: Participants recognized the mentoring relationship as a foundational aspect of the transition to practice. Participants discussed the personal attributes of their mentors

that positively affected their transition. Specifically, they needed a mentor who was available by phone, email, and/ or text and to answer questions, provide feedback and/or discuss ideas. Participants also valued honestly from their mentor, even when the feedback provided was constructively critical. Mentorship was viewed as a way to promote learning and professionally develop. Participants wanted to better themselves as an athletic trainer and learn from their mentor. Feedback was sought regarding topics such as patient care, communication, and networking. This feedback assisted participants in their decision-making and to gain a different perspective. The reassurance they received from their mentor was validating and helped to improve confidence. Participants appreciated having someone to discuss ideas and future actions. Conclusions: The mentor/mentee relationship is essential during the transition. Newly credentialed athletic trainers should seek a mentor who will be available to communicate in various ways and provide regular and constructive feedback. Mentors play an crucial role in educating and professionally developing newly credentialed athletic trainers. Future research should investigate how mentoring relationships influence other aspects of the transition such as patient care, overall job performance, turnover, and satisfaction.

Free Communications, Oral Presentations: Considerations for Junior Faculty Development

Thursday, June 28, 2018, 10:30AM-11:15AM, Room 217–219; Moderator: Kimberly Peer, EdD, ATC, FNATA

Junior Athletic Training Educators' Struggle With Role Conflict

Barrett JL, Mazerolle SM, Nottingham SL: University of Connecticut, Storrs, CT; Chapman University, Orange, CA

Context: An emerging theme in recent faculty preparation research is that doctoral preparation focuses heavily on research preparation and completion of the dissertation. This may occur to the detriment of learning teaching roles and understanding the balance of duties required in higher education. Graduates of terminal degree programs are likely aware of the tripartite responsibilities of scholarship, teaching and service associated with new faculty positions. However, they were probably not responsible for sole management and balance of all those facets during their doctoral preparation, causing problems when such balance is required in their new faculty position. Additional responsibilities of clinical practice or administrative duties may further complicate the transition to junior faculty. **Objective:** Gain an understanding of the role balance challenges for junior athletic training faculty who recently earned their doctoral degree. Design: Phenomenology Setting: CAATE accredited athletic training programs Patients or Other Participants: 4 male and 9 female junior athletic training faculty members with terminal degrees (11 PhD, 2 EdD). Participants averaged 1.5 (\pm .6) years in their current position. Data Collection and Analysis: Recruitment included full-time faculty, eligible for reappointment, in CAATE accredited programs, 1-4 years post-doctoral degree. Participants completed 1 telephone interview, which was digitally recorded and transcribed. The inductive framework of Interpretive Phenomenological Analysis was used to analyze the data. Expert review and piloting of the research guide followed by

multiple analyst triangulation and member checking ensured trustworthiness of the findings. Results: Participants described facing challenges when they are required to balancing the multiple responsibilities of their position. Heavy teaching loads and the significant amount of time required to prepare materials for new courses was particularly burdensome for junior faculty who may only have taught one or two classes in their doctoral program. Additionally, the research requirements of their new position were challenging because they were solely responsible for finding time and resources to carry out their research line. This role conflict caused role overload whereby the requirements of the faculty position are discrepant with the amount of time available to complete the expectations. Junior faculty with the additional responsibility of administrative work experienced greater overload. Conclusions: Junior athletic training educators are susceptible to experiences of role conflict, overload and imbalance after completion of their doctoral degree. The doctoral degree does not prepare them to balance the overwhelming multiple discrepant roles which creates feeling of unease and difficulty in their first few years on the job. Junior faculty must be taught strategies and exposed to a variety of experiences in their doctoral degree to adequately prepare them for their future role. Employers should develop approaches to decrease the burden placed on new faculty if they are to persist and succeed in their new roles.

Alignment of Athletic Training Doctoral Education and Faculty Workload

Nottingham SL, Mazerolle SM, Barrett JL, Coleman KA: Chapman University, Orange, CA; University of Connecticut, Storrs, CT

Context: In order to be successful in academia, athletic training faculty members need to be prepared to achieve in all aspects of their positions, including teaching, research, service, and oftentimes administration. This preparation primarily occurs during doctoral education. Some evidence suggests that doctoral education is incongruent with faculty responsibilities, but this has yet to be specifically investigated in athletic training. **Objective:** Examine the alignment between doctoral education and faculty workload from the perspectives of junior faculty members. Design: Phenomenology. Setting: Higher education institutions with CAATEaccredited programs. Patients or Other Participants: We used purposeful and snowball sampling procedures to recruit full-time faculty members who completed their doctoral education within the past 6 years. Participants included 20 athletic training faculty members (14 women and 6 men) who were 32 ± 3 years of age, averaged 10 ± 4 years of experience as athletic trainers, and had 2 ± 2 years' experience as a full-time faculty member. Participants primarily completed their doctoral education in high level research institutions (n = 17), whereas half held faculty positions in high level research institutions (n = 10). Data Collection and Analysis: We developed, peer-reviewed, and piloted 2 semi-structured interview guides to obtain participants' perspectives on their doctoral preparation, entrance into higher education, and faculty workload. We completed telephone interviews with each participant over the course of four months. Transcribed interviews were analyzed

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by 2 investigators using a phenomenological approach, then reviewed by 2 additional qualitative researchers. Upon completion of analysis, investigators determined that data saturation was obtained. Mechanisms of trustworthiness included member-checking, multi-analyst triangulation, and peer-review. Results: Three themes emerged from this study: 1) attractors to faculty position, 2) workload, and 3) congruency. Participants were primarily attracted to their faculty positions based on the alignment of workload to their professional goals. Faculty workload was dominated by teaching, but included several other responsibilities such as administration, service, and research. The actual time required to complete faculty responsibilities often exceeded participants' allotted workload, leading to challenges managing responsibilities during the first few years of their faculty position. Although most faculty positions focused on teaching, participants' doctoral education was usually more research-focused. This may be partially attributed to incongruence between doctoral education and faculty position institution type, since most participants were trained in high research level institutions but only half held faculty positions in these types of institutions. Conclusions: Athletic training faculty workload is generally teaching-focused and contains additional demands, such as service and administration, that are often not included in doctoral programs. Doctoral advisors should facilitate socialization to these additional responsibilities of faculty positions, in addition to orienting doctoral students to different institution types and how this influences faculty workload. Future faculty members should consider their interests and institution type when searching for doctoral programs and faculty positions.

Junior Faculty Members' Knowledge of Institutional Expectations for Tenure and Promotion Coleman KA, Nottingham SL,

Mazerolle SM: University of Connecticut, Storrs, CT; Chapman University, Orange, CA

Context: Evaluating faculty performance is often done via three primary areas, including teaching, research and scholarship, and service. Recent evidence suggests that doctoral students are aware of these basic tenets; yet lack the knowledge to navigate institution specific expectations for tenure and promotion. **Objective:** Examine the organizational socialization process for the junior Athletic Training faculty members as they learned more about the tenure and promotion expectations at their institutions. **Design:** Qualitative, Interpretative Phenomenological Approach. Setting: Higher education institutions with CAATE-accredited programs. Patients or Other Participants: 19 athletic training faculty members (13 women and 6 men) who were 32 ± 3 years of age and averaged 10 ± 4 years' experience as athletic trainers and 2 ± 2 years as a faculty member. Participants who met the inclusion criteria were identified through professional networks of the researchers and an additional snowball sampling process. Data saturation guided the total number of participants for this study. Data Collection and Analysis: A peer reviewed and piloted, semi-structured one-on-one phone interview was used to facilitate a recall of the junior faculty member's experiences with transition into their current positions and how they were made aware of the promotion and tenure expectations. The interviews were recorded and transcribed verbatim for analysis purposes. Transcribed interviews were analyzed by 2 investigators using a phenomenological approach and then peer reviewed by 2 additional qualitative researchers. Member checks were also completed to support credibility of the

results. Results: Three themes emerged from this study regarding junior faculty member understanding of tenure and promotion guidelines: 1) vague expectations, 2) change in leadership impact on expectations, 3) differing expectations in departments and university levels. While junior faculty members acknowledged that the tenets of promotion and tenure were clear, they identified that the expectations were not quantifiable. Most junior faculty observed that a change in leadership within the department or university caused a shift in expectations, resulting in confusion. Additionally, faculty members perceived that the promotion and tenure guidelines across departments and colleges lacked congruency, which led to uncertainty and difficulty navigating the process. Improvements in the orientation process involving communication, feedback, and support can clarify the expectations. Conclusions: Junior faculty members perceive that tenure and promotion guidelines are challenging to navigate. The confusion that these junior faculty members have is not about the general tenets of tenure and promotion, but rather the institutional differences that exist. The orientation process can be improved through formal ongoing feedback, informal communication and mentorship, and instructional scaffolding. These mechanisms provide junior faculty members with opportunities for institutional and social support, clear expectations, and quantifiable guidelines for promotion and tenure.

Free Communications, Rapid Fire Oral Presentations: Injury Risk Factor Identification and Prediction

Thursday, June 28, 2018, 5:15PM-6:30PM, Room 217-219; Moderator: Marc Norcross, PhD, ATC

Preseason Risk Factors to Predict Lower Extremity Musculoskeletal Injuries in College Athletics

Semrow KM, Sciascia AD, Nitz AJ, Uhl TL: University of Kentucky, Lexington, KY; Eastern Kentucky University, Richmond, KY

Context: Current research intends to expand the preseason physical examination to go beyond medical clearance by identifying preseason risk factors that could predict the occurrence of musculoskeletal injuries. Objective: Assess subjective and objective aspects of physical function, as well as an athlete's previous injury history, to determine if the prediction of future lower extremity injuries can be made utilizing a multifactorial approach. We hypothesized that low pre-season subjective and objective scores, combined with a reported history of injury would best identify athletes with a risk of an in-season lower extremity injury. Design: Prospective cohort study. Setting: University Athletic Training facilities. Patients or Other Participants: A total of 746 participants from 3 collegiate institutions were recruited to participate in the study. There were 51 participants who sustained a knee injury and 43 participants who sustained an ankle injury during the study. Interventions: After collecting demographic information, participants completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) and Foot and Ankle Disability Index (FADI) questionnaires. They then completed 2 physical performance tests, the single leg hop for distance (SLH) and the anterior reach of the star excursion balance test (SEBT). Members of the research team were informed by an athletic trainer at each institution when an injury to the knee or ankle occurred, and recorded injury location, side of the body, and type of injury. Main Outcome Measures: At the end of data collection, participants

were dichotomously categorized as injured or non-injured for data analysis. A multi-logistic regression analysis was used to examine the strength of group identification based on the results from Pearson and chi-square correlations. Models were created based on individual factors, as well as a combination of statistically significant factors to examine a predictive effect on injury. Results: The model predicted that history of a left knee injury increases the risk for a right knee injury ($R^2 =$ 0.314, p = 0.007, OR = 19.5, 95%CI = 2.3, 166) and decreased risk to re-injury to the ipsilateral knee ($R^2 = 0.314$, p = 0.007, OR = 0.051, 95%CI = 0.01,0.44). Conclusions: Consistent with previous literature, a reported history of injury predicts future injury, but is specific to the knee. Preseason screening can identify athletes that would be at risk for a contralateral knee injury and preventative methods could be incorporated to reduce the risk of another injury from occurring.

Exploring the Relationship Between Aerobic Fitness, Functional Movement, Injury and Patient Reported Outcomes in Women's Lacrosse Bindel ME, Cattano NM, Heinerichs S: West Chester University of Pennsylvania, West Chester, PA

Context: The focus of injury prevention programs has begun to shift from solely a movement based approach to an overall well-being approach by utilizing a number of assessments to address the multifaceted nature of injury risk. Previous studies have looked at the impact of functional movement score (FMS) and aerobic fitness (VO,max), and injury. No studies have included patient reported outcomes (PRO) as a means of assessing overall well-being and very few have PRO over the course of a competitive athletic season. **Objective:** To compare patient reported outcomes over the first 4 weeks of a season between individuals with fair VO, max vs. good VO, max and between individuals with high vs. low FMS composite scores. Secondarily, we wanted to examine if there was a relationship between FMS scores and estimated VO2max. Design: Prospective Cohort Study. Setting: Division II University. Patients or Other Participants: Twenty-four healthy NCAA Division II women's lacrosse athletes (age: $19.8 \pm$ 1.0 years). Interventions: The independent variables are the high (score>14) and low (≤ 14) groupings for the FMS composite scores as well as fair $(VO_{2}max \le 41.5)$ and good $(VO_{2}max)$ > 41.5) groupings according to ACSM normative values for female VO₂max scores. The participants completed the FMS and Yo-Yo Intermittent Recovery Level 1 aerobic fitness test prior to the start of preseason and completed a daily readiness questionnaire via email. The results were analyzed using independent t-tests and Pearsons correlations.

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A priori statistical significance was set at $P \le 0.05$. Main Outcome Measures: The dependent variables were the averaged patient reported outcome responses for each of the six questions on the questionnaire at the one, two, three, and four week marks. Results: Average VO₂max score was 41.52 ± 1.51 and FMS composite score was 13.33 ± 2.51 for all participants. There was a difference in estimated VO₂max scores among those who sustained an injury and those who did not sustain an injury (Injury: 42.8mL/min/ kg \pm 1.4, No Injury: 41.0mL/min/kg \pm 1.2; p = 0.006). A strong positive correlation was found between injury and aerobic fitness (r = 0.574, p = 0.006). There were also differences between aerobic fitness groups in questionnaire responses in the averaged week 3 mood (Fair: 1.90 ± 0.14 , Good: 2.50 ± 0.92 ; p = .01) and RPE (Fair: 2.69 ± 1.05, Good: 3.68 ± 0.99 ; p = 0.04). There was no difference between the injured and non-injured groups for FMS composite scores. Conclusions: Those with higher aerobic fitness were found to sustain more injuries throughout the course of the season in addition to reporting worse PRO's for mood and RPE over the course of the third week of training. There was no difference in FMS scores among those who sustained an injury and those who did not indicating aerobic fitness testing could be a more useful assessment in addressing injury risk.

Assessment of Injury Risk Screening Methods for Identification of Functional Impairment

Baker CS, Mollner KE, Zimmerman JA, Dunham WF, Colston MA, Wilkerson GB: The University of Tennessee, Chattanooga, TN

Context: More than half of all injuries reported by high school and college athletes are lower extremity sprains and strains, which can lead to chronic disability. Ankle sprains in particular account for 20% of all injuries treated in ERs, which can increase risk for subsequent injury to any component of the kinetic chain. Targeted interventions for modifiable injury risk factors have the potential to prevent sport-related injury. Injury risk screening can identify individuals who have the greatest potential to benefit from targeted training. Risk screening should include objective measures of performance capabilities and self-ratings of post injury effects. The Sports Fitness Index (SFI) is a 10-item survey that represents global function. **Objective:** To assess associations among injury risk screening measures that included the Ankle Instability Index (AII) and SFI, and the extent to which participants who exhibited self-reported ankle instability also had decreased global measures of function **Design:** Survey Setting: A 1-time electronic survey administered via the Research Electronic Data Capture system (RedCapTM). Patients or Other Participants: 206 college students enrolled in exercise science classes; n = 55 males: 22.3 ± 3.9 years; 178.3 ± 7.9 cm, 79.9 ± 15.2 kg; n = 151 females: 21.3 ± 2.3 years; $166.1 \pm$ 6.9 cm, 65.7 ± 12.1 kg. Interventions: The SFI, a 12-month time-loss injury questionnaire, and the AII were administered electronically via survey link to participants' emails. Any self-reported musculoskeletal injury that resulted in time lost from activity during the previous 12-month period was classified as an injury. Classification of cases as having ankle instability was based on at

least 5 "yes" responses among 9 items comprising the AII. Main Outcome Measures: The SFI was scored on an 0-100 scale. The AII was used to indicate if participants self-reported ankle instability. Exploratory analysis was performed to identify any associations among SFI responses, self-reported injury history, and ankle instability. Receiver operating characteristic (ROC) analyses were used to define cut-points for binary classifications. Cross-tabulation analyses performed to assess strength of associations between binary predictor and status variables. Results: Very strong association identified between SFI \leq 80 and self-reported time-loss musculoskeletal injury during previous 12-month period (Sensitivity 96%; Specificity 40%; $\chi 2(1) = 14.04$; p < .001; OR = 17.92; 95% CI: 2.38, 134.83). Very strong association identified between SFI \leq 76 and ankle instability (Sensitivity 92%; Specificity 49%; $\chi 2(1) = 16.06$; p < .001; OR = 11.74; 95% Confidence Interval: 2.69, 51.14). Conclusions: Our findings revealed that SFI scores appear to provide an exceptionally good means to quantify persisting adverse effects of previous injuries on functional capabilities. Self-ratings of functional capabilities obtained from SFI items can provide information that is highly relevant to injury risk screening, and may serve as a means to identify individuals who need further assessment and/or intervention to improve function and reduce injury risk.

Center of Pressure Regularity Association With Future Noncontact Lower Extremity Injury

Samson CO, Lafe CW, Brown CN: University of Georgia, Athens, GA; Oregon State University, Corvallis, OR

Context: Optimal movement variability is suggested to reflect nervous system adaptability and flexibility response to external stimuli, while too little or too much regularity have been associated with musculoskeletal injury. However, it is unknown if center of pressure (COP) regularity during clinical tests is associated with injury. **Objective:** To determine if anterior-posterior (A-P), medio-lateral (M-L), and resultant (RV) COP regularity during the Functional Movement Screen (FMS) hurdle step is associated with noncontact lower extremity (LE) musculoskeletal injury controlling for previous LE injury frequency. We hypothesized more regular COP trajectories in either plane at baseline is associated with subsequent noncontact LE injury. Design: Cross-sectional study. Setting: Biomechanics Laboratory. Patients or Other Participants: Collegiate club lacrosse, rugby and ultimate frisbee athletes (n = 46; 32 female (12 rugby))16 lacrosse, 4 ultimate), 14 male (14 ultimate); age = 20.2 ± 1.5 yrs; height = 174.6 ± 18.5 cm, mass = 70.8 ± 8.8 kg). Interventions: Participants underwent testing and previous injury screening prior to the competitive season. Ground reaction forces in A-P and M-L directions were recorded with force plates (960Hz) during three trials of the FMS hurdle step for both limbs. COP A-P and M-L trajectories were filtered with a 4th-order low-pass Butterworth filter (10Hz). Multiscale Entropy (MSE) values were calculated to determine regularity of the COP trajectories. Participants completed a weekly survey self-reporting physical activity and injuries occurring for one competitive season. Main Outcome Measures: MSE values were calculated for the limb of interest, identified as the limb subsequently injured or the dominant limb in those uninjured. Point-biserial correlations were used to determine association between MSE values for A-P, M-L, and RV COP and presence of noncontact LE injury($\alpha = 0.05$). One-way ANCOVA was used to determine if A-P, M-L, and RV COP MSE values differed between those sustaining a noncontact LE injury and those without, controlling for previous injury frequency ($\alpha = 0.05$). Results: Of 73 injuries reported, 42 (58%) were identified as noncontact LE injuries. One injury per participant was used in the final analysis (n = 25); the injury with the shortest time lapse since testing was used for those with multiple injuries. In-season noncontact LE injury was not significantly correlated with A-P, M-L, or RV COP MSE values $(p > .05; \text{ power } (1-\beta) = .05-.25).$ No significant differences in A-P, M-L, or RV COP MSE mean values between injured and uninjured participants adjusting for previous injury frequency were identified $(p > .05; \text{ power } (1-\beta) =$.55). Conclusions: COP regularity was not associated with subsequent injury and did not significantly differ between injured and uninjured populations at testing. COP regularity during the hurdle step may not be adequate to identify populations predisposed for injury prior to an injury occurring due to the translation of hurdle step to sport demands. Greater power may be necessary to identify a task that better reflects nervous system flexibility and adaptability associated with common injuries.

Analysis of Patellar Tendinopathy Risk Factors Among Intercollegiate Athletes: A Matched Case-Control Study Reisler TC, Harter RA, Housman JM, Pickerill ML: Dickinson College, Carlisle, PA; Texas State University, San Marcos, TX

Context: Patellar tendinopathy affects as many as 50% of collegiate athletes participating in sports that involve jumping, e.g., basketball, volleyball. A recent systematic review of patellar tendinopathy research identified 40 intrinsic and extrinsic variables that have been investigated as risk factors for patellar tendinopathy, so many clinical measures that the authors could not perform the meta-analysis they intended. The Landing Error Scoring System (LESS) test has primarily been used to screen for neuromuscular deficits that may predispose an athlete to an ACL injury; however, it has been suggested that deficits found by a LESS screening could be useful in predicting an athlete's risk for other lower extremity injuries. **Objective:** To evaluate the known and hypothesized risk factors for patellar tendinopathy among male and female NCAA intercollegiate athletes to determine which outcome measures are most predictive of acquiring this condition. Design: Case-control. Setting: Research laboratory setting. Patients or Other Participants: 60 intercollegiate athletes (age, 20.0 ± 1.2 yrs; height, 178.9 ± 9.8 cm; mass, 80.9 \pm 16.5 kg). Volunteers who presented with chronic patellar tendon pain and scored <80 on the 100-point Victorian Institute of Sports Assessment-Patella (VISA-P) questionnaire were assigned to the Case group. Volunteers without knee pain and a VISA-P score of >80 were assigned to the Control group. Interventions: We utilized a 2:1 ratio of non-injured (n = 40) to injured athletes (n = 20) for a logistic regression analysis, creating 20 triads matched on sex and age (+5 yrs). Main Outcome Measures: A Condition (2) x Sex (2) ANOVA approach was used to identify group differences for 4 variables: standing Q-angle, BMI, waist-to-hip ratio, and 17-point LESS score ($\alpha = 0.05$). Odds ratios were calculated using conditional logistic regression in effort to identify the extent to which these 4 factors increased the risk of patellar tendinopathy. Results: As expected, ANOVA results indicated that the average Q angle for female participants $(14.6 \pm 3.6 \text{ deg})$ was significantly greater than the male participants (10.1 ± 3.2) deg) (p = 0.03). The Case group's LESS scores (4.4 ± 1.4) were not statistically different from the Control group $(3.8 \pm$ 1.3) [p = 0.11]. Results of the logistic regression analysis did not reveal any significant increased risk of patellar tendinopathy associated with standing Q angle, LESS scores, BMI, or waistto-hip ratio (p > 0.05). Conclusions: Our findings indicated that standing Q angle, BMI, waist-to-hip ratio and LESS test score were not significant predictors of patellar tendinopathy risk in this sample of intercollegiate athletes. Future studies should involve prospective, longitudinal experimental designs with a similar population, but employ different outcome measures in the continuing effort to establish causal relationships for patellar tendinopathy.

The Risk of Match Injuries in Amateur US Men's Rugby

Lopez V, Marcano ED, Ma R, Hume PA, Cantu RC, Victoria C, Mettry MT, Pierre DM, Pandit KV, Allen AA: Rugby Research and Injury Prevention Group, Hospital for Special Surgery, New York, NY; Auckland University of Technology, Sports Performance Research Institute, Auckland, NZ; Rugby Codes Interdisciplinary Research Group, NZ; USA Rugby Empire and New England Geographic Union RFUs, New York, NY, and Boston, MA: Northeast Rugby Academy, USA Rugby Development Program, USOC-Community Olympic Development Program, New York, NY; PHLEX NYC Physical Therapy & Advanced Recovery Studio, New York, NY; University of Missouri, Missouri Orthopaedic Institute & Thompson Laboratory for Regenerative Orthopaedics, Columbia, MO; Auckland University of Technology, School of Sport & Recreation, Founder, Sports Performance Research Institute New Zealand, Founding Member SPRINZ Rugby Codes Interdisciplinary Research Group, Associate Member, National Institute for Stroke and Applied Neurosciences (NISAN), Director SPRINZ J.E. Lindsay Carter Kinanthropometry Clinic & Archive, Auckland, NZ; Center for the Study of Traumatic Encephalopathy, Boston University School of Medicine, Boston, MA; Department of Neurosurgery and Sports Medicine, Emerson Hospital, Concord, MA; Neurologic Sports Injury Center, Brigham and Women's Hospital, Boston, MA; Sports Legacy Institute, Waltham, MA; World Rugby, Independent Concussion Group, Dublin, Ireland; New York University, Global Institute of Public Health, New York, NY; City University of New York, City College, New York, NY; State University of New York, Stony Brook, Suffolk, NY; Hofstra University, Hempstead, NY; Sports Medicine and Shoulder Service,

Hospital for Special Surgery, New York, NY; National Basketball Association, New York Knickerbockers, New York, NY; USA Basketball, Colorado Springs, CO

Context: Rugby-7s is an emerging Olympic collision sport in the U.S. International elite play among both genders, has a high incidence of injury. Injury data on U.S Rugby-7s is lacking. **Objective:** To provide match injury epidemiology data for U.S. Rugby-7s. Rugby-7s (7-players-a-side rugby union) is an emerging Olympic collision sport in the U.S. Rugby Union in the U.S. has seen exponential participation and growth, played on greater than 425 university campuses, and considered a strategic market for World Rugby (Chadwick, Center for the International Business of Sport, Coventry University 2010; WorldRugby.org). International elite play has been found to have a high incidence of injury (men = 106/1000ph & women = 187/1000ph) (Fuller CJSM 2010, Gabb BJSM 2014). Injuries in U.S. rugby are not well studied and even less on U.S. Rugby-7s with a significant head/ neck injury rate reported in the amateur to elite U.S. Rugby-7s cohort (Lopez AJSM 2012, Lopez OJSM 2014; Lopez MSSE 2016). U.S. Rugby's relegation to club status, including at the collegiate level, has resulted in its exclusion from instituted injury surveillance systems (NCAA-ISS, National Federation of HS & National Catastrophic Injury in Sport). Knowledge on the incidence and mechanism of injuries will guide appropriate sports medicine protocols necessary for this sport. Athletic trainers will need to be notified of the mechanisms of injuries and severity encountered to guide care. Design: Prospective epidemiology study. Setting: USA Rugby-sanctioned national tournaments (39 U.S. Cities). Patients or Other Participants: Male U.S. players (n = 7565) competing at various levels: college; adult/ senior; sub-elite; and elite. Interventions: Injury data knowledge injury data will provide population-specific evidence-based data to guide injury prevention protocols for the U.S. playing

cohort. Main Outcome Measures: Incidence rate of all time-loss injuries and severity captured via the Rugby Injury Survey and Evaluation (RISE) methodology (2010-2014). Results: Rugby-7s male time-loss match injuries occurred at 49.9/1000 ph (CI: 43.9-56.6) or 11.7/1000AE (CI: 10.3-13.2) (n = 243). Higher injury rates were observed among sub-elite (18.0/1000 AE), elite (15.5/1000 AE), adult (11.7/1000 AE) and lowest among collegiate (3.7/1000 AE) players. Mean injury severity of 27 days (CI: 22.7-31.5) before return to sport was noted. Most injuries occurred to the lower extremity (43.2%). Most commonly injured body part was the head/face (20.2%). Recurrent injury rates were frequent at 22% (71% occurring within 12 months). Concussions were 13.2% of all time loss injuries, with a mean severity of 27.4 days (CI: 19.4-35.3). Conclusions: Our observed injury rates were lower than those reported in elite international cohorts. Tackling is the most common cause of injury in our cohort, education in tackling technique may be important in the prevention of injuries among all levels. Knowledge among playing levels and age groups would guide sport-specific data to nurture welfare and safety protocols. This knowledge would educate and prepare the current and future athletic training population on what types of injuries to address in this emerging sport. The potential to guide care at these events will promote safe growth of Rugby-7s.

Functional Asymmetries and Lower Extremity Injury: Direct and Indirect Effects

Clifton DR, Yang J, Best T, Chaudhari A, Comstock RD, Persch A, Onate JA: School of Health and Rehabilitation Sciences, The Ohio State University, Columbus, OH; Jameson Crane Sports Medicine Institute, The Ohio State University, Columbus, OH; Nationwide Children's Hospital, Columbus, OH; University of Miami, Coral Gables, FL; University of Colorado-Anschutz, Aurora, CO

Context: An inherent risk of lower extremity (LE) musculoskeletal (MSK) injury occurs during athletic participation. Methods for identifying individuals most likely to sustain injuries during sport participation have been studied in an attempt to develop injury prevention programs. To date, no gold standards exist for identifying athletes at highest risk. This gap in knowledge may result from a focus on risk factors' direct effects on injury and a lack of understanding of their indirect effects. Objective: Identify direct and indirect effects of functional performance asymmetries, as well as drop landing technique, on odds of LE MSK injury in boys' and girls' high school soccer and basketball athletes. Design: Prospective cohort study. Setting: High school soccer and basketball athletics. Patients or Other Participants: Male and female high school soccer and basketball athletes. Interventions: Prior to the start of their competitive sport season participants underwent four functional assessments: ankle dorsiflexion (DF) range of motion (ROM) asymmetry, single leg anterior reach (SLAR) asymmetry, anterior single leg hop for distance (SLHOP) asymmetry, and Impression Landing Error Scoring System (iLESS) performance. Participant questionnaires also captured age, sex, sport, and injury history. Main Outcome Measures: LE MSK injury data were reported throughout each

sport season by certified athletic trainers using the injury surveillance system High School Reporting Information Online. Linear and logistic regressions were used to assess whether any of the four functional performance variables were directly or indirectly related to LE MSK injury. An example of an indirect effect was SLAR asymmetry increasing injury risk by increasing SLHOP asymmetry. Statistical significance was set a priori at $p \le 0.05$. Statistical significance of indirect effects were assessed using 95% bootstrapped confidence intervals (CI); an indirect effect was considered statistically significant if the 95% bootstrapped CI didn't include 0.00. Results: Participants included 1,384 males (age = 15.66 ± 1.22 years, height = 1.77 ± 0.09 m, weight = 68.97 \pm 13.15 kg) and 1,261 females (age = 15.49 ± 1.17 years, height = 1.65 ± 0.07 m, weight = 60.54 ± 10.12 kg). None of the four functional performance measures were directly or indirectly related to injury. Only injury history was significantly related to future LE MSK injury. Patients who reported a previous injury were 2.21 (95% CI = 1.38, 3.53, p = 0.001) times more likely to suffer a future LE MSK injury. Conclusions: Ankle DF ROM asymmetry, SLAR asymmetry, SLHOP asymmetry, and iLESS performance were not related to LE MSK injury, directly or indirectly, and therefore may not be helpful in identifying high school athletes at greatest risk of injury. Future research should evaluate the predictive power of other functional performance tests. Injury history was directly related to an increased likelihood of future injury, highlighting the need to obtain accurate injury history during pre-participation evaluations and the ongoing need to develop effective primary injury prevention programs.

Higher Odds of Collegiate Lower Extremity Injury in Student Athletes With History of Lower Extremity Surgery Before Entering College Athletics

McCullough JI, Sanfilippo JL, Kliethermes SA, Brooks MA: University of Wisconsin, Madison, WI

Context: Injury rates in high school athletes continue to rise, including lower extremity (LE) surgeries. LE surgeries can have significant short and long-term impacts including shortening the playing career of high school, collegiate and professional athletes. One recent study has shown that previous knee surgery leaves collegiate athletes more susceptible to future knee injury, especially those requiring another surgery; however there is limited research on other LE surgeries and risk of subsequent injury in collegiate athletes. Objective: Compare the risk of LE injury during collegiate sports participation in athletes with history of LE surgery to those with no history of LE surgery prior to collegiate enrollment. Design: Retrospective cross-sectional review. Setting: Divison 1 collegiate athletics. Patients or Other Participants: 354 athletes from 12 sports [basketball (BB), football (FB), golf (G), ice hockey (HK), soccer (SC), softball (SB), volleyball (VB), and wrestling (WR)] Interventions: All athletes were grouped based on a medical records review indicating if they had sustained a lower extremity surgery within 5 years preceding their freshman year of college (surgical group N = 35: BB N = 1,3%; FB N = 13,37%; GF N = 0, HK N = 5,14%; SC N = 9,26%; SB N = 0, VB N = 2,6%; WR N = 5,14%). Main Outcome Measures: Independent T-tests compared the surgical and non-surgical group based on number of non-contact injuries during collegiate participation, days to first collegiate injury, and days lost with first injury. To further examine odds of LE injury among the two groups, multivariable models were used to control

for years of participation and number of competitions. Results: A higher proportion of athletes with history of LE surgery prior to collegiate enrollment sustained a non-contact LE injury during their collegiate participation compared to athletes with no history of LE surgery [69% (24 athletes sustaining a total of 35 injuries) in the surgical group vs 40% (127 athletes sustaining a total of 319 injuries) in the non-surgical group, p < 0.001]. Controlling for years of participation and number of games played, athletes with a previous history of LE surgery prior to participation in collegiate athletics had a 2.82 times higher odds of sustaining a subsequent collegiate LE injury than those without a history of LE surgery (OR 2.82, 95% CI:1.29 - 6.17, p = 0.009) prior to participation in collegiate athletics. There was no significant difference in days to first collegiate injury [192.5 (221.6) vs 271.3 (273.8), p = .20], or days lost with first injury [34.39 (36.91) vs 32.77 (66.87), p = 0.87] comparing LE surgical group to non-surgical group. Conclusions: Athletes who entered collegiate athletics with history of LE surgery were at almost three times higher odds to sustain a time loss LE injury during their collegiate sports participation than their peers with no surgical history. More extensive collegiate pre-participation exams, screening and interventions may be necessary to reduce injury risk.

Free Communications, Rapid Fire Oral Presentations: Delivery of Health Care in the Collegiate Setting

Friday, June 29, 2018, 7:00AM-7:45AM, Room 217-219; Moderator: Brant Berkstresser, MS, ATC, LAT

Assessment of the Delivery of Athletic Health Care at the Division I Football Championship Subdivision-Level

Sawyer QL, Valovich McLeod TC, Welch Bacon CE, DeZeeuw T: A.T. Still University, Mesa, AZ; Phoenix Suns, Phoenix, AZ; Colorado State University, Fort Collins, CO

Context: There are concerns about adequate staffing, the consistency of quality medical care, and organizational preparation for the changing landscape of professional athletic training education at the Division I Football Championship Subdivision (FCS) level. The Appropriate Medical Coverage for Intercollegiate Athletics document (AMCIA) assesses university demographics to ensure adequate athletic trainer (AT) staffing; however, a previous study of Division I Football Bowl Subdivision institutions showed they typically did not have the recommended number of ATs. Objective: To determine the degree which Division I FCS institutions utilize the AMCIA to meet staffing recommendations. Design: Cross-sectional Setting: Web-based survey Patients or Other Participants: 53 of 125 ATs (42.4% response rate; age = 43.4 ± 9.7 years, AT experience = 20.7 ± 8.1) with knowledge of budget and staffing at their FCS institution completed the survey. Interventions: Participants were solicited via email to complete the Incorporation of AMCIA Guidelines at NCAA FCS-level Institutions survey. The survey was modified from a previously validated survey; questions about organizational use of AMCIA for staffing decisions were used for this inquiry, along with questions about preparation for the change in athletic training professional education and the institution's use of graduate assistants. Main Outcome Measures: The dependent variables were participants' responses to the survey items. Descriptive analyses (mean

 \pm SD, frequencies, percentages) were utilized to describe institutional characteristics and assess familiarity with and use of AMCIA for staffing decisions, including changes to the graduate assistant model. Results: The number of full-time ATs on staff was 6.2 ± 3.0 (range = 1-14). Only half of respondents (n = 27/53) stated they use or used the AMCIA at their university. For those who responded yes, 96.3% (n = 26/27) listed increased staffing as a reason, while 40.7% listed curiosity. For those who responded they did not use the AMCIA, 52.6% (n = 10/19) felt their efforts would be futile due to lack of funding, while 26.3% (n = 5/19) listed unfamiliarity with the AMCIA, and 26.3% (n = 5/19) listed lack of administrative support. Fifty percent (n = 23/46) reported having graduate assistant (GA) ATs on staff $(7.2 \pm 5.5, \text{ range } 1-14)$ with 60.4% (n = 32/46) investigating the impact of the degree change on staffing. The majority (56.3%, n = 18/32) were unsure how GA positions would be filled, while others considered hiring interns (37.5%, n = 12/32), full-time staff (31.3%, n = 10/32), part-time staff (9.4%, n = 3/32), subsidizing clinic/ outreach (15.6%, 5/32), or developing a residency program (12.5%, n = 4/32). Conclusions: Almost half of FCS institutions failed to utilize the AMCIA to make staffing decisions, primarily due to financial constraints of the organizations and administrative resistance. Further, most institutions will need to make significant decisions regarding staffing as graduate assistantship positions are phased out. While many ATs are unsure of how they would fill this void, utilization of the AMCIA is one method others have used to justify increased staffing needs.

A Descriptive Analysis of the National Collegiate Athletic Association Division I Sports Medicine Staff

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Context: Females comprise more than half of the National Athletic Trainers' Association membership, but their representation in Power Five conferences has not been identified. Objective: Determine the distribution of female and male head athletic trainers (AT) in the NCAA Division I Power Five conferences and the frequency of same-sex and opposite-sex sport assignments. Design: Cross-sectional. Setting: Webbased information retrieval. Patients or Other Participants: The 65 universities in the Power Five Conferences (the Atlantic Coast Conference, the Big 12, the Big 10, the Pac-12, and the Southeastern Conference [SEC]) were used for this study. Twelve sports were used to determine healthcare coverage: football, men's and women's basketball, men's and women's soccer, baseball, softball, volleyball, wrestling, and women's gymnastics. Co-ed sports (i.e., swimming and diving, and track) were excluded from the study. Interventions: The universities' athletic department websites were used to locate data. The individual designated as the "head athletic trainer," "director of sports medicine," or similar title (Director) was identified as female or male (in cases of ambiguous participants, a search was performed to determine biologic sex). Primary sport healthcare responsibilities were identified to determine the sex of the provider relative to that of the team. Cases were excluded if institutions did not offer the specific sport or the AT assignment was not listed. Main **Outcome Measures:** Frequencies of same-sex to opposite sex health provisions and leadership (Director) were tabulated for the sample as a whole and

for each conference. An odds ratio was calculated to determine the distribution of same-sex to opposite-sex sport assignment. Results: Of the 65 universities we identified the roles of 780 ATs and 65 Director positions, of which 56 males (86%) and 9 (14%) females were identified as Director. All conferences except the SEC had at least one female Director. Same-sex sport assignments were more frequent for all sports (N = 492, 63.1%). Opposite-sex sport assignments occurred more frequently with female sports being assigned a male AT, with women's soccer having 19 male ATs (29.2%) and softball having 13 (20.0%). Football and men's soccer had the most female ATs assigned to the teams with 4 (6.2%) each. The odds ratio for the overall group data was 2.42; CI = 1.42, 4.11, indicating that there was a 2.42 higher chance that the sports would have a same-sex AT assigned. Conclusions: Females are underrepresented in the Director role in the Power Five conferences. Most collegiate healthcare services are provided by individuals having the same sex ATs as the team. Opposite sex sport assignment occurred most frequently in cases where male ATs were assigned to female sports. Football and men's soccer accounted for the highest number of female ATs working with opposite-sex sports.

Organizational Culture's Effect on Injury Treatment Decision Making

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Context: Athletic trainers (ATs) are often faced with making difficult decisions, especially pertaining to athletes' readiness to return-to-play following injury. Values of ATs and coaches are often dichotomous, and the pressure to make premature return-to-play decisions either to satisfy a coach or for job security purposes does not allow ATs to operate in the best interests of athletes. Currently, it is unknown how pressures from coaches may alter decision making of ATs. **Objective:** To investigate the occurrence of organizational conflict regarding medical decisions of ATs across various athletic affiliations. Design: Online survey. Setting: Collegiate setting (National Collegiate Athletic Association (NCAA), National Association of Intercollegiate Athletics (NAIA), National Junior College Athletic Association (NJCAA)). Patients or Other Participants: 434 ATs responded to the survey (average age = 27.73 ± 3.24 ; average years certified as $AT = 5.17 \pm 2.67$). Respondents represented the following affiliations: NCAA Division 1 (D1) (n =199), Division 2 (D2) (n = 67), Division 3 (D3) (n = 108), NAIA (n = 37), and NJCAA (n = 23). Interventions: Two researchers developed the instrument and sought expertise from a peer reviewer. The survey was administered online using QuestionPro software, with job setting as the primary independent variable. Main Outcome Measures: Likert Scale questions (1 = strongly)agree, 5 = strongly disagree) related to organizational pressures within athletic departments. Kruskal-wallis one-way analysis of variance assessed for differences in organizational conflict across athletic affiliations. Mann-Whitney U post hoc tests determined where differences occurred. Results: We obtained

a 14.47% (434/3,000) response rate. Significant differences between affiliations were observed for "If a new coach was hired, I'd worry about job security" (p = .001), and "My job depends on pleasing coaches" (p = .008). Post hoc results found that D1 ATs disagreed significantly less than D2 (D1 mean rank = 126.73, D2 mean rank = 153.60, U =5319.5, p = .008), D3 (D1 mean rank = 141.25, D3 mean rank = 177.49, U = 8209, p < .000), and NJCAA ATs (D1 mean rank = 108.76, NJCAA mean rank = 135.20, U = 1743.5, p = .046) with the first statement. Significant differences were found between D1 and D3 ATs (D1 mean rank = 144.33, D3 mean rank)= 171.81, U = 8822.5, p = .006), as well as D1 and NJCAA ATs (D1 mean rank = 107.67, NJCAA mean rank = 144.63, U = 1526.5, p = .006) with the second statement. No differences across all affiliations existed regarding pressures ATs face to allow athletes to play before they are comfortable (median = 4), and level of support received from coaching staffs regarding clinical decisions ATs make (median = 2). Conclusions: Pressures ATs face from coaches regarding return-to-play decisions did not differ across NCAA, NAIA, and NJCAA affiliations. ATs working in the D1 setting placed a higher emphasis on the role that coaches play on their job performance and overall job security. However, these data collectively demonstrate ATs are receiving less pressure from coaches compared to previous literature and media reports.

Leadership Development Among Clinical Collegiate Athletic Trainers: Perceived Importance, Practices, and Barriers Gomez CJ: Delaware State University, Dover, DE

Context: Understanding the beliefs, current practices, and barriers of leadership development among clinical collegiate athletic trainers (ATs) will provide valuable information to enhance leadership development opportunities for this population. **Objective:** The objective of the study was to identify the perceptions and practices of leadership development among ATs in the collegiate clinical setting. A secondary objective was to identify the barriers to and preferred delivery of leadership development opportunities. Design: Cross-Sectional Survey Setting: This study utilized an online survey instrument. The target population was collegiate clinical ATs. Patients or Other Participants: The participants were 1000 randomly selected Athletic Trainers who currently work in the clinical setting at the collegiate level. Of those surveyed, 187 respondents completed the survey, for a response rate of 18.7%. Of those respondents, 84 (8.4%) participants indicated that they currently work in a clinical setting. Interventions: The Leadership in Athletic Training survey was developed and validated for this study through an expert review, focus group, and pilot study. The surveys were sent to the participants via email. The surveys collected demographic information and information about the participants' perceptions of the value of leadership in the profession, ways in which they participate in leadership development, perceived barriers to leadership development, and preferred delivery methods of leadership development opportunities. Main Outcome Measures: The four primary main outcome measures included 1) perceived perception of the importance of leadership development, 2) leadership development practices, 3) barriers to leadership development, and 4) preferred methods of leadership development. Results: Of the 84 respondents, 51% were male and 49% were female, and 62% of respondents were between the ages of 25-40 and had been certified for 1-15 years. The respondents were 94% caucasion and 83% had master's degrees. One quarter of the participants (24%) were Head ATs and half (49%) were Assistant ATs. Nearly one-half (48%) of the respondents worked at the NCAA-DI level and 23% worked at the NCAA-D3 level. Thirtynine percent of the repondents indicated holding a leadership position. The ATs agree or strongly agree that Leadership

Development should occur throughout their entire career (89%) and is important to them personally (87%). The ATs also agree or strongly agree that Leadership can advance and enhance the recognition of the profession (94%) and can impact patient outcomes (82%), turnover rates (78%), burnout (71%), and work/ family conflict (65%). The ATs reported they had been involved in leadership development during an educational setting (33%), during their career (60%), and in the past year (60%). The most common methods of leadership development that the ATs participated in were individual readings, informal mentorships, scenario discussions, and continuing education at a national convention. About half of the respondents (47%) have engaged in leadership development in the past year, mostly utilizing informal methods of leadership development. Respondents primarily prefer to participate in less-structured leadership development opportunities and list time as their largest barrier to engaging in leadership development. Conclusions: ATs believe leadership development should continue throughout their career and is important for them and for the profession. More than half of the respondent indicated they were involved in some level of leadership development in the past year. Most leadership development is informal.

In what manner do clinical collegiate Athletic Trainers participate in Leadership Development?



Journal of Athletic Training

Female Athletic Trainers' Perceptions of Challenges Associated With Providing Athletic Training Services to Collegiate Ice Hockey Players Young RA, Thrasher AB, Snyder MM: Western Carolina University, Cullowhee, NC

Context: Female athletic trainers (ATs) are obtaining roles traditionally held by male ATs; however, they might face challenges with gaining employment and upward mobility. Prior research has explored experiences faced by female ATs providing care to football, yet challenges associated with providing care to collegiate ice hockey have not been explored. **Objective:** Explore challenges faced by female ATs providing care to collegiate ice hockey players. Design: Phenomenological Qualitative Setting: Individual phone interviews Patients or Other Participants: 15 female ATs who provide athletic training services to collegiate ice hockey players participated in this study $(34.9 \pm 7 \text{ years}; \text{ provid-}$ ing care to men's ice hockey: 8, women's: 7, NCAA Division I: 9, Division III: 6). Data saturation guided the number of participants. Data Collection and Analysis: Participants were interviewed via phone using a semi-structured interview guide. Interviews were recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via peer review and multi-analyst triangulation. Results: Four themes emerged: 1) role entry, 2) challenges, 3) successes, and 4) respect. Role entry for some participants required previous hockey experience, while others "lucked" into the role. Barriers to role entry were due to concerns from coaches about females working with male hockey players. Challenges faced by our participants included facility and travel logistics such as athletic training rooms inside of locker rooms, balancing the heavy workload and personal life, and upward mobility into professional ice hockey. Initially,

age was a challenge because many participants entered into their role early in their career and had to prove themselves. Gender was not seen as a big challenge. Many participants reported successes in their career, such as support from peers, coaches, and administration, appropriate relationships formed with patients, athletic team successes, and patient care successes including injury prevention. Other successes included gaining additional roles and responsibilities and being promoted within their organization. Participants felt well respected in their roles; often this was due to working hard to earn respect, building relationships, and the culture of respect cultivated in their institution and within athletic training services. Participants also thought personal characteristics, such as working hard, committing to the team, and proving themselves impacted respect. Conclusions: Most of our participants felt that gender was not a large factor impacting their role as an AT with collegiate ice hockey. Bigger challenges were associated with age; however, some felt they had to work harder as females to prove themselves and gain respect. Participants faced challenges and successes that all ATs face, regardless of gender or setting. Gender may play a role in initially obtaining employment with male ice hockey teams; however, as more female ATs enter into this setting, it becomes less challenging.

Free Communications, Rapid Fire Oral Presentations: Clinical Tips for Improving Outcomes Following Anterior Cruciate Ligament Reconstruction

Friday, June 29, 2018, 8:00AM-9:00AM, Room 217–219; Moderator: Christopher Kuenze, PhD, ATC

Unresolved Knee Pain in a Multisport Interscholastic Athlete

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Background: A 16 year-old female multisport interscholastic athlete presented to the AT 6 weeks after being kicked in the anteromedial right knee. The patient reported persistent knee pain and swelling that increased secondary to activity. The athletic trainers' physical examination identified swelling in the pes anserine, deep to a surgical scar. Palpation elicited point tenderness over the pes anserine that was hard in nature. AROM was limited due to pain. PROM was full, but painful. MMT was 5/5 with pain. All stability tests were negative and the patient was neurovascularly intact. The patient's medical history was significant for a right ACL autograft 3 years prior, involving biodegradable screws at the tibial and femoral graft attachment sites. Differential Diagnosis: Contusion, pes anserine bursitis, pes anserine tendinopathy, medial tibial condyle avulsion, and infection. Treatment: Initial treatment included massage and therapeutic ROM exercises. The patient was permitted to continue with activity. Status-post 8 weeks, the patient was not improving and was referred to the orthopedist who performed her ACL reconstruction. The orthopedist differentially diagnosed the patient with pes anserine hematoma or bursitis deep to the surgical scar. The orthopedist instructed the patient to continue with the athletic trainer's plan of care and re-evaluate as necessary. Status-post 10 weeks, the patient continued to report no changes and was referred to a primary care sports medicine specialist (PCSMS). The PCSMS's physical examination identified continued medial knee extra-articular swelling, tenderness, full

AROM, and normal stability. An MRI was ordered and revealed an extrusion of the tibial screw over the pes anserine. Additionally, the PCSMS ordered a diagnostic US which revealed a significant soft tissue thickening around the extruded screw, and referred the patient back to the orthopedist. Status-post 12 weeks, the patient reported a fever and increased pain, swelling, and erythema. The patient was seen by her primary care physician, prescribed antibiotics, and was referred back to the orthopedic surgeon. Four days later without improvement, the patient went to the emergency department. The attending physician ordered blood work that identified a systemic infection. The patient was referred to an in-house orthopedist, admitted, prescribed IV antibiotics, and scheduled for surgery to remove the hardware. Two days post-op, the patient was instructed to continue with oral antibiotics, analgesics, anti-inflammatories, discharged, and instructed to follow up with the initial orthopedist. Status-post 14 weeks, the patient was seen by the initial orthopedist for suture removal. Physical examination revealed a resolved infection and a well-healed incision. The patient was permitted to return gradually to activity, discharged, and instructed to return if any complications developed. Statuspost 4 months, the patient noticed an object surfacing from the scar and manually removed the remaining screw fragment. The patient returned to full activity without further complications. Uniqueness: Biodegradable screw complications typically spur from a torsional force; however, this rejection resulted from acute compression. Additionally, infectious complications occur in 0.2% of biodegradable hardware, with a reoperation rate of 0.3% due to device-related problems. Lastly, biodegradable hardware is designed to degrade within one year, with full osteointegration requiring 3 years post-surgery; however, this patient's screw

was removed in full continuity. Conclusions: Retraction of a tibial ACL graft screw should be considered in post-ACL reconstruction patients presenting with persistent pain, swelling, and erythema over post-surgical sites. Also, reconstruction anchor screw retraction can occur in athletes with acute compression forces at the knee. Moreover, it is critical to understand that biodegradable hardware degrades at different rates. Consequently, a lack of degradation can lead to foreign body reactions. As such, it is important to monitor the patient's progress, recognize a lack of biodegradable hardware degradation, and refer when necessary.

Is the Quadriceps Tendon Superior to the Patellar Tendon as an Autograft Choice in ACL Reconstruction? Outcomes of Muscular, Physical, and Patient-Reported Function

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Context: Various graft types in anterior cruciate ligament reconstruction (ACLR) can affect long-term outcomes. The patellar tendon (PT) autograft remains the standard graft of choice for anterior cruciate ligament reconstruction (ACL), but several complications, such as anterior knee pain and increased donor site morbidity, provide reason to continue the search for a more optimal graft. The quadriceps tendon (QT) offers a unique soft-tissue option with larger and stronger anatomical area from which to harvest the graft. However, there is little information on long-term clinical outcomes. Objective: To compare muscular, functional, and patient-reported outcomes in individuals with QT versus PT autografts.

The hypothesis is that individuals with QT autografts will demonstrate superior outcomes. Design: Retrospective cohort. Setting: Research laboratory setting. Patients or Other Participants: Active individuals with history of primary, unilateral ACLR with QT or PT autografts are recruited. Data collection is ongoing and will yield a larger sample size at time of presentation. To date, we have collected 12 participants: 28 years; 10 males; 12 mo. post-ACLR; Tegner Activity Level = 7 ± 2 . Interventions: Knee extensor maximum voluntary isometric contraction (MVIC) and peak isokinetic strength at 60°/s was measured bilaterally with an isokinetic dynamometer, and normalized to body mass. Voluntary activation deficit (%) was determined by superimposing a burst of electrical stimulation over the quadriceps muscle during MVIC testing. Maximal cross-sectional area was measured bilaterally for each of the quadriceps muscles via magnetic resonance imaging (MRI). Assessor was blinded to graft type and side of ACLR. Functional testing included the single leg hop test. Limb symmetry indexes were expressed as a percentage of involved limb over uninvolved limb. Self-reported function was determined with the International Knee Documentation Committee (IKDC) questionnaire. Main Outcome Measures: The independent variable is autograft group. The dependent variables are MVIC, isokinetic strength, cross-sectional area, and hop test scores expressed as limb symmetry indexes (%), in addition to IKDC scores. Given the small sample size, the nonparametric Wilcoxon ranksum test was used to compare interlimb differences between QT and PT autograft groups. Results: Means, standard deviations, and *p*-values from 12 individuals are presented in Table 1. Contrary to the hypothesis, there were no significant differences between groups. Conclusions: Although individuals with OT autografts did demonstrate deficits in muscle size and function in the reconstructed limb, these deficits were comparable to those in individuals with PT autografts. Surgeons can feel more confident in the long-term clinical effects of using this procedure compared to the more standard PT autograft approach. The results of this study provide new information to guide athletic trainers to understand the long-term outcomes and tailor rehabilitation specifically for patients with QT autografts.

Table 1. Limb Symmetry Indexes and Patient-Reported Outcomes between QT and PT

 Autograft Groups

	QT Autograft (n=6)	PT Autograft (n=6)	<i>p</i> -value
Knee Extensor MVIC (%)	79.6 ± 23.4	61.4 ± 16.6	0.150
Activation (%)	101.2 ± 5.1	93.5 ± 10.7	0.200
Isokinetic Strength (%)	74.0 ± 9.4	67.5 ± 17.8	0.748
Vastus medialis CSA (%)	80.0 ± 2.0	76.4 ± 13.1	0.439
Vastus lateralis CSA (%)	86.7 ± 7.0	91.0 ± 27.2	0.999
Vastus intermedius CSA (%)	82.8 ± 6.7	77.7 ± 14.1	0.302
Rectus Femoris CSA (%)	87.3 ± 13.0	85.4 ± 10.3	0.796
Hop Test (%)	84.9 ± 7.1	87.1 ± 12.7	0.873
IKDC Score	68.9 ± 5.9	71.5 ± 4.6	0.469

* = significant *p* values (*p*<0.05). QT = quadriceps tendon, PT = patella tendon, MVIC = maximum voluntary isometric contraction, CSA=cross-sectional area

Clinical Predictors of ACL Reconstruction Outcomes Nine Months After Surgery

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Context: Many patients display significant neuromuscular and biomechanical deficits after anterior cruciate ligament reconstruction (ACLR). These mechanics are associated with high rates of second ACL injury and poor surgical outcomes. Currently, there is a gap in knowledge about what metrics early in rehabilitation are predictive of surgical outcomes at the end of rehabilitation. This information can positively impact clinical decisions during rehabilitation in order to improve care and improve outcomes. **Objective:** To determine if clinical tests (drop landing mechanics, strength, and sport readiness scores) collected four months post-ACLR are predictive of patient reported outcomes at nine months post-ACLR. Design: Single cohort. Setting: Research laboratory. Patients or Other Participants: 33 participants (18 females; 19.3 ± 3.0 years; 173.7 ± 9.2 cm; 74.2 ± 16.7 kg) with a history of primary, unilateral ACLR volunteered for this study. Additionally, subjects were between 15-26 years of age and expressed desire to return to sport at the end of rehabilitation. Participants were tested 4 and 9 months post-ACLR. Interventions: Participants completed the International Knee Document Committee 2000 subjective form (IKDC) and ACL returnto-sport after injury scale (RSI) at each time point. Participants also completed five successful trials of a drop landing task. Participants landed from a 30cm box to two force plates and then immediately jumped for maximal height. An electromagnetic tracking system interfaced with non-conductive force plates was used to capture joint motion and forces during the drop-landing maneuver. Isometric strength of the gluteus maximus, gluteus medius, quadriceps, and hamstring were measured

via dynamometer. Main Outcome Measures: The primary criterion variable was IKDC score 9 months post-ACLR. Predictor variables at month 4 included the reconstructed limb: IKDC score, peak muscle strength, peak knee and hip flexion angles, peak knee extension moment, vertical ground reaction force (VGRF), and between limb asymmetries for each variable (if applicable). Between limb asymmetries were calculated as a percentage of the uninvolved limb (% = involved limb/ uninvolved limb *100). A stepwise logistic regression was used to determine variables assessed at month four that predicted IKDC score at month nine (a < 0.05). Results: IKDC (month 4: 70.3 \pm 9.7%; month 9: 87.4 \pm 9.8%) and RSI (month 4: $53.1 \pm 25.1\%$; month 9: $65.3 \pm 65.3\%$) scores increased during the observation period. Knee extension moment asymmetry (98.7 \pm 36.7%) and RSI at month four entered into the model. They explained 70.7% of the variance in month 9 IKDC score $(R^2 = 0.707, P < 0.001)$. <u>Conclusions:</u> Clinical as well as psychological metrics, measured 4 months post-ACLR, are predictive of subjective knee function 9 months post-ACLR. More symmetrical knee extension moment and higher scores on the RSI are associated with better outcomes. Identifying factors associated with a positive outcome later in the rehabilitation process may provide clinicians with areas in which to focus their rehabilitation efforts.

ACL-R Patients Are Minimally Responsive to Psychological Intervention Coupled With Physical Rehabilitation Sheehan K, Zaichenko D, Medina McKeon JM: Ithaca

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Context: Self-efficacy is a key factor for sports performance and aslo for rehabilitation performance following injury. Psychological intervention has been demonstrated to improve self-efficacy during sports performance, but is rarely addressed for individuals in a sports injury rehabilitation program. Objective: To quantify the effect of psychological intervention on knee-related self-efficacy in ALC-R patients participating in post-surgical rehabilitation. Data Sources: PubMed was searched through September 2017. Search terms included iterations of "ACL", "rehabilitation", "adhere", "psychology", and "postoperative". The search was limited to studies published within the last 10 years and published in English. A hand search followed. Study Selection: Selection criteria required investigation of 1) psychological intervention to enhance knee-related self-efficacy and 2) included patients completing ACL-R physical rehabilitation. Data Extraction: The factors assessed was psychological intervention (combinations of guided imagery, relaxation, education). The outcome was knee-related self-efficacy (self-efficacy) for present and future knee ability, as measured by the Athletic Injury Self-Efficacy Questionnaire (AIESQ) or Knee Self-Efficacy Scale (K-SES). For both scales, 100% indicates highest knee-related self-efficacy. Two investigators extracted means, standard deviations, and sample sizes at 6wks, 24wks, and/ or 52wks post-surgery. Hedge's g effect sizes (ES) [95% CIs] were used to determine the influence of psychological intervention on self-efficacy at the difference time points. A summary model was used to pool these results. The PEDro scale was used identify potential threats to validity. Data Synthesis:

Three studies met selection criteria and were then analyzed. Study design varied: 2 studies were RCTs; 1 study was a nonrandomized clinical trial. Summary knee-related self-efficacy mean ± SDs scores were similar at post-intervention (psychological intervention = 83.4 \pm 17.3% vs. control mean = 82.2 \pm 13.7%). The summary model indicated that the pooled effect of psychological intervention on self-efficacy was weak (ES = 0.2 [-0.3, 0.7], p = 0.50). Included studies had PEDro scores of 4/10, 4/10, and 8/10. All 3 studies failed to blind the patients and treating therapists. Two studies did not randomize participants or conceal group allocation. Conclusions: Psychological interventions are effective at enhancing rehabilitation outcomes and important component of the recovery process, when necessary. Knee-related self-efficacy is a key factor in rehabilitation for postoperative ACL outcomes. Although psychological intervention did not increase knee-related self-efficacy, there was a possibility that a ceiling effect may have influenced the results. The average knee-related self-efficacy scores at baseline were within less than 20% of the maximum score. Additionally, there was a chance that the regular interaction with a clinician may have a similar effect to the experimental condition. However, in those with a knee-related self-efficacy deficit, psychological intervention may be beneficial, and ultimately improve clinical outcomes. ATs should assess knee-related self-efficacy and consider referring ACL-injured patients who demonstrate lower than expected self-efficacy scores.

Clinician Knowledge of Best Practice After Anterior Cruciate Ligament Injury

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Context: Sports medicine professionals, namely athletic trainers and physical therapists play a key role in the rehabilitation and recovery of anterior cruciate ligament (ACL) injuries. The best practices for ACL rehabilitation is largely based on expert opinion with little data on what clinicians are actually doing and whether they are incorporating the latest recent evidence into their rehabilitation practice. **Objective:** To determine clinician knowledge of latest evidence regarding post-operation ACL rehabilitation. Design: Cross-sectional survey. Setting: Online survey. Patients or Other Participants: 18,506 people were originally contacted to participate in this survey, all being members of The Ohio Occupational Therapy, Physical Therapy, and Athletic Trainers Board. 1066 people started the survey; a response rate of 5.8% and 936 people completed the survey, for a response rate of 5.1% however, there were only 693 usable (complete data) surveys for analysis, making the final response rate 3.7% (37.53 ± 10.59 years, 293 males, 397 females, and 3 unidentified). Two hundred two (29.1%) of the respondents had been credentialed in their respective field for less than five years and 172 (24.8%) of them had been credentialed for 5-10 years. Interventions: A rehabilitation survey was used to assess specific rehabilitation practices (knowledge of potential neural changes induced by injury, general rehabilitation practices, and specific therapeutic applications) for ACL rehabilitation. Face validity of the survey was established through emailing the survey to six selected experts in the field of Athletic Training and\or Physical Therapy. Qualtrics (Provo, UT) was used in order to create and distribute the survey. Main Outcome Measures: Descriptive statistics were calculated for each question. Two groups were created based on
the question "Do ACL injuries cause neuroplasticity?". Chi square analysis and Phi Coefficients were calculated for the two groups regarding knowledge of neuroplasticity and ACL injury, and implementation of neurocognitive strategies during early, mid, and late stages of ACL rehabilitation. The alpha level was set at p < 0.05 for all analyses. Results: A majority of the participants, 484 (69.8%), answered yes to the question "Do ACL injuries cause neuroplasticity?" and 461 (66.5%), also answered yes to the question "In your rehabilitation of ACL injuries do you address neuroplasticity?". Overall, clinicians consider neurocognitive aspects in musculoskeletal rehabilitation (n = 521; 75.5%). The Chi Square was significant for two questions: "Do you consider neurocognitive aspects in your musculoskeletal rehabilitation or prevention strategies?" ($\chi^2 = 8.44$; p = 0.01; $\varphi = 0.11$) and "In your practice, do you perform exercises for body parts other than the ACL involved/injured knee?" ($\chi^2 = 5.51$; p = 0.02; $\varphi = 0.11$). However, the phi coefficients were small indicating a low effect for the two comparisons. Conclusions: The majority of clinicians are incorporating latest evidence into post-injury therapy and assessment. Rehabilitation should not only focus on motor learning but may consider incorporating neurocognitive training after a musculoskeletal injury.

A Comparison of Patient Outcome Measures, Jump-Landing Adaptations, and Strength Deficits Between ACL Reconstructed Individuals and Matched Healthy Controls Funk JW, Morrison KE, Stearne D, Cattano NM: King University, Bristol, TN; West Chester University of Pennsylvania, West Chester, PA

Context: Anterior cruciate ligament tears are common among females and these individuals are cleared by physicians to resume normal activities after anterior cruciate ligament reconstruction (ACLR), yet many still report poor patient reported outcomes in the short and long-term. It remains unclear as to if these poor patient reported outcomes may be linked to strength deficits or landing characteristics post-ACLR. **Objective:** To compare patient reported outcomes (PRO), knee flexion and extension strength deficits, and Landing Error Scoring System-Real Time (LESS-RT) scores between females with ACLR and matched healthy controls (CON). Secondly, to determine if a relationship exists between these variables. Design: Cross sectional cohort study. Setting: Division II University. Patients or Other Participants: Twenty two physically active individuals between the ages of 18 and 25. Eleven physically active females with unilateral ACLR and eleven healthy controls matched by age, height, weight and activity level. Interventions: The independent variable was ACLR (ACLR vs CON). Each participant completed the Knee injury and Osteoarthritis Outcome Score (KOOS), standardized testing procedure for the Landing Error Scoring System-Real Time (LESS-RT), and four repetitions of bilateral isokinetic knee extension/ flexion testing at 60 degrees per second. Independent t-tests were conducted to determine if significant differences existed between group. Pearson's correlations were run to determine significant correlation between variables.

Statistical significance was set a priori at $p \le 0.05$. Main Outcome Measures: Dependent variables were PRO scores in the 5 KOOS subscales, knee extension deficits (% strength compared to healthy knee), knee flexion deficits (% strength compared to healthy knee), and LESS-RT scores. Results: ACLR reported significantly lower PRO scores in 4 of the 5 KOOS subscales. The pain subscale was significantly lower in ACLR (88.67 ± 9.74) than CON (99.18) \pm 1.94), p = 0.006. The symptom subscale had the lowest mean score in the ACLR group (77.67 ± 21.76) vs CON (95.55 ± 5.66) , p = 0.017. The subscales of sports/recreation and quality of life were significantly lower in the ACLR group (82.08 ±17.12), (79.33 ±17.19) than CON (95.45 ± 7.89) , (97.82 ± 4.85) respectively p = 0.027, p = 0.003. The subscales of sport/recreation, and symptoms were moderately, inversely correlated with knee extension deficits, respectively, (r = -.516, p = 0.012; r =-0.449, p = 0.032). Knee flexion deficits displayed a moderate, inverse correlation with LESS-RT scores, (r = -0.434), p = 0.039). <u>Conclusions</u>: Individuals with ACLR are experiencing complications within 5 years post-ACLR. While the KOOS has been proved valid and reliable at determining patient outcomes, it may also be effective at identifying those individuals who are suffering from strength deficits. This is especially useful in settings that do not have access to expensive strength testing equipment.

Strength Measures at 12 Weeks Following Anterior Cruciate Ligament Reconstruction Are Related to Biomechanical Performance at Time of Return to Sport

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Context: Hip and knee strength are both considered to be important variables for determining readiness for safe return to sport following anterior cruciate ligament reconstruction (ACL-R). Evidence related to the amount of hip versus knee strength in the early post-operative phases and the ability of this ratio to predict lower extremity biomechanical performance at time of return to sport (RTS) is limited. **Objective:** To compare the relationship between hip abduction/ knee extension strength ratio at 12 weeks post-operative ACL-R and lower extremity biomechanical performance at time of RTS. Design: Correlational study design Setting: Clinical Research Laboratory. Patients or Other Participants: Twentyfour ACL-R participants (age 15.4 ± 1.1 , height 162.5 ± 7.5 cm, weight 63.4 ± 8.8 kg) were assessed for hip abduction and knee extension strength at 12 weeks following surgery and lower extremity biomechanical performance at time of RTS. Interventions: Isometric hip abduction strength was measured using a handheld dynamometer. Isokinetic quadriceps strength was measured at 60 deg/sec on an isokinetic dynamometer. Bilateral knee joint moment and net power was assessed using an eight-camera infrared motion capture system and two force plates while participants performed five consecutive single limb squats (SLS). Main Outcome Measures: Hip abduction and quadriceps strength were normalized to body weight and averaged across two and five trials, respectively. Hip abduction/quadriceps strength ratio (HABD/QUADS) was defined as hip abduction strength divided by knee extension strength. Energy absorption (integration of the negative portion of the net power curve) of the knee joint, knee extension (KEXT) moment, and knee abduction (KABD) moment were calculated during the loading phase of the middle three trials of the SLS task and normalized to height and weight. Pearson product moment correlations were calculated to examine the relationship between HABD/QUADS at 12 weeks and KEXT moment, KABD moment and EA of the knee at time of RTS between the involved and uninvolved limbs. Results: Involved limb HABD/ QUADS at 12 weeks was positively correlated with KEXT moment (r = 0.496, p = 0.01) and EA of the knee (r = 0.596, p < 0.01) at time of RTS. There were no significant relationships between involved limb HABD/QUADS at 12 weeks and KABD (p = 0.53) at RTS or uninvolved limb HABD/QUADS at 12 weeks and KEXT (p = 0.10), KABD (p= 0.12), or EA of the knee (p = 0.09) at RTS. Conclusions: As the ratio of hip abductor to quadriceps strength increases (less quadriceps) at 12 weeks following ACL-R, deficits in single limb loading during the SLS is seen at time of RTS. Restoration of knee strength in the early phases of rehabilitation following ACL-R is important in order to regain optimal usage of the knee joint.

Free Communications, Oral Presentations: Keeping Runners Healthy: Environmental and Overuse Injuries

Friday, June 29, 2018, 10:45AM-12:15PM, Room 217-219; Moderator: Neal Glaviano, PhD, ATC

Exercise Dependence and Medial Tibial Stress Syndrome in a Division I Female Cross Country Runner: a Case Study

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Background: A female cross-country runner (age = 20 years; height: 1.91 m; mass: 56.9 kg) with a previous history of depression, anorexia, and bulimia nervosa, presented with increasing right proximal shin pain at the beginning of winter training. Initial evaluation revealed early-onset medial tibial stress syndrome, which was treated conservatively for the following two weeks with instrument assisted soft tissue mobilization, intrinsic foot, glute and calf strengthening. Although she was limited to strictly non-weight bearing activity, her symptoms remained persistent. At this time, she was referred to our team physician, nutritionist, and behavioral psychology department for further evaluation. Differential Diagnosis: chronic exertional compartment syndrome, tibial stress reaction or fracture, fibular stress reaction or fracture, medial tibial stress syndrome. Treatment: The physician and athletic trainer outlined a structured non-weight bearing treatment plan, consisting of supervised agua jogging, elliptical, and bike workouts until the patient became asymptomatic. The athlete's adherence to the treatment plan was demonstrated by completing rehabilitation at least three times during the week. Despite consistent treatment sessions with the athletic trainer, her symptoms continued to worsen. After an additional two weeks of rehabilitation, x-rays confirmed a proximal periosteal tibial stress reaction, and she was again limited in weight-bearing training. In spite of continuation of rehabilitation and controlled training parameters, her reporting of pain remained high. Approximately four weeks post-imaging, a follow-up

x-ray revealed a full transverse fracture through her tibia. Over the following weeks, the healthcare team was notified of the athlete completing numerous additional unsupervised cross-training sessions lasting between two to four hours at the university recreational center. Furthermore, the athlete's roommate confided in the coach that she observed the athlete skipping multiple meals throughout the week, and was behaving similarly to previous episodes of binging and purging. Even though there were several interventions between the athlete, coaches, and medical staff about the importance of compliance to the physician's recommendations, she continued to complete additional workouts in secrecy. Based on her numerous referrals, and previous physical and mental health history, the athlete decided that it was in her best interest to remove herself from all team activities. Uniqueness: The literature reports that approximately less than 1% of the population suffers from exercise dependence (EXD), however the co-occurrence rate with anoretics is three times higher than other diagnoses of disordered eating. EXD is often described as a manifestation of uncontrollable exercise, increased tolerance, and associated anxiety/depression with withdrawal of activity. A component of EXD related to this athlete specifically is continuance - the perpetuation of exercise despite comprehension of the potential to increase the physical deficits and interpersonal strains. Populations commonly affected by EXD include young women, high-performance athletes, and high achievers with associated body dysmorphia. Although this patient presents with several red flags in regards to the female athlete triad, the effects of a possible underlying diagnosis of EXD and additional bio-psychosocial disorders on her initial shin pain make this case unique. Conclusions: Even though the diagnosis of EXD is rare, there are a number of screening tools

available for clinicians to utilize with the referral process should concerning histories present themselves. The Exercise Addition Inventory is a simple survey with significant reliability when paired with other disordered eating questionnaires. Athletic trainers should be well-educated about the long-term health risks of relative energy deficiency in sport, and employ supplemental resources when working with high-risk teams such as cross country, volleyball, and aesthetic sports such as gymnastics, cheerleading, and swimming.

Beliefs, Knowledge and Influence of Education Regarding Optimizing Heat Safety During Summer Road Race Participation

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Context: There is little knowledge on how educating runners may correct common misconceptions surrounding heat safety and hydration strategies. **Objective:** To investigate 1) beliefs and knowledge about heat safety and hydration strategies among recreational runners and 2) the effectiveness of an educational video. Design: Cross sectional survey. Setting: Runners registered for the 2017 Falmouth Road Race (FRR; n = 8,319) were surveyed. <u>Patients or</u> **Other Participants:** Contact email addresses of registrants were obtained from FRR. Twenty-five percent of total registrants (n = 2,091) completed at least one of the three surveys instrumented. Interventions: A 5.3-minute video and an 11-question survey regarding heat safety and hydration strategies was developed and implemented at the 2017 FRR. The survey was emailed to all FRR registrants three times; 1) nine weeks before the race (PRE_{RACE}) , 2) after viewing the video ($POST_{EDU}$) and 3) the afternoon of the race $(POST_{RACE})$. Invitations to view the video were sent to registrants who completed PRE_{RACE} Change in survey score was calculated for $\mathrm{EDU}_{_{\mathrm{YES}}}$ (completed $\mathrm{PRE}_{_{\mathrm{RACE}}}$ $POST_{EDU}$, and $POST_{RACE}$) and EDU_{NO}

(completed PRE_{RACE} and $POST_{RACE}$) using one-way analysis of variance for PRE_{RACE}, POST_{EDU}, POST_{RACE} comparisons, and paired t-test for PRE_{RACE} and POST_{RACE} comparison. <u>Main Outcome</u> Measures: Scored total of responses to two multiple choice questions and nine 5-point (strongly agree-strongly disagree) Likert Scale questions. Likert Scale questions were graded by adding one point for each question that registrants demonstrated beliefs that matched best practices outlined in the video. <u>Results:</u> PRE_{RACE} results showed: 96.4% of respondents answered strongly agree or agree to the statement about the importance of staying hydrated from the day before the planned activity, 93.2% correctly recognized dark color urine is not a sign of euhydration, and 91.7% believed dehydration may place a runner at risk for heat syncope. Conversely, <50% of respondents knew the number of days required to achieve heat acclimatization, the role of sweat rate calculation to optimize one's hydration strategy, and the risk of water intoxication from drinking too much water. Scores from EDU_{YES} (n = 164) and EDU_{NO} (n = 826) were compared for further analysis. There were no differences in survey score at PRE_{RACE} between EDU_{YES} and $\text{EDU}_{\text{NO}}(p)$ = 0.23). In EDU_{VES}, an improvement in survey score from $\text{PRE}_{\text{\tiny RACE}}$ to $\text{POST}_{\text{\tiny EDU}}$ was observed (mean difference [MD] = 2.00; 95% confidence interval [CI] [1.68, 2.33], p < 0.0001) and 73% of the improvement in the score was retained from $POST_{EDU}$ to $POST_{RACE}$ (MD = -0.54; 95% CI = [-0.86, -0.21],p < 0.001). The improvement in survey score from PRE_{RACE} to POST_{RACE} was significantly greater in EDU_{YES} than EDU_{NO} (MD = 0.95; 95% CI = [0.61, 1.28], p < 0.0001). <u>Conclusions:</u> The video successfully shifted runner's beliefs and knowledge to better optimize their performance in the heat. Utilization of such intervention needs further investigation on its effectiveness in modifying runner behaviors on the day of the race.

Addiction to Running and Physical Activity Characteristics in Injured and Healthy Runners Beard MQ, Torp DM, Donovan L: Capital University, Columbus, OH; University of North Carolina, Charlotte, NC

Context: As of 2017, 65.6 million Americans were running recreationally. The primary motivations for running are to stay healthy and relieve stress. Unfortunately, running-related musculoskeletal injuries (RRMIs) still affect up to 80% of runners. When runners are removed from running due to a RRMI they report increased anxiety, irritability and tension, anger and insomnia. The Commitment to Running Scale (CR Scale) was designed to measure runners' addiction to running. CR scores have yet to be established for healthy runners with a previous RRMI and without a history of a RRMI. **Objective:** To determine the difference in CR score and running characteristics between healthy runners who reported a previous RRMI (Hx-RRMI) and runners who report no history of a RRMI (NoHx-RRMI). Design: Crosssectional survey. Setting: Laboratory. Patients or Other Participants: One hundred and thirty-four healthy, recreational runners volunteered (39.07 \pm 10.22 yrs, 170.96 \pm 9.81 cm, 71.32 \pm 13.47 kg). Interventions: All participants completed a paper survey prior to participating in a laboratory study. Questions regarding previous injury and RRMI history were used to assign runners into either the Hx-RRMI or NoHx-RRMI groups. Main Outcome Measures: Questions pertaining to demographics and current and previous running participation were included in the survey. Also included was the CR Scale with 12 Likert scale statements (1 = strongly disagree to 5 = strongly agree). A higher score indicates a greater level of addiction to running. Internal consistency was measured using Cronbach's alpha and determined to be high (0.863). Independent t-tests were used to analyze the difference for all variables between the Hx-RRMI and NoHx-RRMI groups. Results: Eighty-nine runners reported a history of a RRMI (Hx-RRMI) while forty-five were injury free (NoHx-RRMI). There was a significant difference in CR score between the Hx-RRMI (50.76 ± 5.69) and NoHx-RRMI groups (47.93 ± 6.5) ; p = 0.01). There were no differences between groups for demographics (age, height, mass), years running and competing, number of races per year, running sessions per week, miles run per week, or average 5K pace (p > 0.05). Conclusions: Runners with a previous RRMI have not been running or competing longer, and do not run more sessions or miles per week, races per year, or run faster than the NoHX-RRMI runners. However, runners with a previous RRMI are more addicted to running. An addiction to a positive event such as running can turn negative when health is compromised. By using the CR score clinicians can understand a runner's dedication and motivation for returning to running after a RRMI. The CR Scale could help clinicians determine which runners may be resistant or non-compliant with rehabilitation plans that promote removal from running and adjust the rehabilitation plan accordingly. Future research should use the CR Scale to investigate the tendencies and perceptions of injury and treatment in a larger group of runners.

Foot Intrinsic Muscle Function and Activation, and Exercise Related Leg Pain in Runners Nedimyer AK, Pietrosimone BG, Luc-Harkey BA, Wikstrom EA: University of North Carolina at Chapel Hill, Chapel Hill, NC; Brigham and Women's Hospital, Boston, MA

Context: Exercise-related leg pain is particularly pervasive, with 18.2% to 92.4% of runners experiencing pain in their lifetime. However, the underlying physiologic mechanisms and intrinsic risk factors of these injuries are poorly understood. The intrinsic muscles of the foot (i.e. the foot core) are critical to foot function, and poor intrinsic foot muscle function leads to the development of poor foot mechanics. Poor foot mechanics have been hypothesized to be a mechanism of exercise related leg pain; thus, poor foot core function may be a modifiable risk factor for the development of exercise-related leg pain. **Objective:** The purpose of this study was to compare the activation of the foot intrinsic musculature between runners whom have and have not experienced exercise-related leg pain within the past 3 years. **Design:** Case control study. Setting: Clinical Research Laboratory. Patients or Other Participants: A total of thirty active runners participated. Active runners were defined as those running five or more miles per week for at least four consecutive weeks. Twentyfour individuals had a history of previous running-related injury (leg pain due to running in the last three years) but were not currently symptomatic (age: 21.66 ± 2.44 years, mass: 66.84 ± 10.03 kg, height: 169.21 ± 19.34 cm, runs per week: 4.37 ± 1.30 , miles per week: 14.16 ± 8.88). Eight individuals without a history of previous running-related injury comprised our control group (age: 23.50 ± 3.89 years, mass: 63.64 \pm 8.64 kg, height: 161.83 \pm 19.08 cm, runs per week 4.62 ± 1.38, miles per week: 16.06 ± 9.41). Interventions: While standing in a weight-bearing, subtalar neutral position, diagnostic

ultrasound was used to image the foot intrinsic musculature in a relaxed state and contracted state (while holding a short foot contraction). Main Outcome Measures: Primary outcome measures included cross sectional area (CSA) and thickness of the abductor hallucis (AH). flexor digitorum brevis (FDB), and flexor hallucis brevis (FHB) muscles during both the relaxed and contracted state. CSA was defined as the area (cm²) within the fascial borders of the muscle. Thickness (cm) was defined as the width of the muscle belly. Independent samples t-tests examined the differences in CSA and thickness for each muscle between injured and control groups. Alpha level was set to P < 0.05 a priori. **Results:** Significant group differences were noted for FHB CSA [control: 1.47 \pm 0.10 cm², injured: 1.23 \pm 0.22 cm², p < 0.001] and for FHB contracted thickness [control: 1.26 ± 0.16 cm, injured: 1.07 ± 0.18 cm, p = 0.015]. No other significant differences between groups were found (p > 0.05). <u>Conclusions:</u> Active runners with a history of exercise-related leg pain demonstrate smaller CSA and contracted thickness of the FHB muscle compared to uninjured active runners, consistent with the existing literature. Muscle size can be indicative of muscle performance and strength, which may suggest that weaker and/ or less activated intrinsic foot muscles may play a role in injury risk, however future research is needed to confirm this hypothesis.

Sensorimotor Deficits in Distance Runners With Medial Plantar Pain

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Context: Medial plantar pain is a unique clinical entity experienced by distance runners. Clinical presentation of medial plantar pain is complex, and likely multifactorial, making diagnostic differentiation challenging. **Objective:** To determine if differences exist in plantar sensation, toe-flexion strength, foot morphology, pain-pressure thresholds, and joint mobility in long distance runners with and without medial plantar pain before and after a 6-mile run. Design: Descriptive study. Setting: Laboratory. Patients or Other Participants: Seven distance runners with medial plantar pain (four males, three females; aged 22.3 ± 3.7 years; BMI 22.3 \pm 3.5 kg/m²) and seven matched healthy controls (four males, three females; aged 20.3 ± 1.0 years; BMI 22.0 \pm 1.7 kg/m²) were recruited from a public university. Interventions: Participants ran a 6-mile outdoor course at a self-selected pace while wearing their own preferred footwear. Main **Outcome Measures:** Pressure-pain thresholds (PPT) were measured with an algometer at the midpoint of the medial longitudinal arch, the plantar fascia origin, and over the posterior tibialis distal musculotendinous junction. Plantar cutaneous sensation was measured with monofilaments at the heel, base of the 5th metatarsal, and 1st metatarsal head. Clinical tests of foot morphology, weight-bearing dorsiflexion (WBDF), forefoot joint mobility, hallux and lesser-toe flexion strength, and a seated tibial nerve provocation test were also completed. All of these measures were taken both pre-and post-run. Data were analyzed with mixed-model group by time ANOVAs. Cohen's d effect size estimates with 95% confidence intervals were calculated for pre-post change scores in each group. Results: A significant group by time interaction was observed for PPT at the mid-arch (Control: pre: 83.0 ± 27.4 N, post: 79.5 \pm 22.6 N; Symptomatic: pre: 90.5 \pm 31.9 N, post: 70.1 ± 32.7 N; p = .03) and posterior tibialis (Control: pre: 75.7 ± 19.5 N, post: 65.7 ± 14.2 N; Symptomatic: pre: 75.8 ± 20.4 N, post: 51.1 ± 11.9 N; p = .05) sites. Only the posterior tibialis in the symptomatic group demonstrated a significantly large decrease in PPT following the run (d = 1.5, 95% CI: 0.3 to 2.7). Both groups demonstrated a decreased plantar sensation threshold at the base of the 5^{th} metatarsal (p = .04), decreased PPT at the plantar fascia origin (p = .001), and a significant increase in tarsometarsal extension (p = .01)and WBDF (p = .01) ROM following the run. Pre-post change effect sizes for each group may be seen in the Figure. There were no other significant main effects or interactions. Conclusions: Medial plantar pain appears to be a primarily neurosensory entity without evidence of motor deficit. Symptomatic runners had greater changes in PPT at the mid-arch and distal posterior tibialis muscle compared to controls following the run as exhibited by lower levels of pressure being necessary to evoke a pain response after the run. These findings that may suggest central pain sensitization. Clinicians should consider using sensorimotor testing of the ankle-foot complex when managing patients with medial plantar pain.



Figure 6. Cohen's d effect size estimates and 95% confidence intervals for pre-post change scores for measures taken before and after a 6-mile run. The symptomatic group reported substantial medial plantar pain when running while the control group was asymptomatic. PPT = pressure pain threshold. TMT = tarsometatarsal.

A Non-Rearfoot Strike Transition Program Improves Loading, Pain, and Function in Runners Recovering From Lower-Extremity Injury

Miller EM, Freisinger GM, Watson DJ, Goss DL:Keller Army Community Hospital, West Point, NY; United States Military Academy, West Point, NY; United States Air Force Academy, Colorado Springs, CO

Context: Rearfoot strike (RFS) runners have demonstrated greater average vertical loading rates (AVLR), reduced cadence, and greater incidence of repetitive stress injuries than runners using a non-rearfoot strike (NRFS) pattern. ADDIN EN.CITE 1-2 Running with a NRFS pattern may assist previously injured patients return to activity with reduced lower-extremity loads and pain during running. **Objective:** The purpose of this study was to further investigate the changes in AVLR, cadence, and pain when transitioning previously injured runners from a RFS to a NRFS running style. We hypothesized that following the transition from RFS to NRFS, a decrease in AVLR and pain with running and increase in cadence would be observed. Design: Prospective Cohort. Setting: The study was conducted at West Point, NY at the Arvin Cadet Physical Therapy Clinic and Mahan Hall Chemical and Mechanical Engineering Lab. Patients or Other Participants: A convenience sample of twenty-seven Cadets and active duty Soldiers recovering from running-related injury were recruited to participate in the study (mean age = 25.3 ± 9.9 yrs, mean $ht = 1.7 \pm 0.1 m$, mean wt = 73.0± 12.0 kg). Interventions: Initially and at 10 weeks running kinetic data were assessed with an instrumented treadmill sampling at 1,000 Hz. Foot strike pattern (FSP) was assessed from a Casio High Speed EX-ZR200 digital camera sampling at 240Hz. After initial data collection, each participant received a 30-minute training session focused on instruction of a return to run program.

Nine of the participants received additional training with a clinician and 18 of the participants received training with an instrumented sock; both training methods encouraged NRFS FSP transition by focusing on landing off the heel and a step rate of 180 steps per minute. Main Outcome Measures: The dependent variables of this study include; FSP, AVLR, and pain measured by the single assessment numeric evaluation (SANE). FSP were investigated via descriptive statistics. AVLR and pain were investigated via paired samples t-tests using SPSS v.19. Results: Mean AVLR of the right leg reduced from 58 \pm 12 body weights/second (BW/s) initially to 38 ± 13 BW/s (p < .001). Mean AVLR of the left leg reduced from $55 \pm$ 15 initially to 35 ± 14 BW/s (p < .001). Mean step rate increased from 169 ± 8 to 174 ± 7 steps/minute (p < .001). Mean SANE scores increased from 79 \pm 18 to 93 \pm 10 out of 100 (p < .001). Conclusions: All runners demonstrated significant improvement in all outcomes after participating in a NRFS return to run program. The results of this study suggest that individuals recovering from lower-extremity injury may benefit from changes in running form.

Friday, June 29, 2018, 12:30PM-1:45PM, Room 217–219; Moderator: Mark Merrick, PhD, ATC, FNATA

Dry Cupping With Motion is Effective for Achieving Small Gains in Hamstring Flexibility in Healthy Adults

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Context: The evidence for myofascial decompression, in the form of dry cupping with motion(DCm), to improve hamstring flexibility is lacking. However, DCm is becoming more popular as a treatment selection. Objective: To determine the effects of DCm on hamstring flexibility, as measured by allowable knee extension(Knee EXT) ROM. **Design:** Repeated measures. Setting: Clinic. Patients or Other Participants: Means + SD are presented. Twenty-one healthy volunteers with no history of lower extremity injury participated (n males = 10, n females =11; height = 170.8 ± 7.1 ; mass = 75.2 \pm 15.9; age = 20.3 \pm 1.3). Selection criteria required that volunteers were not engaged in any flexibility training. Interventions: One limb was randomly allocated to DCm. Allocation was concealed; the other limb served as control. The participant was secured to the table in prone. The treatment limb was lowered off the side of the table until the foot was flat on the floor. The table was adjusted so that limb was at 125° hip flexion/45° knee flexion. Six 2-in. plastic dry cups were applied to the posterior thigh, 3 aligned with the biceps femoris and 3 with semitendinosus/ semimembranosus. For the stretching task, the participant extended to a hip 90°/knee 0° position, or as far as possible, by pushing the foot into the floor to the stretch the hamstrings. DCm was applied for 4-min, cycling between 30s of stretch position, and 10s relaxed in the starting position. The control limb was not treated. Main Outcome Measures: Knee EXT ROM was assessed with the participant in supine, with the hip at 90°, with the participant secured to the table in supine at the hip and across the pelvis. The knee was passively extended to a standardized resistance (males: 8 kg, females: 7 kg), as measured by dynamometer. At end-range, an image of Knee EXT angle was captured for analysis. Limb testing order was randomized. Participants were asked if either or both limb(s) felt more flexible. A blinded assessor performed measurements of Knee EXT. Knee EXT angles at pre-treatment and post-treatment for both limbs were entered into a 2-way (within-within) RM ANOVA. The SE measure and the minimal detectable change (MDC) was calculated from the control pre-post data. Results: There was a significant time x treatment limb interaction (F(1,20) = 7.2)p = 0.01). The limb treated with DCm $(\text{pre} = 18.9^\circ \pm 9.9, \text{ post} = 10.2^\circ \pm 6.8)$ increased ROM more than the control limb (pre = $17.2^{\circ} \pm 10.2$, post = 12.9° \pm 8.6). The SE measure = 2.9°; MDC = 4.1°. 86% reported the treated limb as "feeling more flexible". Conclusions: While both groups increased in ROM, the treatment limb increase was 2x greater than the control. This increase was small, yet significant. Further, the treatment group markedly surpassed the MDC, while the control barely met that metric. With this relatively brief treatment of DCm, more participants also reported perceptions of increased flexibility on the treated limb. Research into the added benefit of DCm to improve flexibility or treat other soft tissue restrictions is warranted.

The Therapeutic Effects of Dry Cupping on Iliotibial Band Tightness

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Context: The iliotibial band (ITB) plays a vital role in movement and can become tight if overused. This tightness can lead to a wide array of injuries in an otherwise healthy individual. Previous research has proved the need to treat a tight ITB, but techniques previously researched have not proven to be effective in reducing ITB tightness. Dry cupping is a method in which suction is generated from a vacuum-sealed cup using a pump in order to alleviate pain, reduce tightness, and promote healing. Recently, cupping has been used as a therapeutic treatment to relieve muscular tightness. Currently, there is no research on the effectiveness of dry cupping in relieving lower extremity tightness, particularly to the ITB. **Objective:** To determine if dry cupping is an effective treatment intervention in releasing ITB tightness and increasing hip and knee range of motion in a physically active population. Design: Controlled laboratory study. Setting: Athletic Training Laboratory. Patients or Other Participants: Forty healthy participants (17 males, 23 females; age: 21 ± 1.8 years; height: 170.94 \pm 10.81 cm; weight: 74.20 ± 13.67 kg) with ITB tightness as determined by a positive Ober's test (-12.79 \pm 6.86 degrees). Participants were excluded if there was current pain and/or injury to the leg in the past year, had an intervention for ITB tightness in the past three months, blood flow dysfunctions, hemorrhagic disorders, cancer, or a possibility of pregnancy. Interventions: Participants were randomly assigned to either the dry cupping or sham cupping (cup with a 1mm hole pierced at the top) groups. While in a side-lying position with pillow between slightly bent knees, four stationary cups, using three pumps, were placed along the ITB for seven minutes after scanning the area from greater trochanter to lateral femoral condyle for adhesion points. A 2x3 mixed model ANOVA was performed. Main Outcome Measures: Hip adduction achieved during Ober's test, active and passive hip flexion, and active and passive knee flexion pre, immediately post, and 24 hours post intervention. **Results:** There were no significant differences between groups for any measure (p > .305). However, after running effect sizes between groups for immediate post and 24 hours after intervention, some variables had strong effect sizes. namely Ober's (immediate post: -.66 (-1.3- -.03); 24-hours post: -.67 (-1.3--.03)) and active and passive hip flexion (active 24-hours post: .67 (.03-1.3); passive 24-hours post: .66 (.02-1.29)). Conclusions: Our findings indicate that a single intervention of dry cupping is probably effective in reducing ITB tightness and increasing hip flexion ranges of motion. These changes can be observed immediately after the intervention, as well as maintained 24 hours post-intervention. Clinicians should consider dry cupping as an intervention tool to improve ROM from a tight ITB.

Measuring Popliteal Artery Blood Flow Following a Moderate Fire and Air Vacuum Cupping Treatment

Hilliard MW, Gange K, Hackney K, Peterson R: North Dakota State University, Fargo, ND

Context: Cupping therapy has become an increasingly popular method of alternative medicine. Unfortunately, no quantitative measures on the effects of cupping therapy have yet to be studied despite claims that cupping therapy improves blood flow, and lymphatic drainage. **Objective:** The primary research questions that guided this study included: Does fire cupping applied at moderate intensity increase blood flow through the popliteal artery in a healthy population? Does air vacuum cupping applied at moderate intensity increase blood flow through the popliteal artery in a healthy population? Comparatively, does either fire or air vacuum cupping increase blood flow through the popliteal artery more than the other? Design: This study used a pre and post test experimental design. Independent variables included both fire and air vacuum cupping. The dependent variables were skin surface temperature and average blood flow velocity. Setting: A research laboratory. Patients or Other Participants: A convenience sample of 30 college aged males (30 males; 21.55 ± 2.19) were recruited to participate. Baseline measurements taken included skin surface temperature and popliteal artery blood flow velocity. Interventions: For the cupping treatments, 2" Khang-Zhu vacuum cups and 2" Royal Massage glass cups were used. A Phillips HD11 XE Ultrasound System with a L12-5 linear transducer was used to measure popliteal blood flow. Four surface thermocouples [T1-4] were used to measure skin temperature changes before and after the treatment. Thermocouples were placed at the following locations: T1 was 3" distal of the popliteal fossa, T2 was 3" proximal to the popliteal fossa placed medially, T3 was 3" proximal to the

popliteal fossa placed laterally, and T4 was 7" proximal to the popliteal fossa. Main Outcome Measures: The rate of blood flow and skin temperatures were measured. Results: Blood flow from fire cupping increased in the popliteal artery 10.5ml/min ± 24.35ml/min. All four surface temperatures during fire cupping decreased in a range of 0.17°C to 1.36°C. Blood flow from air cupping decreased 24.52 ml/min ± 39.49 ml/min. All four surface temperatures during air vacuum cupping decreased in a range of .28°C to 1.65°C. On average, fire cups maintained their suction better than air vacuum cups. Conclusions: These results suggest that the vacuum strength of fire and air vacuum cups, decreases blood flow directly beneath the application sites as a result of subcutaneous pressures. However, popliteal blood flow was increased with fire cupping but not air vacuum. An explanation for this could be that fire cups on average stayed adhered to the skin longer than air vacuum cups. Also, it is possible that the inability to accurately control pressures exerted by fire cupping creates more subcutaneous tissue expansion. More research is needed to support or refute the use of cupping therapy for increasing blood flow.

The Effects of Deep Oscillation Therapy for Individuals With Lower Leg Pain

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Context: Lower extremity (LE) pain accounts for 13-20% of injuries in the active population. One common pathology responsible for LE pain is medial tibial stress syndrome (MTSS). Deep oscillation therapy (DOT) may improve range of motion and reduce pain following musculoskeletal injuries. **Objective:** To determine the effectiveness of DOT on closed-kinetic chain ankle dorsiflexion and pain in individuals with and without shin pain. Design: Single-blind, cohort Setting: Research laboratory Patients or Other Participants: Twenty active participants completed this study. Participants completed the MTSS Score to determine group assignment. Ten individuals reporting shin pain with a minimum MTSS score of 1 (male = 5; female = 5; age = 23 ± 3 years; height = $171.5 \pm$ 11 cm; weight = 74.8 ± 13.8 kg; MTSS Score = 2.3 ± 1.25 points) and ten healthy individuals reporting no shin pain and a score of zero on the MTSS score (male = 4; female = 6; age = 22 \pm 2 years; height = 171.7 \pm 9.5 cm; weight = 81.4 ± 16.3 kg) completed the study. Interventions: Participants reported for a single DOT session performed by one researcher to their affected limb (unhealthy) and matched limb (healthy). The intervention parameters included a 1:1 mode and 70-80% dosage. The intervention began by stimulating the lymphatic channels at the cisterna chyli (1 min), the inguinal lymph node (1 min), and the popliteal lymph node (1 min) at a frequency of 150 Hz. Next, the researcher treated the triceps surae complex for 11 minutes (4 min at 120 Hz, 3 min at 85 Hz, 4 min at 20 Hz). Finally, the participant was treated distal to the popliteal lymph node at 25 Hz (5 min). Total intervention time was 19 minutes. Main Outcome Measures: Independent variables were time (pre and post) and groups (healthy and unhealthy). The dependent variables included preand post-intervention measures of pain (10 cm visual analogue scale (VAS)), and ankle dorsiflexion (weight-bearing lunge test (WBLT), cm). Statistical analyses included descriptive statistics and F-test comparisons between and within groups. Results: On the measure of pain, there was a significant effect of time, as well as time and group. Followup independent-samples t-test identified a significant difference in the pre-VAS scores for healthy (mean = 0.18 ± 0.57 cm) and unhealthy (mean = 2.03 ± 1.65 cm) groups (p < 0.01), and no significant difference in post-VAS scores for healthy (mean = 0.00 ± 0.00 cm) and unhealthy (mean = 0.99 ± 1.58 cm) groups (p = 0.08). Paired-samples t-test identified a significant difference in pain (mean = 0.6 ± 0.86 cm, p = 0.005). We identified a significant effect of time but no interaction effect for ankle dorsiflexion. Follow-up independent t-test did not identify a significant difference for WBLT at pre (healthy mean = 12.96 \pm 3.45 cm, unhealthy mean = 13.24 \pm 3.58 cm, p = 0.170) and post (healthy mean = 11.02 ± 2.55 cm, unhealthy mean = 11.60 ± 2.37 cm, p = 0.245). Paired-samples t-test identified a significant difference for ankle dorsiflexion $(\text{mean} = -0.43 \pm 0.59 \text{ cm}, \text{ p} = 0.004).$ Conclusions: Our results suggest that DOT may be a viable treatment for decreasing pain in individuals with lower leg pain. DOT improved ankle dorsiflexion for all participants but not to the minimal detectable change reported in the literature.

Effects of Extracorporeal Pulse Activation Therapy (ESWT) as an Adjunct to Traditional Treatment in Patients With Chronic Lower Extremity Overuse Injuries Ballard EA, Johnson MT, Colvin GR, Scifers JR: Mary Baldwin University, Staunton, VA; St. Luke's University Health Network, Bethlehem, PA; Moravian College, Bethlehem, PA

Context: Extracorporeal Shockwave Therapy (ESWT) is a non-invasive treatment method that delivers acoustic pressure waves, known as orthotripsy, through an applicator head to the site of pain or pathology. These acoustic pressure waves stimulate metabolism, enhance circulation and accelerate tissue healing. Evidence suggests that this modality is best utilized to treat chronic tendinopathies that are unresponsive to conservative care for greater than 6 months. **Objective:** The objective of this study was to determine if ESWT improved treatment outcomes in patients suffering from chronic lower extremity overuse injuries. Design: The design of this study is a retrospective chart review of patients who received ESWT as an adjunct to conservative rehabilitation. Setting: This data was collected in an outpatient sports medicine clinic. Patients or Other Participants: 13 subjects with chronic, overuse, lower extremity pathologies that were resistant to conservative treatment participated in the study (8 males, 5 females, average age 42.54 ± 15.14 years). Interventions: Subjects received an average of 4.69 ± 1.65 ESWT treatments in addition to conservative care. ESWT treatment was delivered through an applicator using a radial acoustic pressure wave. Treatment frequency and applicator head type were determined by the depth of target tissue and the amount of adipose tissue present in the treatment area. Treatment intensity was determined based on patient tolerance to ESWT. Pre and post-intervention assessment of pain and function were completed using a subjective pain scale and the Focus on Therapeutic Outcomes (FOTO) measure. A Global Rating of Change (GROC) was also administered as a post- intervention measurement for each patient. Main Outcome Measures: Changes in pain and FOTO scores were used to determine the effectiveness of adding ESWT to a traditional treatment plan. Results: Paired T-tests demonstrated a statistically significant difference in pain before (3.77 ± 1.74) and after (1.62 ± 1.74) 1.76) addition of ESWT treatment (p = 0.0016). FOTO scores also showed statistically significant improvement before (39.43 ± 13.44) and after (47.85) \pm 6.99) addition of ESWT treatment (p = 0.0057). Patients rated their overall improvement, using the GROC, as 85% following the addition of ESWT to their treatment program. Conclusions: The findings of this study suggest that ESWT is a useful addition to traditional care for decreasing pain, and improving function and quality of life in patients with chronic, overuse lower extremity injuries. It should be noted that this research study had a limited number of participants and, thus, it is difficult to generalize these results to a larger population. It should also be noted that there is limited clinical evidence to support specific treatment parameters when utilizing ESWT. Future studies should use a larger sample size, utilize a control group that does not receive ESWT treatment, and compare clinical outcomes across multiple treatment groups.

Free Communications, Rapid Fire Oral Presentations: Anterior Cruciate Ligament Reconstruction Comparisons and Interventions

Friday, June 29, 2018, 2:00PM-3:15PM, Room 217-219; Moderator: Grant Norte, PhD, AT, ATC

Agility and Balance in Patients With ACL Reconstructed Knees Kirsch A, Bodkin S, Saliba S, Hart

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Context: Anterior Cruciate Ligament Reconstruction(ACL-R) is common among active individuals, often aimed to restore joint stability and return to previous levels of activity. With high incidence of poor outcomes such as reinjury, it is suggested that current batteries of muscular assessments may not be identifying deficits present within this population. It is currently unknown if functional deficits can be better identified through established and novel agility and modified balance tasks. Objective: The purpose of this study was to compare lower extremity agility and balance between ACL-R patients and healthy controls. Design: Descriptive laboratory study. Setting: Laboratory. Patients or Other Participants: A total of 47 individuals, 22 individuals with ACL-R (age: 23.3 ± 5.6 years, height: 173.5 ± 8.9 cm, mass: 70.7 \pm 8.9 kg, time-since surgery: 28.11 \pm 19.3 months) and 25 healthy individuals (age: 23.0 ± 6.4 years, height: 172.5 ± 9.2 cm, mass: 69.81 ± 10.87 kg), were recruited from a university setting for participation in this study. Interventions: Participants performed three agility tasks consisting of one bilateral assessment (Agility T-Test) and two unilateral assessments (17-Hop test, Mat-Hop test). Balance tasks were administered bilaterally for a 10-second trial in three positions (straight knee, bent knee at 30° knee flexion, and a single-leg squat), on two surfaces (firm and foam) with their eyes open and closed. Main Outcome Measures: All agility tasks were measured by time until completion (seconds). Eyes open balance tasks quantified postural stability through center of pressure (COP) average velocity (m/s). Eyes closed tasks measured postural stability through errors established from the Balance Error Scoring System. We used independent samples t-tests for between group comparisons and 2-way ANOVA for interactions among group and position. Post hoc tests were used where appropriate. Alpha level was 0.05 for all

comparisons. Results: Individuals with ACL-R had significantly slower times than healthy controls for the agility T-Test (p = 0.05). No differences were found between groups for the unilateral measures of agility. For the eyes open balance assessments, we observed a significant position by group interaction ($F_{2.86} = 3.91$, p = 0.024) indicating worse postural stability in the bent knee task in ACL-R participants (52.1 \pm 1.9 m/s) compared to healthy controls $(46.9 \pm 1.8 \text{ m/s})$ (Figure 1). Eyes closed balance tasks revealed no differences between groups measured in errors. Conclusions: Patients who have undergone ACL-R perform differently than healthy controls in agility and balance tasks. Individuals following ACL-R presented slower times for bilateral measures of agility; however, no differences were found with unilateral tasks. Patients following ACL-R demonstrate worse postural stability when assessed in a best knee position. Single leg balance assessed with bent knee position may increase demand on the quadriceps and increase postural control deficits in patients with ACL-R.



Figure 1: Significant group by position interaction for center of pressure (COP) average velocity during single leg balance assessments.

Visual Accuracy in ACL-Reconstructed Individuals During a Single-Leg Balance Task

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Context: The three modalities of postural control (visual, vestibular, and somatosensory) integrate external sensory input in order to maintain one's postural stability. Patients following ACL-Reconstruction (ACLR) experience an altered somatosensory input through the loss of mechanoreceptors in the ACL following injury and reconstruction. It is hypothesized that individuals following ACLR compensate these proprioceptive changes with greater reliance on visual mechanisms during activities. It is unknown if visual compensatory patterns are implemented in order to maintain postural stability within the ACLR population during functional tasks. **Objective:** To examine visual gaze accuracy during a single-leg balance task in individuals following ACLR compared to healthy, active controls. Design: Case-Control. Setting: Laboratory. Patients or Other Participants: A total of 20 individuals, 10 ACLR (age = 19.9 ± 1.7 years, height $= 1.67 \pm .12$ m, mass $= 73.1 \pm 16.9$ kg, time post-surgery = 22.3 ± 15.4 mo.) and 10 Healthy Controls (age = $21.1 \pm$ 1.3 years, height = $1.71 \pm .05$ m, mass = 73.6 ± 12.8 kg), participated in the study. Interventions: Visual Gaze patterns were obtained during 20 second single-leg balance trials while the participant was instructed to look at targets presented on a screen 6-meters away for two separate tasks. During Task 1, the visual target was presented in a central location for the duration of the trial. During Task 2, the visual target randomly moved to one of nine target locations for a duration of 2 seconds each (Squares; Figure 1). Main Outcome Measures: Visual Gaze patterns were obtained through the EyeLink II Gaze Tracking system incorporated through The MotionMonitor Biomechanics Software. Visual absolute error distance (meters) was quantified by the distance between the participant's average gaze position and the target for the duration of the target presentation. For Task 2, the targets were stratified into superior, middle, and inferior target levels. Statistical analysis included

a 2-way ANOVA and post-hoc tests where appropriate. Alpha level was 0.05. Results: For Task 1, there were no differences between visual gaze error between ACLR and healthy participants (p = .89). For Task 2, there was a significant interaction between group and target level; $F_{2.36} = 3.76$, p = .033. Post-hoc analyses demonstrated ACLR participants to have significantly greater visual gaze error for the superior targets (ACLR = .70 + .44 m, Healthy = $.34 \pm .15$ m, p = .028) and the inferior targets (ACLR = .67 + .25 m, Healthy = $.31 \pm .13$ m, p = .001) but no differences in visual gaze error were found for the middle targets (p = .82). Conclusions: ACLR patients demonstrate greater visual gaze error when looking upward or downward compared to healthy individuals while maintaining single-limb postural stability. Individuals following ACLR may rely on visual input differently while balancing compared to healthy controls.



Figure 1: A representative sample of visual gaze patterns. The boxes represent the visual targets and the dotted lines represent the visual gaze patterns during a 1-second time epoch while looking at each target.

Influence of Hip Strength, Trunk and Pelvis Position on Single Leg Landing Kinematics in Healthy and ACLR Females Whicker CR, Nguyen A, Crisafulli GA, Bell DR, Trigsted SM: High Point University, High Point, NC; University of Wisconsin Madison, Madison, WI

Context: The relationship between hip strength and altered landing biomechanics that increase risk of ACL injuries remains unclear. Trunk and pelvis position during landing could influence neuromuscular hip function and mediate the role of hip strength on landing kinematics. Furthermore, understanding this relationship in those with ACL reconstruction (ACLR) may help develop more effective screenings to identify those at greatest risk of injury. **Objective:** To determine the influence of hip strength, trunk and pelvis position on lower extremity landing kinematics during a single leg hop (SLH) in healthy and ACLR females. Design: Descriptive study. Setting: Research laboratory. Patients or Other Participants: Thirty-six females with ACLR and 14 controls $(19.4 \pm 1.7 \text{ yrs},$ 168.5 ± 6.7 cm, 66.9 ± 9.4 kg) participated. Interventions: Isometric hip abduction (ABD) and extension (EXT) strength were evaluated using a handheld dynamometer. 3D biomechanics of the reconstructed (ACLR) or dominant (healthy) limb were collected during 3 trials of a single-leg hop (SLH) for distance. Main Outcome Measures: Normalized peak isometric hip strength (%BW), trunk and pelvic angles at initial contact (IC = vGRF > 10 N) and displacements, and peak hip and knee kinematics during the deceleration phase (IC to peak knee flexion) of the SLH were used for analyses. Separate step-wise, linear regressions determined the extent to which hip strength, trunk and pelvis position predicted hip and knee kinematics in healthy and ACLR females. Results: Healthy: Less contralateral trunk displacement (-4.29 \pm 4.05°) predicted less knee internal

rotation (10.86 \pm 7.22°, R² = 0.347, P = 0.034); less contralateral pelvic drop displacement (-1.3 \pm 3.24°, R² = 0.354, P = 0.032), and less ipsilateral trunk lean at IC $(8.45 \pm 6.78^{\circ}, R^2_{change} = 0.288,$ P = 0.018) predicted less knee external rotation $(0.63 \pm 8.44^{\circ})$; greater contralateral pelvic drop at IC $(-9.31 \pm 7.24^{\circ})$. $R^2 = 0.331$, P = 0.040), greater ABD strength (0.43 \pm 0.11%BW, R² _{change} = 0.283, P = 0.022), and less pelvic drop displacement (-1.13 \pm 3.24°, R^2_{change} = 0.181, P = 0.020) predicted less hip adduction $(8.79 \pm 8.81^{\circ})$; less contralateral pelvic drop displacement (-1.13 \pm 3.24°) predicted less hip internal rotation $(3.83 \pm 9.20^{\circ}, R^2 = 0.335, P =$ 0.038). ACLR: Greater ipsilateral trunk rotation displacement $(-3.07 \pm 3.44^{\circ})$ predicted less knee flexion (54.64 ± 11.21°, $R^2 = 0.313$, P < 0.001), greater hip flexion $(-49.69 \pm 10.22^{\circ}, R^2 = 0.165, R^2 = 0.1$ P = 0.016), and less hip adduction (8.09 $\pm 6.86^{\circ}$, $R^2 = 0.117$, P = 0.045); less trunk flexion at IC ($36.44 \pm 9.65^\circ$, R² = 0.123, P = 0.038), greater contralateral trunk rotation at IC ($1.17 \pm 8.27^\circ$, R^2_{change} = 0.288, P = 0.018), and greater trunk flexion displacement $(3.74 \pm 3.91^{\circ})$, $R_{change}^2 = 0.288, P = 0.018$) predicted less knee internal rotation $(4.41 \pm 7.17^{\circ})$. Conclusions: Trunk and pelvis position appear to play an important role in controlling lower extremity motion during single-leg landings. Frontal plane trunk and pelvic positions and motions were observed to be stronger predictors of peak hip and knee kinematics in healthy females. Similarly, trunk positions and motions were stronger predictors of landing kinematics in ACLR females. These landing strategies provide insight toward understanding the neuromuscular function of the hip and identifying those at greatest risk of ACL injury. Ongoing work is examining how these landing strategies influence activation of the hip musculature.

Single-Leg Jump Performance Before and After Exercise in Healthy and ACL Reconstructed Individuals

Bookbinder HA, Slater LV, Hertel J, Hart JM: University of Virginia, Charlottesville, VA

Context: Young individuals who return to sport after anterior cruciate ligament reconstruction (ACLR) have an increased risk of contralateral injury or ipsilateral graft tears. Many clinicians measure symmetry during functional testing to assist with return to play decisions, however testing is completed in a rested state rather than fatigued when injury risk is highest. **Objective:** To compare changes in performance on the single-leg hop and 4-jump test in healthy and ACLR individuals before and after exercise. **Design:** Repeated Measures Descriptive Laboratory Study. Setting: Laboratory. Patients or Other Twenty-five healthy Participants: $(9M/16F, 19.5 \pm 1.6 \text{ years}, 69.6 \pm 8.5 \text{ kg})$ 173.5 ± 8.8 cm) and 27 ACLR (7M/20F, 19.7 ± 2.2 years, 71.1 ± 17.4 kg, 170.6 \pm 9.6 cm, 26.3 \pm 24.7 months from surgery) volunteered. Interventions: All participants completed the single-leg hop for distance and the 4-jump test before and immediately after exercise. The 4-jump test included four consecutive single-leg maximal vertical jumps. The exercise included five rounds of exercise consisting of five minutes of treadmill intervals and one minute of agility for a total of 30 minutes. Main Outcome Measures: Limb symmetry index (LSI) and involved limb were recorded for single-leg hop for distance, average ground contact time (GCT) and average jump height during the 4-jump test. Involved limb single-leg hop for distance was normalized to the participant's height. LSI was calculated as involved limb/nondominant limb divided by the uninvolved limb/dominant limb. Differences between group and time were compared using a repeated-measures ANOVA. Post hoc tests included independent t-test for group and paired t-tests for time. Cohen's d effect sizes were calculated for all significant differences. Results: There was a significant group by time interaction for single-leg hop LSI (p = 0.04). The healthy group had a greater LSI pre-exercise compared to the ACLR group (d = 0.57). There was no difference between groups after exercise. Healthy individuals also hopped farther on the involved limb before (d = 0.65) and after exercise (d = -0.60) compared to ACLR. The ACLR group had greater GCT LSI before (d = 0.31) and after exercise (d = 0.53). There was a significant group by time interaction for involved limb GCT (p = 0.03). There was no difference in GCT between groups before exercise, however ACLR had increased GCT after exercise compared to the healthy group (d = 0.38). The healthy group had greater jump height LSI before (d = 0.38) and after exercise (d = 0.84). The ACLR had less involved limb jump height compared to healthy before (d = 0.75) and after exercise (d = 0.79). Conclusions: ACLR individuals became more symmetric post-exercise, which may be due to adaptations of the involved limb caused by fatigue. Changes in performance and symmetry may provide additional information regarding adaptations to physical demands of exercise after ACLR.

Effects of a 4-Week Plyometric Intervention on Biomechanics, Strength and Function After ACL Reconstruction Jeon H, Pfeiffer S, Thomas AC:

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Context: ACL injuries occur at a rate of over 200,000 per year in the United States and over half are treated with surgical reconstruction (ACLR). After ACLR, patients demonstrate quadriceps weakness and stiffer landing subjecting themselves to a greater stress on the ACL and increased risk of re-injury. **Objective:** Determine if a focused plyometric intervention in patients following ACLR can improve sagittal plane jump landing biomechanics, knee extensor/flexor strength, and single leg (SL) forward hop distance. Design: Randomized controlled trial. Setting: Research laboratory. Patients or Other Participants: Thirteen patients post-ACLR (plyometric: N = 6, age: 20.0 ± 2.1 years, body mass index[BMI]: 22.9 ± 2.8 kg/m², time since surgery: 41.7 ± 29.3 months; Control: N = 7, age: 21.6 \pm 3.4 years, BMI: 25.6 \pm 5.1, time since surgery: 43.3 \pm 25.2 months) participated in this ongoing investigation. Participants were excluded if they had collateral ligament injury or severe osteochondral lesion concurrent to the ACL injury. Following baseline testing, individuals were randomly allocated to the plyometric or control groups via sealed, opaque envelope. Interventions: Participants completed a 4-week (3x/week) plyometric exercise intervention or no intervention (control group). Both unilateral and bilateral exercises were performed. Difficulty was progressed once a participant reported a Borg rating of perceived exertion (RPE) value ≤ 12 for two consecutive sessions. Main Outcome Measures: Participants were assessed at baseline and 1 week post-intervention. Kinematic (200Hz) and synchronous kinetic (1000Hz) data were collected during a jump-landing task. Participants stood atop a 30cm box located 50% of

their height away from two force plates. Immediately upon landing, participants performed a maximal vertical jump. Peak vGRF and sagittal plane biomechanics at peak vGRF were extracted from the initial landing and averaged across trials. Isokinetic knee extensor and flexor muscle strength were tested at 60°/s. The peak torque value for each muscle group was obtained over 5 trials and normalized to body mass (Nm/kg). SL forward hop distance was averaged from 3 attempts as participants jumped forward as far as possible from a SL and landed on the same leg while maintaining balance. An intention-to-treat analysis was utilized. Separate one-way ANOVAs compared changes in dependent variables between groups for the ACLR limb. Alpha was <0.05 for all analyses. Results: There were no differences in change scores for knee flexion angle (Plyometric: $4.6 \pm 8.7^{\circ}$; control: $-0.9 \pm 10.1^{\circ}$; P = 0.32), external knee extension moment (Plyometric: -0.09 ± 0.09 Nm/kg*m; control: 0.04 \pm 0.22 Nm/kg*m; P = 0.21), or peak vGRF (Plyometric: -0.01 ± 0.24 N/kg; control: 0.10 ± 0.18 N/kg; P = 0.35) between groups. Changes in quadriceps (Plyometric: 0.21 ± 0.41 Nm/kg; control: 0.15 ± 0.23 Nm/kg; P = 0.759) and hamstring (Plyometric: 0.03 ± 0.10 Nm/kg; control: 0.16 ± 0.21 Nm/kg; P = 0.182) strength did not differ between groups. SL forward hop distance change scores (Plyometric: 12.89 ± 15.67 ; control: 1.72 ± 4.07 ; P = 0.095) were not different between groups. Conclusions: Preliminary analysis reveals that plyometric exercise does not improve knee joint biomechanics, strength, or function in patients after ACLR. However, as patients were an average of 4 years post-ACLR, future studies are needed to determine the utility of early, focused plyometric intervention at improving biomechanics and function.

Association Between Time Since Surgery and Plantar Cutaneous Sensation in Patients After ACL Reconstruction

Krysak SM, Collins KA, Turner MJ, Hubbard-Turner T, Thomas AC: University of North Carolina at Charlotte, Charlotte, NC

Context: Deficiencies in plantar cutaneous sensation have been observed in patients post-ACL Reconstruction (ACLR). However, these studies have all been conducted on patients less than 2 years post-operatively. Therefore, it is unknown if these deficits persist beyond this 2 year post-operative time point. **Objective:** Determine if there is an association between time since surgery and plantar cutaneous sensation in patients after ACLR. Design: Correlational research. Setting: Research Laboratory. Patients or Other Participants: Fourteen recreationally active adults (age: 20.43 ± 1.70 years; body mass index: $26.08 \pm 4.83 \text{ kg/m}^2$) with a history of ACLR participated. Interventions: The independent variable for analysis was time since surgery. Participants were recruited from the university community at any time point after they had been cleared to return to full activity following ACLR. The average time since surgery was 43.8 ± 27.3 months (range: 10-93). Graft type was not restricted. Main Outcome Measures: Plantar cutaneous sensation was examined bilaterally utilizing the 20 piece Semmes-Weinstein Monofilaments (SWM) while participants lay prone on a table. Light touch detection thresholds were assessed at the plantar aspect of the head of the first metatarsal, base of the fifth metatarsal, and the medial and lateral malleoli. All testing locations were labeled prior to assessment. Utilizing the SWM, a nylon monofilament was applied perpendicular to the skin in order to create a 'C' shape. Participants stated 'yes' at the point in which a monofilament was detected. A validated 4-2-1 stepping algorithm was utilized in order to determine detection thresholds. Based on a positive or negative detection, the monofilament size was either increased or decreased according to the algorithm until the detection threshold was identified. Testing sites were randomized in order to avoid an order effect. Pearson product moment correlations determined the association between time since surgery and plantar cutaneous sensation at each site for both the ACLR and uninjured limbs. Results: Time since surgery was associated with sensation over the lateral malleolus of the uninjured limb, such that greater time since surgery was associated with poorer sensation (r = -0.575; P = 0.031). Sensation was not associated with time since surgery at the remaining sites in the uninjured limb or any site in the ACLR limb. Conclusions: Despite previous reports of plantar cutaneous sensation deficits within the initial 2 years post-operatively, our results indicate that sensation in the ACLR limb is not associated with time since surgery. Future longitudinal studies may investigate how sensation changes within individuals in the subsequent years following ACLR. As sensation deficits may impair gait and postural control, it is important to understand how long these deficits are present so that interventions to combat these deficits can be implemented.

The Immediate Effects of Plantar Massage and Textured Insoles on Gait in Patients Following ACL Reconstruction Collins KA, Turner MJ, Hubbard-Turner T, Thomas AC: University of North Carolina, Charlotte, NC

Context: Gait impairments are common following anterior cruciate ligament reconstruction (ACLR) and may contribute to re-injury or osteoarthritis development. Plantar cutaneous sensation deficits have been reported following ACLR. It is possible that these sensory deficits impact gait and may be a method through which gait can be improved. **Objective:** Examine the efficacy of plantar massage and textured insoles as clinical interventions to alter plantar sensation and improve gait after ACLR. Design: Crossover study. Setting: Research laboratory. Patients or Other Participants: Fourteen recreationally-active volunteers (age: 20.43 \pm 1.70 years; body mass index: 26.08 \pm 4.83 kg/m²) who were an average of 43.71 ± 27.32 months post-ACLR participated. Interventions: Participants completed two testing sessions, receiving one intervention per session. Plantar massage consisted of a 5-minute massage targeting the plantar surfaces of both feet, combining effleurage and petrissage techniques. Textured insoles were made from coarse sandpaper, cut to fit into participants' shoes, and worn during gait. Main Outcome Measures: Gait and plantar cutaneous sensation analyses were completed prior to and following each intervention. Bilateral gait analysis was completed via 3D motion capture synchronized with inground force plates while participants walked at standard gait speed (1.4m/s \pm 5%). Gait data were processed using a standard inverse dynamics approach. Plantar cutaneous sensation analysis was conducted bilaterally utilizing Semmes Weinstein Monofilaments with a 4-2-1 stepping algorithm at the plantar aspect of the head of the first metatarsal, base of the fifth metatarsal, and the

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medial and lateral malleoli. Gait data were analyzed using limb X time X condition repeated measures ANOVAs. T-tests were utilized to make post hoc comparisons. Plantar cutaneous sensation data were analyzed via Wilcoxon Signed Rank tests to compare differences between limbs, conditions, and time. Alpha was set a priori at <0.05. Results: The ACLR limb was more abducted during walking than the contralateral limb (-1.6 \pm 4.1°; P = 0.028) regardless of time or condition. The ACLR limb demonstrated poorer sensation than the contralateral limb over the fifth metatarsal (4.08 [3.61, 4.31]; P =0.016) and medial (4.08 [4.08, 5.07]; P = 0.028) and lateral (4.56 [3.61, 5.18]; P = 0.046) malleoli. Massage increased sensation over the first (3.61 [2.83, 4.74]; P = 0.026) and fifth (3.61 [3.61, 4.08]; P = 0.039) metatarsals and medial (4.08 [3.61, 4.74]; P = 0.035) and lateral $(4.20 \ [3.61, 4.74]; P = 0.043)$ malleoli in the ACLR limb. Following textured insoles application, sensation improved over the 1st (3.61 [2.83, 4.74]; P = 0.027) and 5th (3.61 [3.61, 4.08]; P = 0.011) metatarsals and medial malleolus (4.08 [3.22, 4.74]; P = 0.007) of the ACLR limb. Conclusions: Plantar massage and textured insoles improved plantar cutaneous sensation in the involved limb following ACLR. Neither intervention improved gait biomechanics. Additional investigations of other sensory interventions should be performed to optimize treatment and improve gait biomechanics following ACLR.

Arch Height Index and Plantar Pressure Distributions in Females Post-ACL Reconstruction Lundin MJ, Cattano NM, Breymeier MM, Anderson HJ, Morrison KE: West Chester University, West Chester, PA

Context: The potential long-term complications of ACL injuries can span from a reduction in activity levels to the development of osteoarthritis. Research has focused on gait adaptations pre and post 1 year ACL reconstruction (ACLR) and have found considerable changes in lower extremity gait patterns. There has been limited research to examine if foot type and plantar pressure distributions may contribute to these gait adaptations 1-5 years post ACLR, which may predispose individuals to long-term complications. **Objective:** To evaluate the differences in arch height and plantar pressure distributions in females post ACL reconstruction and healthy matched controls. Design: Observational cohort. Setting: Division II University. Patients or Other Participants: Forty physically active college females between the ages 18 to 25 participated in the study. The ACLR participants (n = 20, age: 20.5 ± 2.5 y, Body Mass Index (BMI): 25.45 ± 5.95 kg/m²) had ACLR within 5 years of study participation and were medically cleared for physical activity. Healthy control participants (CON) (n = 20, age: 20 ± 2 y, BMI: $23.85 \pm 3.65 \text{ kg/m}^2$) were matched by age, mass, height, and physical activity level. Interventions: The Arch Height Index (AHI) Measurement System was used to measure the bilateral AHI and arch stiffness for each subject. Plantar pressure distributions were analyzed on a Tekscan© plantar pressure mat at 100 frames per second during a barefoot walking gait at a self-selected speed. A total of 3 trials were captured and plantar pressure values were averaged for analysis. The primary aims were analyzed between groups (ACLR vs. CON) using independent t-tests ($P \leq$ 0.05). Main Outcome Measures: Arch

height index (AHI), arch height stiffness (AHS), heel contact time (HCT), center of force deviation medial (Dem), center of force deviation lateral (Del), center of force excursion index (EX) and peak pressure gradient (PPG). **Results:** Analysis of plantar pressures revealed no significant differences between groups for variables HCT [CON $(.408 \pm .0692)$ vs. ACLR $(.419 \pm .068)$ (p = .614)], Dem [CON (-.65 ± .335) vs. ACLR $(-.59 \pm .493)$ (p = .655)], Del $[CON (1.35 \pm .459) vs. ACLR (1.33)]$ \pm .581) (p = .905)], EX [CON (19.0 \pm 5.731) vs. ACLR (18.1 \pm 7.799) (p = .68)] or PPG [CON (332.3 \pm 58.94) vs. ACLR (303.45 ± 52.42) (p = .11)]

With regard to arch characteristics there was no significant difference (p =.351) in AHS between CON (5988.21 ± 2685.33) vs. ACLR (5279.76 ± 2011.18), but there was a trend towards significance (p = .083) in AHI values between CON($.370 \pm .0236$) vs. ACLR $(.359 \pm .018)$. **Conclusions:** Although we were unable to identify significant differences in plantar pressure distributions, there was a noted trend that AHI values were lower in the ACLR group indicating a more planus foot. This may increase pronation during stance, which causes internal tibial rotation and preloads the ACL. This change in loading at the knee may have contributed to their original injury risk, but may also put these individuals at greater risk of long term complications. It has been shown that an increase in pronation in gait increases the knee adduction moment, which has been linked to the development of OA at the knee.

Anterior Cruciate Ligament Reconstruction Does Not Alter Variability of Sagittal Knee Joint Kinetics During Running Grindstaff TL, Chaput M, Famer B, Anderson K, Lanier AS, Knarr BA, Wichman C, Turman KA: Creighton University, Omaha, NE; University of Nebraska, Omaha, NE; University of Nebraska Medical Center, Omaha, NE; GIKK Ortho

Specialists, Omaha, NE

Context: Individuals with a history of anterior cruciate ligament reconstruction (ACL-R) demonstrate altered knee joint gait biomechanics that differ from healthy individuals. These measures typically reflect the average of a number of strides, but does provide detailed insights into the inherent strideto-stride variably necessary to adapt to a changing environment. Previous studies have shown individuals with a history of ACL-R, relative to healthy controls, demonstrate alterations in stride-to-stride knee joint kinematic variability during walking and running, but have not described changes in knee joint kinetics. **Objective:** To determine differences in nonlinear measures of sagittal plane knee joint kinetics during running in individuals within 2 years of ACL-R compared to a healthy group. We hypothesized that individuals with a history of ACL-R would demonstrate decreased variability in sagittal plane knee joint kinetics compared to healthy controls. Design: Cross-sectional study. Setting: University research laboratory. Patients or Other Participants: Fifteen individuals with a history of ACL-R (10 female, 5 male; mean \pm SD age = 20.1 ± 5.6 y; height = 172.9 ± 8.0 cm; mass = 70.3 ± 13.6 kg; time since surgery = 12.2 ± 5.2 months; IKDC = 87.7 ± 13.4) and eighteen healthy participants (11 female, 7 male; age = 19.9 \pm 4.4 y; height = 175.1 \pm 9.3 cm; mass = 68.3 ± 12.1 kg; IKDC = 97.1 ± 4.5) were recruited from the surrounding community. Interventions: Participants performed 2 minutes of running on an instrumented treadmill with embedded

force plates (1000 Hz) interfaced with an eight camera motion analysis system (250 Hz). Main Outcome Measures: The primary outcome measure was variability of external knee flexion moments and calculated using sample entropy. A mixed model ANOVA was used to determine differences between sides (involved/uninvolved; nondominant/dominant) and groups. Results: There was not a significant group x side interaction (F = .583, p = .45) or a significant group main effect (F = 3.23, p = .08). Individuals in the ACL-R group did not have significant differences (p =.20) between the involved limb (.2249 \pm .0737) relative to the uninvolved limb $(.2527 \pm .0750)$ and healthy individuals did not have significant differences (p = .58) between the nondominant (.1950) \pm .0745) and dominant (.2037 \pm .0663) limbs. Conclusions: Individuals with a history of ACL-R did not demonstrate variability in knee joint loading that was different from healthy controls. Although previous research has demonstrated altered variability in sagittal plane knee motion in individuals with a history of ACL-R, this did not translate to altered variability of knee joint moments. Future studies should determine if there are a subset of individuals with ACL-R who would demonstrate changes in knee joint loading variability and determine the clinical relevance of these changes.

Heat/Hydration Best Practices Forum: Unique Perspectives: A Comprehensive Debate Relative to Minimizing Legal Risk in Athletic Training

Wednesday, June 27, 2018, 8:00AM-9:00AM, Room 220–222; Moderator: Gretchen Schlabach, PhD, ATC Discussants: Jeff Konin, PhD, PT, ATC, FACSM, FNATA; Randy Cohen, ATC, DPT

History of Ankle Pathology in US Marines Entering 6 Month Officer Training Course

Johnson ZD, Barrett AS, Gribbin TC, de la Motte SJ: Consortium for Health and Military Performance, Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Ankle sprains are one of the most common injuries sustained by members of the US Armed Services; they lead to lost duty time and are a threat to operational readiness. Up to 40% of those who suffer an ankle sprain will develop Chronic Ankle Instability (CAI), which often goes unaddressed and may contribute to risk for other musculoskeletal injuries (MSK-I). Identifying the prevalence of ankle sprain and/or CAI symptomology (i.e. ankle pathology (AP)) is the first step in a systematic approach to injury prevention. **Objective:** To describe the history of ankle sprains and CAI symptomology (defined here as AP) in United States Marine Corps (USMC) Officers entering their six month officer training course at The Basic School (TBS). Design: Cross-sectional survey. Setting: TBS, Marine Corps Base, Quantico, VA. Patients or Other Participants: 190 USMC Officers (Males = 167; 24.7 ± 3.0 years, Females = 23; 25.5 ± 3.9 years). Interventions: A brief, seven-item questionnaire on ankle pathology (AP) (e.g. ankle injury history; chronic ankle instability symptoms) was administered as part of a larger study of USMC officers entering training at TBS. Responses of "Yes" or "No" were recorded for "Have you ever sprained your ankle", "If yes, does it currently interfere with any physical activity?", and "Within the past six months have you felt that your ankles are not supporting you, or are giving way?" Main Outcome Measures: Prevalence of ankle sprain history and current ankle symptomology. Descriptive statistics, Pearson Chi Square and Fisher's Exact Tests for small sample sizes were used to compare responses between

sexes. Results: A total of 190 (Males = 167; Females = 23) USMC Officers completed the survey prior to beginning TBS training. Approximately half of all officers (n = 94/190, 49.5%) reported a history of ankle sprain upon entry to TBS. There were no differences by sex (Males = 83/167; 49.7%, Females = 11/23; 47.8%; $\chi 2 = 0.28$, p = 0.87). Of the 94 who reported a prior ankle sprain, 19.1% also reported symptoms of "giving way" within the past 6 months (n = 18/94), and 8.5% of those with ankle sprain history reported their ankle "currently interferes" with physical activity (n = 8/94). Neither of these results differed by sex ("Giving way": Males = 14/83, 16.8%; Females = 4/11; 36.4%; Fischer's Exact Test p = 0.21and "Currently Interferes": Male = 6/83, 7.2%; female = 2/11, 18.2%; Fischer's Exact Test p = 0.24). Conclusions: The first step in a systematic approach to injury prevention includes identifying incidence and prevalence of injury conditions. In our study, half of USMC Officers entering TBS reported some type of past or current ankle pathology. History of an ankle sprain has previously been recognized as a contributing risk factor for future MSK-I. This information is important for gaining a comprehensive understanding of which underlying pathologies should be targeted with injury prevention strategies during military training.

Musculoskeletal Injury Risk Among Army ROTC Cadets Bruce SL, Bertsos ML, Marshall DL, DiMasso AE: Wright State University, Dayton, OH

Context: To date, very little data has been published related to musculoskeletal injury risk among our servicemen and servicewomen. We used a cohort of Army ROTC cadets to help identify those factors which may place the individual at high risk for injury. Objective: The purpose of this study was to predict which Army ROTC cadets were at high risk for injury based on baseline testing and pre-participation survey of joint specific functional limitations. Design: Cohort design Setting: A four-year, primarily nonresidential, research doctoral, STEM-dominate university from the midwest region of the United States. Patients or Other Participants: Fiftythree participants from an Army ROTC program volunteered for this study. There were 39 males (age: $21.1 (\pm 3.8)$; Ht (cm) 177.67 (±7.4); Wt (kg) 79.25 (±10.79); BMI 25.12 (±3.2)) 20 females (age: 20.1 (±1.18); Ht (cm) 161.29 (±9.99); Wt (kg) 62.43 (±8.73); BMI 24.15 (±3.97)). Interventions: Baseline testing included 3 muscular endurance, core resistance exercises: single-leg wall sit hold, horizontal trunk extension hold, and postural balance test unilateral squat hold; Army Physical Fitness Test assessed at baseline included: push-ups, sit-ups, 2-mile run, and completion of the Sports Fitness Index, a joint specific, functional limitation survey. Additionally, participants were baseline tested on a Dynavision unit to assess reaction time, central and peripheral vision. Injury data for the academmic year were recorded. Bayesian analysis was used to analyze the data. Main Outcome Measures: Administration of the Sport Fitness Index survey, 3 core muscular endurance tests, the Army Physical Fitness test, and the Dynavision to assess reaction time and central and peripheral vision were done prior to ROTC cadet training. Cadets

self-reported injuries (dependent variable) throughout the academic year to the research team, since no athletic trainer was assigned to provide health care. A musculoskeletal injury was operationally defined as any condition suffered by a cadet that affected either their activities for daily living or ROTC physical training activities. Receiver operating characteristic analysis was used to identify dichotomization of predictor factors. These factors were analyzed separately and collectively for their predictive value in terms of sensitivity, specificity, positive and negative likelihood ratios, odds ratio, relative risk, and Fisher's Exact 1-sided p-value. All parameters will be reported with the 95% confidence intervals. Logistic regression analysis was used to identify the strongest set of predictor variables. **Results:** Logistic regression identified 2 factors as the strongest modifiable risk factors related to prediction of musculoskeletal injury: Sport Fitness Index score of \leq 79; Dynavision Hits, Outside ring/Inside ring ratio of ≤ 1.19 . The presence of either factor or both of the factors demonstrated 94% sensitivity, 60% specificity, a positive likelihood ratio 2.34 (95% confidence interval = 1.36, 4.04), a negative likelihood ratio 0.104 (95% confidence interval = 0.026,0.418), an odds ratio 22.5, (95% confidence interval = 4.16, 121.69), a relative risk 5.53, (95% confidence interval = 4.51, 6.77), and a Fisher's Exact Test (one-sided) p < 0.001. Conclusions: A low Sport Fitness Index (\leq 79) and a low Dynavision Hits, Outside ring/ Inside ring ratio (≤ 1.19) appear to be modifiable risk factors for musculoskeletal injuries to Army ROTC cadets when administered preparticipation. The predictors used in this study need to assessed prosectively with a larger sample of ROTC cadets.

Assessing Changes in Knowledge, Attitudes, and Beliefs Towards Injury Prevention During Marine Corps Training

Dartt CE, Donahue CC, Gribbin TC, Deuster PA, de la Motte SJ: Consortium for Health And Military Performance, Uniformed Services University, Bethesda, MD

Context: Musculoskeletal injury (MSK-I) continues to be one of the largest threats to readiness in the military. Injury prevention (IP) interventions can be implemented to decrease risk of MSK-I. To foster efficacy of IP programs, it is important to have an accurate representation of participants' beliefs, motivators and barriers towards IP. **Objective:** To describe changes in beliefs of U.S. Marines regarding IP before and after training at School of Infantry-West (SOI-W). Design: Cross-sectional survey. Setting: Camp Pendleton, California Patients or Other Participants: Male U.S. Marines entering training at SOI-W (N = 311). Interventions: A brief questionnaire was administered to male Marines $(19.7 \pm 1.7 \text{ yrs}, 176.6 \pm 7.5 \text{ cm},$ 74.6 ± 8.3 kg) at SOI-W entry and graduation. Participants rated their agreement regarding lower extremity injury (LEI) and prevention on a 5-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree" with the following: "I would be willing to perform specific training and exercises to prevent LEI in my own spare time if I was provided instructional resources and guidance," "I would like specific training and exercises designed to prevent LEI to be a required part of my physical training while at the School of Infantry," and "LEI can be prevented by doing specific training and exercises." Main Outcome Measures: Knowledge and beliefs about LEI prevention. Responses were collapsed into three discreet categories of "agree," "neutral," and "disagree." Wilcoxon signed-rank test were used to assess changes between response categories over training. Results: Prior to training,

the majority agreed they would like IP exercises included in training at SOI-W, and Wilcoxon signed-rank test showed a significant change (n = 311; Z = -2.31, p = 0.02) towards agreement post-training (PRE-POST: Agree: 64% vs. 69%; Neutral: 30% vs. 27%; Disagree: 5% vs. 3%). Prior to training, Marines generally agreed they would be willing to perform IP exercises in their own spare time with a significant change (n = 310;Z = -2.14, p = 0.03) toward increased agreement following training (PRE-POST: Agree: 79% vs. 84%; Neutral: 20% vs. 15%; Disagree: 1% vs. 1%). Finally, the majority agreed that LEI can be prevented with specific training and exercises and shifted towards increased agreement (n = 309; Z = -2.21, p = 0.03) post-training (PRE-POST: Agree: 79% vs. 83%; Neutral: 20% vs. 16%; Disagree: 1% vs. 1%). Conclusions: After completing SOI-W training, a greater percentage of Marines agreed that LEI could be prevented with IP exercises, which increased significantly from training entry. There was also a significant increase in the percentage of Marines who were willing to perform IP exercises during training and on their own time compared to entering training. Based on these initial findings, we are working with SOI-W to design and deliver a targeted integrated IP program through training and on their own time for Marines at SOI-W.

Impact of Protein or Carbohydrate Supplementation on Musculoskeletal Injury Rates in Initial Army Training

McGinnis KD, McAdam JS, Roberts MD, Lockwood CM, Sefton JM: Warrior Research Center, Auburn University, Auburn, AL; Molecular and Applied Sciences Laboratory, Auburn University, Auburn, AL; Lockwood LLC, Draper, UT

Context: Musculoskeletal injury (MSI) contribute to high costs during Army initial entry training (IET). Objective: Determine if improved fueling can result in decreased MSI. Design: This study implemented a randomized placebo controlled, double blinded study, and subjects were compared with unit historical MSI data collected by our laboratory. Setting: Military training post, Army initial entry training Patients or Other Participants: Male Army IET Soldiers were divided into once or twice daily protein or carbohydrate groups: protein 1 shake (n = 50, n = 50)age 21.3 ± 3.2 , 76.8 kg ± 12.8 , 173.2 cm \pm 7.8); carbohydrate 1 shake (n = 50, age 22.9 ± 3.8, 77.8 kg ± 15.3, 175.1

 $cm \pm 7.8$); protein 2 shakes (n = 56, age 18.6 ± 0.9 , 73.4 kg \pm 2.7, 173.1 cm \pm 6.1); or carbohydrate 2 shakes (n = 56,age 18.6 ± 1.2 , $72.3 \text{ kg} \pm 10.9$, 173.2 $cm \pm 5.1$). Historical data was analyzed from the same unit, same months for 2015/2016. Non-matched pairs group averages were used for comparison. Interventions: Each participant consumed either a protein (38.6g Protein, 19g Carbs, 7.5g Fat) or carbohydrate shake (0.5g Protein, 63.4g Carbs, 3.9g Fat) twice or once a day immediately following physical training and prior to bed or prior to bed only. Main Outcome Measures: MSI data were recorded by the unit's Athletic Trainer using a customized injury data collection system. Odds Ratio (OR) and Chi square (χ^2) was calculated for each group to compare consumption of supplementation versus no supplementation, one versus two supplementation shakes per day, and carbohydrate versus protein supplementation. Results: There was a significant difference in MSI between participants who consumed two shakes a day and participants that consumed no shakes ($\chi^2 = 60.12$, CI = 3.40-8.39, p < 0.001). Soldiers who were not

supplemented were 5x (OR = 5.34) more likely to incur an MSI than those consuming two shakes. Participants who consumed two shakes a day were also significantly less likely to incur an MSI than participants that consumed one shake a day ($\chi^2 = 10.60$, CI = 1.53-6.05, p = 0.001). Participants who consumed one shake were 3x more likely to incur an MSI than participants who consumed two shakes a day. However there was no significant difference between participants who consumed one shake and Soldiers who were not supplemented ($\chi^2 = 1.59$, CI = 0.86-2.03, p = 0.208). There was no significant difference between protein or carbohydrate supplementation for one ($\gamma^2 =$ 0.059, CI = 0.74-4.09, p = 0.809) or two daily shakes ($\chi^2 = 1.65$, CI = 0.34-2.30, p = 0.198). Conclusions: Intake of either protein or carbohydrate shakes resulted in decreased MSI in IET soldiers. Twice daily shakes of either supplement were more beneficial than one daily shake. IET soldiers not supplementing with protein or carbohydrate presented the highest rate of MSI.



Journal of Athletic Training

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Factor Structure of a Knowledge, Attitude and Beliefs Survey on Lower Extremity Injury in a Military Training Setting Donahue CC, Gribbin TC, Dartt

CE, Kazman JB, de la Motte SJ: Consortium for Health And Military Performance, Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Understanding participants³ knowledge attitudes and beliefs (KABs) about injury risk factors and injury prevention can provide meaningful considerations for the development of injury prevention programs (IPP). Our group has recently adapted a lower extremity injury (LEI) and prevention KAB survey used with Australian Rules Football Players for use in a military setting. The survey was developed using Health Belief Model (HBM) constructs and the Reach, Efficacy/Effectiveness, Adoption, Implementation and Maintenance (RE-AIM) framework. In order to identify common themes for the adapted KAB survey as they relate to injury and injury prevention in military training, we employed factor analysis in an effort to better understand underlying relationships between survey questions. **Objective:** To describe the factor structure of a 19-item KAB questionnaire regarding injury risk and prevention in male U.S. Marines entering training at the School of Infantry-West (SOI-W). Design: Cross-sectional survey with a theoretical basis derived from the Health Belief Model. Setting: Camp Pendleton, California Patients or Other Participants: Male U.S Marines entering SOI-W (N = 466; 19.27 ± 1.39 yrs). Interventions: A brief, 19 item 5-point Likert scale questionnaire asking about KABs towards LEI was administered as part of a larger study at SOI-W. Main Outcome Measures: Beliefs about lower extremity injury and its prevention; latent variable dimensions underlying survey responses (i.e. factors, or relationships between survey questions) Results: A total of 466 male Marines completed the KAB survey at initiation of SOI-W training.

For all 19 survey items, communalities were all above 0.3, confirming that each item shared common variance with other items in the survey. Based on the scree plot, three factors with eigenvalues greater than 1.5 were identified and extracted. Extracted factors accounted for 37% of the variance in responses, and were classified as follows: Factor 1: "Attitudes towards IPP participation," consisting of 7 items, (i.e. "LEI can be prevented by doing specific training and exercises")(16.7% variance); Factor 2: "Beliefs about military training related injury risk and prevention," consisting of 6 items (i.e. "Participating in military training will help me to avoid LEI in the future")(12.5% variance); and Factor 3: "Beliefs about injury outcomes" consisting of 5 items (i.e. "LEIs do not usually limit me from military training")(8.5% variance). Conclusions: Factor analysis on our adapted KAB questionnaire identified three common dimensions (e.g. factors) regarding injury risk and prevention in military training. These findings appear to be consistent with the original questionnaire dimensions, as described using the HBM. Further analyses are planned to generate "construct scores", which will provide additional understanding about end-users attitudes and beliefs towards IPP participation, beliefs about military training related injury risk and prevention and beliefs about injury outcomes. Ultimately this data will be used to inform the development of an IPP and promote successful IPP implementation.

Assessing Knowledge, Attitudes, and Beliefs About Lower Extremity Injury During USMC Officer Training

Barrett AS, Johnson ZD, Gribbin TG, de la Motte SJ: Consortium for Health and Military Performance, Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Musculoskeletal injury (MSK-I) is the leading cause of lost duty days in the U.S. Military and a threat to military readiness. Sustaining a primary MSK-I is the single greatest contributor to recurrent MSK-I as well as long-term pain and osteoarthritis. Currently little is known about Service members' knowledge, attitudes and beliefs (KABs) about MSK-I and the potential consequences of continued participation in military training with MSK-I. Assessing these KAB in Service members can provide injury prevention program (IPP) implementation context, to include barriers and drivers for consideration during IPP development in training environments. **Objective:** To assess the knowledge, attitudes, and beliefs of Marine Officers entering The Basic School (TBS) in Quantico, VA regarding participating in military training with a lower extremity injury (LEI). Design: Cross-sectional Survey Setting: The Basic School at Marine Corps Base Quantico, VA. Patients or Other Participants: Marine Corps Officers entering training at TBS (N = 204; Male = 176; 24.7 ± 2.9 years; Female = 25; 25.3 \pm 3.8 years). Interventions: A brief, 5-point Likert scale questionnaire regarding KABs towards LEI was adapted from a similar survey conducted in Australian Rules Football. The current questionnaire was administered as part of a larger study of Marine Corps Officers enrolled at TBS; responses ranged from "Strongly Agree" to "Strongly Disagree". Available responses were collapsed into discreet categories of "agree", "disagree", and neutral. Main Outcome Measures: Knowledge and beliefs regarding participating in military training with a LEI, described in frequencies and percentages. Results: Over two-thirds of Officers (76%; 139/182) agreed that military training exercises have a high risk of LEI, while 16.5% (30/182) were neutral and 7.1% (13/182) disagreed. The overwhelming majority of Marines (90.7%; 165/182) agreed with the statement "Marines who continue to take part in military training with LEI are likely to suffer physical problems later in life"; 8.2% (15/182) were neutral and only 1% (2/182) disagreed. Approximately half (54.5%; 91/167) of Officers were confident they knew appropriate exercises and training methods to reduce LEI risk, while 26.3% (44/167) were neutral and 19.4% (32/167) were not confident. Finally, 84.8% (156/184) reported they would like specific exercises designed to prevent LEI as a required part of physical training at TBS; 13.6% (25/184) were neutral, and 1.6 % (3/184) disagreed. Conclusions: The majority of Marine Officers entering TBS recognize the high risk of LEI during military training, and increased risk of physical problems later in life if they train with a LEI. Although half believe they currently know appropriate exercises to reduce LEI risk, the majority demonstrate a willingness to incorporate injury prevention exercises into physical training. These results provide information on IPP implementation barriers and drivers to consider during IPP development early in officer training to reduce the risk of primary or secondary injury.

The Relationship Between Self-Reported Lower Extremity Function and Functional Tests in Career Firefighters Games KE, Winkelmann ZK, Shea

ME, Eberman LE: Tactical Athlete Research and Education Center, Indiana State University, Terre Haute, IN

Context: Approximately 50% of all fireground and non-fireground injuries are categorized as strains, sprains, and muscular pain with a large majority of these injuries occurring in the lower extremity. Patient reported outcomes (PROs) are tools that athletic trainers use to assess function and progress of patients. Currently, limited research has examined the relationship among PROs and functional activity in career firefighters. **Objective:** To examine the relationship between the Lower Extremity Functional Scale (LEFS) and measurements of lower extremity power and ankle dorsiflexion. Design: Retrospective analysis of patient records. Setting: Athletic training facility serving firefighters. Patients or Other Participants: We analyzed records of 94 firefighters in a medium sized Midwestern community (age = 40.2 ± 9.2 y; sex = 94 (100%) male, 0 (0%) female; height = 178.0 ± 8.9 cm; weight = 105.9 ± 29.14 kg; leg dominance = 84 (88.4%) right, 11 (11.6%) left; years of experience = 14.3 ± 9.4 y). Interventions: We reviewed patient records from an annual mass screening of firefighters who utilize the athletic training clinic. We extracted specific data from the patient record including: age, sex, height, weight, leg dominance, years of experience, total LEFS score, vertical jump height, and left and right leg weight bearing lunge test (WBLT) scores. We transferred the data into an electronic database for analysis. Main **Outcome Measures:** Our outcomes of interest included the LEFS (total score), vertical jump height (in), left leg WBLT score (cm), right leg WBLT score (cm). The LEFS is a validated, 20-item PRO used to measure a patient's initial function, ongoing progress, and outcome in

the lower extremity. The vertical jump test is a test commonly used to measure overall lower extremity power. The patient records indicated the mean jump height of three trials as measured by a vertical jump mat. The WBLT is a functional measure of ankle dorsiflexion. The patient records indicated the mean distance between the great toe and the wall of three trials for both the right and left legs. We examined the relationship between the total LEFS score, mean vertical jump height, and left and right leg WBLT scores using multiple Pearson correlations. Results: The mean LEFS scores were 75.5 ± 7.9 points indicating very high (93%) function. The mean vertical jump scores were 17.3 ± 3.5 in. The mean left and right WBLT scores were 9.94 ± 3.1 cm and 9.91 ± 3.4 cm, respectively. The Pearson correlations revealed weak linear relationships between the LEFS and vertical jump height (r =0.320; p = 0.004), left leg WBLT score (r = 0.325; p = 0.003), and right leg WBLT score (r = 0.222; p = 0.04). Conclusions: Our data suggest that firefighters with no current history of lower extremity injury have high levels of function. Functional measures of lower extremity performance may be associated with self-reported function. Future work should compare groups of healthy firefighters and those with a current lower extremity injury.

Free Communications, Rapid Fire Oral Presentations: Performing Arts

Wednesday, June 27, 2018, 10:30AM-11:30AM, Room 220-222; Moderator: Michelle Pye, PhD, ATC

Healthcare Availability in Drum Corps

McPherson AM, Hatheway Lewis M, Docherty CD: Indiana University, Bloomington, IN; University of North Texas Health Science Center, Fort Worth, TX

Context: While marching band members have been shown to require high physiological output and to suffer significant injuries, no published studies have investigated injury incidence in the elite and athletic touring units known as drum corps. These groups, competing as part of the Drum Corps International (DCI) competitive circuit, have no overseeing rules or regulations regarding healthcare (HC) provisions. Therefore, it is imperative to establish availability of healthcare and preventative services. **Objective:** To investigate the characteristics of healthcare service availability to drum corps members. Secondarily, to establish injury incidence during the DCI season. Design: Cohort Study. Setting: DCI drum corps Patients or Other Participants: 887 drum corps members from 35 independent DCI drum corps (male: n = 498, female: n = 389, age = 18.7 ± 1.8 yrs, height = 1.7 ± 0.1 m, weight [start of season] = 72.0 ± 16.6 kg, drum corps experience = 2.0 ± 1.3 yrs). **Interventions:** Participants completed an online epidemiologic questionnaire that was developed and disseminated using the Qualtrics platform. Participants answered questions according to their experience during the 2015 DCI season. Item categories included: demographic information, HC availability, injuries experienced, and pain experienced. Main Outcome Measures: Injury occurrence (number of acute injuries, number of chronic injuries), HC provided (yes/no), HC provider type (12 categories), consistent HC provider (yes/ no), consistent HC provider type (12 categories), and pre-season physical required (yes/no). Healthcare responses were grouped according to respective

drum corps, then aggregate data was used to report descriptive statistics. Injury incidence measures were calculated. Results: Retrospective, member self-reported data demonstrated an injury incidence proportion of 0.52 (95% CI: 48.9%, 55.4%) and estimated clinical injury incidence of 1.31. Twentynine (20 World-Class, 9 Open-Class) of the 35-represented corps were reported to provide HC services of some type. However, only 40% (14) of these corps maintained a consistent provider over the course of the season. The most frequent (37.9% of corps with HC) and most consistent HC provider (46.6% of corps with a consistent HC provider) was the athletic trainer. Perhaps most surprisingly, in 31% (9) of the corps with HC services, members reported they were "unsure" what type of provider was available. Only 16 of the corps required members to have any type of pre-participation physical completed. Conclusions: Drum corps members self-report a high incidence of both acute and chronic injuries over the course of a season. Unfortunately, these members also report low availability of HC services, which may include a high proportion of volunteer-only services. The drum corps setting, as well as the marching arts setting broadly, provides an avenue for the athletic trainer to establish themselves as the preferred provider for this underserved population. Continued research is needed to further establish injury prevention and care needs and should focus on HC provider-reported data.

Characterization of Drum Corps Hydration Practices and Their Effect on Athletes' Hydration Status

Stein JK, Aguilar D: Weber State University, Ogden, UT

Context: In the sport of drum corps, young athletes are continuously exposed to high heat and humidity, increasing the risk for heat illnesses (HI). Corps vary in traditions, staff, skill level, and finances, which may affect the dehydration prevention practices they implement to keep members safe. Documentation of these practices between groups is lacking, thus sharing effective corps practices to reduce HI may benefit the organization. **Objective:** Our objective was to collect data within Drum Corps International on current hydration practices that may influence member hydration and to assess if any practices are associated with reported HI or dehydration symptoms. We hypothesized that having medical staff and providing longer water breaks would improve HI outcomes and that sections in the corps will have different practices and reported symptoms. Design: Crosssectional. Setting: Online survey. Paper survey in the field. Patients or Other Participants: Fifteen of forty-nine corps in the 2017 summer tour completed the online survey for staff. Four corps volunteered for paper member surveys. A total of 191 members (age >18 y) completed the paper survey for members. All corps sections (hornline, drumline, pit, colorguard, and drum majors) were represented. Interventions: The staff survey assessed corps prevention practices, particularly presence or lack of medical staff, HI screenings, and reported duration of water breaks. Independent variables from the member survey included section and diuretic beverage consumption. Main Outcome Measures: Dependent variables included corps reported number of HI and dehydration symptoms reported by members. Independent samples t-tests for each prevention practice was used to determine differences between mean symptom occurrence, symptom frequency, and reported HI cases. Differences in mean symptom variables and diuretic use between the sections were determined by one-way ANOVA. Results: Five corps reported >10 HI cases during the summer, three of those corps reporting >23. Corps with medical staff had more reported HI cases (M = 12.44, SD = 9.905) than those without (M = 4.50, SD = 3.564). Having medical staff was correlated with performing more HI screenings (r = .656, p = .008). Corps with reported shorter water breaks (<2 minutes) had significantly more headaches [t(164) = 2.094], p = .038] and muscle cramps [t(161) = 2.415, p = .017] than corps who gave longer breaks (>5 minutes). The hornline consumed caffeinated beverages significantly more often than the guard (p = .031) and drumline (p = < .001). Among the sections, the hornline had the fewest headaches (M = 3.34, SD =5.248)—significantly [F(4,183) = 2.63, p = .036] fewer than the pit (M = 10.07, SD = 12.792). Conclusions: It was observed that HI in drum corps were prevalent. Corps with medical professionals reported more HI; this may be due to increased HI screenings, which are beneficial. Providing water breaks >2 minutes may help reduce headaches and muscle cramps among members. In this study, no significant associations between any other dehydration prevention practices and HI outcomes were observed.

Assessing Lower Extremity Injury Risk in an International Drum Corps Using the Weight Bearing Lunge Test

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Context: The Weight Bearing Lunge Test (WBLT) has been used to evaluate those at risk for suffering a lower extremity injury (LEI) in a traditional athletic population. With athletic training's expansion into non-traditional settings it is important to assess if screening tools can still provide value in range of settings. Currently, there is a dearth of information regarding specific models for injury risk assessment in drum corps patients. **Objective:** To examine the WBLT as a screening tool for LEI risk in drum corps patients. Design: Practice-Based Research. Setting: Drum Corps Facilities. Patients or Other Participants: Two hundred thirty-eight drum corps patients from an international drum corps group that competes seasonally in the Mid-Atlantic region (Male = 173, Female = 65, Age = 19.49 ± 1.05 yrs) were screened as part of the pre-participation exam prior to the 2016 and 2017 seasons. Individuals free of LEI at the time of screening were included. Interventions: The WBLT was used to screen patients by the end of the first week of participation. LEI incidence was recorded daily throughout two competitive seasons, totaling approximately 110 days. LEI was classified as an injury that caused removal from participation. Main Outcome Measures: The WBLT was performed 3 times on both limbs using the kneeto-wall principle in which the patient lunged toward the wall with their knee while keeping their heel fixed to the floor. The average of the maximal distance in centimeters (cm) of the great toe from the wall for both limbs indicated the WBLT Average (WBLTAv). WBLT Asymmetry (WBLTAsy) was the absolute difference between limbs. T-tests were used to determine if there was a significant difference between those who sustained a LEI (Injured) and those who did not (Uninjured) for WBLTAv

and WBLTAsy. For dependent measures associated with significant group differences, receiver operator characteristic curves (ROC) were performed to examine injury risk using area under the curve (AUC). Lastly, cut-off scores that produced the maximal values of sensitivity and specificity were identified. Alpha level was set *a priori* at p < 0.05. **<u>Results</u>**: The injured WBLTAv $(10.40 \pm$ 3.09 cm) was less compared to the uninjured (n = 151, 11.52 \pm 2.87 cm, p = 0.005). The injured WBLTAsy (n = 87, 1.00 ± 1.45 cm) was greater compared to the uninjured (n = 151, 0.54 ± 1.35 cm, p = 0.015). The AUC from the ROC analysis for WBLTAv and WBLTAsy was 0.596 and 0.601 respectively. A WBLTAv measure of 11.47cm was associated with a sensitivity of 0.678 and a specificity of 0.510. A WBLTAsy measure of 0.75cm was associated sensitivity of 0.552 and a specificity of 0.629. **Conclusions:** Drum corps patients with lower WBLTAv or higher WBLTAsy measures were more likely to sustain a LEI during a competitive drum corps season. This data demonstrates that the WBLT could be viable as a screening tool in the marching arts and provides initial cut-off values.

Dynamic Screening Tests for Ballet Dancers

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Context: A ballet dancer's career can be significantly hindered by an injury. Previous literature has evaluated potential risk of injury in ballet by assessing muscle strength and/or flexibility. However, to date, there have been no dynamic screening tests established to predict injury in ballet dancers. **Objective:** To evaluate the ability of dance-specific dynamic movement tests to identify performance differences between injured and healthy ballet dancers. Design: Cohort Study Setting: A Midwestern collegiate ballet program. Patients or Other Participants: Seventy-four healthy, collegiate ballet dancers volunteered to participate in this study (15 male; 59 female; $20.1 \pm$ 1.3 years old; 169.4 \pm 9.4 cm; 58.0 \pm 9.8 kg; 8.6 ± 3.3 years of formal training). Participants were divided into two groups, injured and healthy, based on occurrence of injury throughout one semester of an academic year. Additional injury data were captured related to injury status, joint/location of injury, recurrence rate during semester, and subsequent activity modification/time loss. Interventions: Each participant completed functional tests as part of a wellness screen at the beginning of the semester. Tests included: balance error scoring system(BESS) on firm surface; turnout assessment in standing; active turnout assessment on functional footprints; airplane; topple; and sauté. All tests were completed on both right and left limbs, except BESS which assessed non-dominate limb. Main Outcome Measures: Six dependent variables were captured: BESS test (errors), airplane test (repetitions), standing turnout assessment (degree), active turnout assessment (degree), developmental sequence (pass/fail), topple (pass/fail), sauté(pass/ fail). The parametric data were analyzed with a multivariate analysis of variance and the nonparametric data were analyzed with a Chi squared test of independence. Results: Fifty-one dancers sustained an injury during the tracking period. Thirty-six of the injuries were chronic. Seventy-percent of the injuries occurred to the lower extremity (foot = 10; ankle = 21; knee = 5; hip = 9). Thirteen injuries were recurrent. Only 7 injuries required time loss from activity. The MANOVA showed no significant differences between injured and healthy dancers (p = 0.64). Means and standard deviations for injured and uninjured groups respectively: standing turnout 157.4 ± 7.4 vs 155.8 ± 10.4 , active turnout 128.3 ± 15.1 vs $130.8 \pm$ 15.1, airplane tests 1.7 ± 1.6 vs $1.9 \pm$ 1.7, BESS single leg stance 2.6 ± 1.2 vs 2.1 ± 1.3 and BESS tandem stance $0.9 \pm 0.7 \ 0.9 \pm 0.9$, respectively. There was also no significant association in performance of these tests and injury status (developmental sequence, p = 0.35; topple, p = 0.69; and sauté, p =0.35). Conclusions: These functional tests may not be sensitive enough to identify performance differences between injured and healthy ballet dancers. Dancers have good neuromuscular control and strength that allows them to complete each test even with biomechanical deviations noted in their movements. Utilizing these tests as a means to identify performance differences between dancers may not be the most appropriate use of the information gathered. Instead, objective dance-specific tests like the airplane and sauté should be used to assess movement quality for the purposes of optimizing performance.

Physical-Performance Test Profiles in Freshmen Collegiate Dancers: A 6-year Longitudinal Prospective Study

Ambegaonkar JP, Cortes N, Hansen-Honeycutt J, Caswell SV: Sports Medicine Assessment Research and Testing (SMART) Laboratory, George Mason University, Manassas, VA; Department of Dance, George Mason University, Manassas, VA

Context: Dance is physically demanding, with 85% of all dancers suffering injury during a single performance season. More than 450 collegiate-based dance programs exist in the United States. Athletic trainers (AT) are providing care in many of these collegiate dance programs. These ATs often use physical-performance tests (PPT) norms derived from extensive study of athletes to identify at-risk dancers and make return-to-activity and rehabilitation decisions. Although both dancers and athletes require strength, endurance, and balance, the physical demands differ extensively between dance and sports. Yet, little published research exists describing PPT profiles in dancers **Objective:** To describe PPT profiles in collegiate dancers **Design:** Descriptive epidemiology Setting: Collegiate Patients or Other Participants: 171 healthy dancers (Females n = 153, Males n = 17, 18.3 + 0.8 years, 164.5 + 7.1 cm, 60.6 + 8.5 kg, dance-experience = 12.3 +4.1 years) Interventions: Participant demographics(sex, age, experience, weekly dance and non-dance training hours), anthropometrics(height, weight, hypermobility status), and physical performance of the lower body, upper body, core, and balance (mean + SD) were recorded at the start of the academic year over a 6-year period (2010-2016). Main Outcome Measures: Vertical Jump height(cm):maximum of 3-jumps; Single-leg-hop Distances(cm) bilaterally combined over 3 hops/leg; Push-ups (number), Medicine ball (3kg) throw for distance (cm); Anterior, Extensor, Left-side and Rightside plank hold times (s); Star Excursion Balance reach scores combined bilaterally across the anterior, postero-medial and posterolateral directions (% leglength), and 9-point Beighton hypermobility scores. Finally, weekly dance and non-dance training hours were recorded. Results: Dancers' Vertical Jump heights and Single-leg-hop distances were 42.7 + 9.3 cm and 135.2 + 17.1 cm respectively. On average, dancers performed 19.7 + 10.6 Push-ups, and threw a 3-kg Medicine ball to a distance of 313.3 + 83.7 cm. The dancers' anterior, extensor, left-side and right-side plank hold times were 119.8 + 58.3 s, 138.6 + 96.7 s, 62.2 + 24.0 s, and 68.8+ 30.3 s respectively. Dancers' combined Star Excursion Balance(% leglength) reach scores were 80.6 + 11.2%leg-length. The average Beighton hypermobility score was 3.9 + 2.3, and 69 dancers (41.1%) were hypermobile (scores > 4/9 on the Beighton hypermobility criteria). Dancers took part in 25.6 + 9.4 hours of weekly dance training, and an additional 7.2 + 18.2 hours of non-dance training. Conclusions: To our knowledge, this is among the first longitudinal prospective descriptions of PPT profiles in collegiate dancers. Dancers generally scored lower on the PPTs than previously reported in collegiate athletes. Additionally, a greater proportion of dancers were classified as hypermobile. However, as PPT profiles differ between athletes participating in sports with different demands, it was not surprising that our findings demonstrate dancers' PPT profiles to be different from athletes. Athletic trainers may use our findings to establish baseline PPT values in collegiate dancers. Future researchers should investigate if dancers PPTs have predictive value for injury risk similar to athletes.

Pre-Participation Dance Screening Predictors of Injury in Collegiate Dancers

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Context: Research demonstrates that a pre-participation dance screening examination can identify performers who are at greater risk for injury. The literature has identified factors such as foot type, endurance level, dance-specific function, and turn out measurement as commonly observed clinical measures that aid in predicting injury in professional dancers. However, the value of pre-participation screening as an injury predictor in collegiate dancers is unknown. **Objective:** The objective of this study was to evaluate dance-specific measures for their predictive value regarding injury in collegiate dancers. Design: The design of this study was a prospective cohort study. Setting: The data was collected in a collegiate rehabilitation center. Patients or Other Participants: 21 healthy subjects participated in the study (21 females, average age 19.9 ± 4.2 years). Interventions: Dancers were screened for safe participation in a collegiate dance company prior to initiating the 2016-2017 performance season. The screening measures included both common orthopedic assessments and dance-specific measures. Dancespecific measures included single leg sauté, foot posture index, airplane test, 3-minute step test, and functional footprint. Dancers were then tracked during the performance season to determine which pre-participation measures were the best predictors of injury in this population. Main Outcome Measures: Injuries incurred as a result of participation in dance were tracked. In order to determine the relationship between the independent variables and injury, a binomial linear regression was performed. Results: Multiple regression models were analyzed. The only model that significantly predicted likelihood of injury included the independent predictor variables single leg sauté, foot

posture index, airplane test, 3-minute step test, and functional footprint. The logistic regression model was statistically significant, $\chi^2(5) = 15.790$, p = 0 .007. The model explained 42.1%(Nagelkerke R²) of the variance in injury and correctly classified 81.0% of cases. Sensitivity was 77.8%, specificity was 83.3%, positive predictive value was 77.8% and negative predictive value was 83.3%. Of the five predictor variables, only one was statistically significant: foot posture index (p = 0.027). For every 1-unit increase in foot posture index scores, the odds of injury increased 1.333 (95% CI: 1.033-1.719). Conclusions: The findings of this study suggest that the combination of single leg sauté, foot posture index, airplane test, 3-minute step test, and functional footprint as a group are somewhat successful in predicting injury in collegiate dancers. Furthermore, this study identified foot posture index score as the best single predictor of injury in this population.

Health-Related Quality of Life (HRQoL) and Injury Incidence in Dancers

Fauntroy VN, Hansen-Honeycutt JA, Caswell SV, Cortes N, Ambegaonkar JP: Sports Medicine Assessment Research and Testing (SMART) Laboratory, George Mason University, Manassas, VA; Department of Dance, George Mason University, Manassas, VA

Context: Dance is a physically demanding activity, with dancers having an overall 85% injury rate during a single performance season. Dance participation (class, rehearsal, and performance) may increase dancers' injury risk and affect their overall physical, mental, social, and general health. Health-Related quality of life (HRQoL) measures like the SF-20 survey encompass multiple domains that are important to examine overall wellbeing. The SF-20 survey includes six aspects of health status: physical functioning (6 items), role functioning (2 items), social function (1 item), mental health (5 items), general health perceptions (5 items), and bodily pain (1 item). However, if HRQoL changes over a single semester, and if dance exposure or HRQoL can predict injury risk in dancers is unclear. Objective: We (1) compared dancers' HRQoL between the start (HRQoL-begin) and end of the semester (HRQoL-end), and (2) examined if dance exposure or HRQoL could predict injury risk in dancers. Design: Epidemiological. Setting: University. Patients or Other Participants: 20 dancers (23.4 +/- 4.3 years, 170.7 +/- 7.7 cm, 70.2 +/- 18.9 kg). Interventions: We recorded dancers' injuries and overall dance exposure hours over a 16-week semester, and dancers' HRQoL using the SF-20 questionnaire at the start (HRQoL-begin) and end (HRQoL-end) of the semester. Main Outcome Measures: HRQoLbegin and HRQoL-end were compared using paired t-tests. Overall injuries and dance exposure hours (DEhr) were used to calculate injury incidence rates. A logistic regression examined whether dance

exposure or HrQoL influenced injury status, $p \le 0.05$. **Results:** Overall, 16 dancers of the 20 dancers had 24 injuries (3.8/1000 DEhr; 95% CI: 2.3-5.3). Dancers took part in 350 +/- 43.1 hours of dance-related activity over the semester. Dancers' HRQoL remained similar across the semester (HRQoL-begin = 1557.3 + /-427.1, HRQoL-end = 1500 + 533.1, $t_{1/9}$ = .58, p = .57). HRQoL -begin or -end, or dance exposure did not predict injury status [*Nagelkerke* $r^2 = .27$, $x^2 = (3, N = 16)$ = 6.1, p = .36]. <u>Conclusions:</u> Although dancers danced for almost 22 hours/ week, and 80% of the dancers did get injured, HRQoL (begin or end) remained the same over the semester. HROoL (-begin or -end) and dance exposure did not influence injury status over the semester. Future researchers should explore: (1) how many hours of dance participation is appropriate to maintain performance while still mitigating injury risk, (2) which HRQoL measures are appropriate for dancers, and (3) how often these measures should be administered to understand dancers' health and injury risk.

Rehabilitation of an Open Total Talar Dislocation in a Recreational Athlete, a Level 4 CASE Study Rivera LA: Appalachian State University, Boone, NC

Background: A 46 yr old female dancer and runner sustained an open talar dislocation while transitioning between trampolines at a trampoline park. While landing on a spring, the patient experienced an inversion force tearing soft tissue and dislocating her talus anterio-laterally. The patient was transported to the emergency room (ER) with an extruded talus and neurovascularly intact extremity. Differential Diagnosis: Most commonly, talus dislocations occur with fractures and can be accompanied by damage to the vascular structures in the area. Treatment: At the ER radiographs were negative for fracture. The ankle was debrided, the patient was administered intravenous pain control, and the talus was manually reduced. The patient was diagnosed with a type III pantalar dislocation. After discussing risks, she was taken to the operating room for further debridement and a primary repair of the lateral capsule and ligaments. The peroneal tendons were located and found to be intact. She was released NWB for 6 weeks in a short leg Cadillac splint. Two weeks post injury she reported to the athletic training clinic to begin rehabilitation focusing on core strength and hip and thigh ROM and strength. After following up with an ankle specialist 3 weeks post injury, she was placed in an orthopedic boot and allowed to begin NWB foot and ankle rehabilitation. By week 11 she was full weight bearing in the boot and walking in an ankle brace between weeks 12-13. Her treatment and rehabilitation progressed to include manual therapies, ROM and strengthening exercises and proprioceptive activities. Additionally the end of each rehabilitation session for the first several weeks included a 15 minute guided body scan meditation. This coincided with her transitioning off of opiates to no pain medication. Throughout her recovery several follow-up radiographs were performed to monitor for avascular necrosis of the talus, one of the most common complications. At this point, no signs of necrosis have been noted and she walks without a limp. She has chosen not to pursue running or pointe ballet but is open to other forms of dance. Uniqueness: Open total talar dislocations account for less than 1% of all reported dislocations. Due to the rarity of this injury, and the unique presentation of no fracture, established treatment and rehabilitation protocols for athletic trainers and other rehabilitation professionals were not found. Treatment and rehabilitation decisions were based on physician parameters and the patient's signs and symptoms and activity goals. The patient's history as a ballet dancer performing at a local studio helped establish goals but also created challenges. Realistic expectations of ROM and function after such an injury were discussed at length. With regard to psychology aspects of rehabilitation the patient saw her talus extruding and fear of re-injury during rehabilitation, especially when introducing new exercises, was often present. Meditation was found to be an effective modality for anxiety, and was dedicated time that she looked forward to during each visit Conclusions: Open talar dislocations without accompanying fractures are rarely reported. Injuries without significant documentation or consensus on treatment and rehabilitation challenge clinicians to return their patient to their previous level of activity. These opportunities encourage clinicians to establish strong communication with the patient to provide integrated care while maintaining integrity of the healing process.

Free Communications, Rapid Fire Oral Presentations: Curricular Concerns in Professional Education

Wednesday, June 27, 2018, 11:45AM-12:30PM, Room 220-222; Moderator: Lindsey Eberman, PhD, ATC

Developing Cognitive Skills Through Active Learning: A Systematic Review of Healthcare Professions Harris N, Welch Bacon CE: Florida International University, Miami, FL; A.T. Still University, Mesa, AZ

Context: Active learning techniques may serve as a method of preparing Millennial students with cognitive skills needed for success in the 21st century workforce. However, evidence supporting learner-centered instruction has relied heavily on students' satisfaction with the active learning experience. While both faculty and students have reported high satisfaction, greater evidence is needed to substantiate a shift toward learner-centered instruction within health professions education. **Objective:** To systematically review the literature to determine whether active learning is more successful as compared to traditional learning at producing cognitive skills in healthcare profession students. Data Sources: An electronic search was conducted in 4 databases including EBSCO-CINAHL, EBSCO-Sport Discus, Educational Resources Information Center, and PubMed. Search terms included: -millennial AND health education, -active learning AND knowledge retention, -flipped classroom AND learning outcomes, -problem based learning AND learning outcomes, -problem based learning AND student confidence, -active learning AND critical thinking, -higher order thinking AND active learning. Study Selection: After removal of duplicates, an initial screen of titles and abstracts was completed independently by 2 authors, followed by full text review. Original research articles were included if they were published in English between 2007-2017, and evaluated learning outcomes of an active learning intervention. Studies of non-healthcare disciplines, studies including practicing healthcare

practitioners, and original research studies that did not address the primary research questions were excluded. Data Extraction: The initial search yielded 1951 articles, with 396 undergoing a title/abstract screen. Full-text review was completed for 185 articles with 154 meeting study criteria and inclusion in this review. Study design, healthcare discipline, intervention used, assessment measures, outcome(s) measures, main results, and conclusions were extracted as appropriate. Data Synthesis: Articles were categorized based on their capacity to answer one or both of the research questions of interest and the conclusions were summarized according to the active learning technique used and its effectiveness in regard to the studied learning outcome. Out of 85 studies on lower-order cognition, 61 (72%) indicated that active learning techniques were effective at achieving improved recall, understanding, and/or application of course material in health professions students. Furthermore, 58 of 69 studies (84%) on higher-order cognition supported the use of active learning over traditional instruction for improving student's confidence in or performance of analytical, evaluative, and creative skills. Conclusions: Beyond the high levels of satisfaction reported with the active learning experience, gains to both lower-order and higher-order cognition were established to be equal, and more often, greater to the use of traditional learning methods. Despite this supporting evidence, the need for high-quality and well-designed prospective studies using validated assessment measures are needed to evaluate whether the active learning experience positively influences newly certified healthcare professionals transition to clinical practice and performance in the workforce.

Foundational Scientific Knowledge in Athletic Training Curricula

Wehring SP, Emerson DM: Gannon University, Erie, PA; University of Kansas, Lawrence, KS

Context: During 2015, the Commission on Accreditation of Athletic Training Education (CAATE) first publicly identified the fact that they believe strong foundational scientific knowledge produces the best health care providers. In May 2016, a proposed accreditation standard delineated that all athletic training (AT) programs must include: anatomy, biology, chemistry, physics, physiology, and psychology as prerequisite knowledge. No studies to date have examined the relationship of foundational scientific knowledge course inclusion in AT curricula as a predictor of Board of Certification (BOC) passrates. **Objective:** To determine if there is a significant relationship between required foundational scientific knowledge courses and 3-year aggregate first-attempt BOC pass-rates among CAATE accredited professional AT programs. (1) What foundational scientific knowledge courses are currently included in AT degree programs nationwide? (2) Does inclusion of individual and combinations of science courses have a correlation with AT programs' 3-year aggregate first-time BOC pass rate? Design: Quantitative Setting: All CAATE accredited professional programs in the United States as of February 2016. Patients or Other Participants: Three hundred and forty-nine (n =349) CAATE accredited professional AT programs. Interventions: SPSS was utlized. Alpha level was set at .05. Independent variables included 8 courses: biology, chemistry I and II, physics I and II, physiology, and psychology. The continuous dependent variable was the BOC first-time pass rate for each AT program. Main Outcome Measures: Descriptive statistics for each individual science course required within AT curricula were gathered and regressed on BOC pass-rates, shown in Table 1. Physics I and II were the only statistically significant individual course predictors of the BOC pass-rate. Physics and chemistry combined led to a significant

mean BOC score when compared to AT programs that do not require the courses. Results: Physics I was most significant, compared to the other courses, when predicting BOC pass-rates, accounting for a 6% variance (t(204.85) = $-5.103, r^2 = 0.06, P < .001$). Degree programs that required physics and chemistry demonstrated a significantly higher BOC mean of 82 + .17 compared to programs that do not require the courses having a mean of 77 + .19, (t (347) = $-2.179, r^2 = .014, P = .03$). <u>Conclusions:</u> The intent of this study was to gain empirical evidence to assist leaders in AT education to make informed curricular decisions on which courses to include as pre- requisites for graduate AT curricula. The findings of this study were the first step in evaluating foundational scientific knowledge courses being taught in AT curricula across the nation. The next step is to evaluate the foundational scientific knolwedge content needed to successfully complete graduate level professional CAATE accredited AT programs and successfully pass the BOC examination.

Course	n (%)	$M \pm SD$	F	r^2	P-value
Biology					
Yes	169 (48)	.80 <u>+</u> .18	.13	0.00	.714
No	180 (52)	.79 <u>+</u> .18			
Chemistry I					
Yes	145 (41.5)	.81 <u>+</u> .10	1.56	.004	.212
No	204 (58.5)	.78 <u>+</u> .17			
Chemistry II					
Yes	32 (9.2)	.84 <u>+.</u> 16	2.32	.007	.129
No	79 (90.8)	.79 <u>+</u> .18			
Physics I					
Yes	97 (27.8)	.87 <u>+</u> .15	22.41	0.061	.000
No	252 (72.2)	.77 <u>+</u> .18			
Physics II					
Yes	17 (0.5)	.89 <u>+</u> .10	5.03	.014	.026
No	332 (95.1)	.79 <u>+</u> .18			
Physiology					
Yes	329 (94.3)	.74 <u>+</u> .18	1.69	0.005	.195
No	20 (0.6)	.80 <u>+</u> .20			
Psychology					
Yes	247 (70.8)	.79 <u>+</u> .19	1.43	.004	.232
No	102 (29.2)	.81 <u>+</u> .16			

Table 1. Descriptive Statistics and Regression Analysis for BOC Pass Rate by Course Present (ves/no), N = 349.

Abbreviations: BOC=Board of Certification

Athletic Training Educators' Knowledge and Confidence About Competency-Based Education

Mace KL, Welch Bacon CE: Boston University, Boston, MA; A.T. Still University, Mesa, AZ

Context: Competency-based education (CBE) is gaining popularity in the education of allied health professionals as it affords an individualized approach for students to demonstrate concept mastery, rather than an approach that is solely based on grades. Athletic training educators' knowledge of CBE is not known. While there may be a role for CBE in the education of athletic training students, an understanding of the familiarity current educators have with CBE is necessary prior to exploring CBE opportunities in athletic training. **Objective:** To assess athletic training educators' knowledge and confidence of CBE. Design: Cross-sectional. Setting: Self-reported online survey. Patients or Other Participants: Of the 849 emails sent to athletic training educators, 206 accessed the survey (24.3% response rate) and 163 educators (age = 44.8 ± 10.3 years; years of experience = 21.8 ± 10.0 years; years of experience as an educator = 5.4 ± 9.4 years) completed the survey (82.7% completion rate). Interventions: Participants were emailed and asked to complete a survey regarding CBE. The survey consisted of a pre-test confidence rating scale, 9 multiple-choice questions, a post-test confidence rating scale and demographic items. Face and content validity of the survey was established prior to distribution. Main Outcome Measures: Descriptive statistics were calculated to describe overall participant demographics and composite knowledge scores. Mann Whitney U and Kruskal-Wallis *H* tests (P < .05) were used to describe group differences, while Spearmanrank correlation coefficients were used to assess relationships. Independent variables included years of athletic training experience, years of experience as an educator, highest degree attained,

program type, and participation in continuing education on CBE. Dependent variables were the scores calculated from participant responses regarding knowledge and pre/post-test confidence. Knowledge scores were tabulated by awarding 1 point for the correct answer with a maximum achievable score of 8; 1 of the 9 multiple-choice questions was removed during data analysis. Results: Composite knowledge scores were low with an average of 3.25 ± 1.9 correct responses out of 8 (40.6%). Average confidence scores decreased from $2.8/4.0 \pm 0.6$ pre-test to $2.0/4.0 \pm 0.7$ post-test. Composite knowledge scores were not found to be related to years of experience as an athletic trainer (P = 0.79, r = -0.02) or years of experience as an educator (P = 0.75 r = -0.03). Participants' knowledge, pre-test confidence, and post-test confidence did not significantly differ regardless of highest degree attained $(P_{\text{knowledge}} = 0.21; P_{\text{pre-test}} = 0.29; P_{\text{post-test}} = 0.97), \text{ program type } (P_{\text{knowledge}} = 0.78;$ $P_{\text{pre-test}} = 0.89; P_{\text{post-test}} = 0.46), \text{ or recent}$ participation in continuing education on CBE ($P_{\text{knowledge}} = 0.37$; $P_{\text{pre-test}} = 0.06$; $P_{\text{post-test}} = 0.23$). **Conclusions:** An overall lack of knowledge and average confidence with the concepts of CBE were demonstrated by current athletic training educators. While the profession of athletic training may explore a competency-based framework for education, knowledge of the concepts regarding CBE among educators should first be addressed and improved.

The Relationship Between Role Clarity, Interprofessional Pedagogy, and Quality Outcomes in a Health Professions Course Sniffen K, Breitbach A, Briggs E: Saint Louis University, St. Louis, MO

Context: Interprofessional education enables multiple professions to learn collaboratively to improve quality care.1 This learning is often facilitated by pedagogy designed to enhance collaboration, plans of care, and role clarity, which may be important for both group and patient outcomes.² **Objective:** This study examines role clarity, group composition, and quality outcomes among case study groups. Interprofessional groups and higher role clarity were both expected to be positively related to higher quality outcomes. Differences in baseline levels of role clarity were also explored. Design: Using a quasi-experimental design, baseline levels of role clarity were assessed, physical therapy (PT) students were randomly assigned to either interprofessional or non-interprofessional groups, and athletic training (AT) students were randomly assigned to interprofessional groups. Groups completed two case studies, with quality outcomes assessed after each. Setting: The study was conducted in a classroom setting during a Therapeutic Modalities course. Patients or Other Participants: Our target population is health professions students. A convenience sample of 22 AT and 90 PT students was used, with an 87.5% response rate. Interventions: The intervention consisted of two case studies, in which groups applied therapeutic modalities, outcomes, measures, contraindications, and parameters based on patient history, presentation, and goals. Main Outcome Measures: Role clarity was assessed using a validated measure (= .93).³ Scale scores were created by averaging item responses. Quality outcomes were assessed by rating case study responses on three criteria (accuracy, reasoning, thoroughness). **Results:** Compared to PT students, AT

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students reported significantly higher levels of role clarity (MAT = 5.71, SDAT = 1.06; MPT = 5.07, SDPT =1.18; t (27.36) = 2.26, p = 0.032, d =.55). Results do not support hypotheses, as no significant linear relationships were found. Rather, role clarity exhibited a nonlinear relationship with quality outcomes. Significant variance in case study thoroughness was explained as a quadratic function of role clarity (p =.048, R2 = .14). Conclusions: In our sample, differences in baseline levels of role clarity were found between professions, but the extent to which this finding can be generalized is unclear. We suspect previous clinical observation hours among AT students may be related to their enhanced role clarity. Results also suggest interprofessional group composition was unrelated to quality outcomes. However, considering previous research,4 we speculate that incorporating a process of guided reflection may yield different results. Lastly, the curvilinear relationship in our model suggests that moderate (rather than extreme) levels of role clarity are optimal for thoroughness in identifying therapeutic modalities in clinical cases. We plan to examine this curvilinear relationship further in future research.

Perceptions of Scholarship Requirements in Professional Athletic Training Programs: A Report From the Athletic Training Clinical Education Network

Cavallario JM, Welch Bacon CE, Walker SE, Van Lunen BL, Lindley TR, Eberman LE: Athletic Training Clinical Education Network, Boston, MA; A.T. Still University, Mesa, AZ; Old Dominion University, Mesa, AZ; Old Dominion University, Norfolk, VA; Ball State University, Muncie, IN; Northwestern University, Evanston, IL; Indiana State University, Terre Haute, IN

Context: The transition of the professional athletic training degree to the master's level has highlighted the paucity of available information on the inclusion of scholarship requirements in the professional education of athletic trainers. **Objective:** To explore the perceptions and experiences of implementing student scholarship within a professional program. Design: Consensual qualitative research. Setting: Individual phone interview. Patients or Other Participants: 17 program directors of professional programs (age = 45 \pm 7 y; years as an administrator = 13 \pm 7 y; female = 11, 64.7%; male = 6, 35.3%, public institution = 11, 64.7%, private institution = 6, 35.3%; professional bachelor's program = 12, 70.6%, professional master's program = 3, 17.6%, both = 2, 11.8%; doctoral granting university = 8, 47.1%, master's granting university = 7, 41.2%, other = 2, 11.7%). Programs reported an average of 3 ± 1 core faculty (range = 1-5 faculty) supporting 37 ± 21 students (range = 3-96 students), with $3 \pm$ 2 faculty (range = 1-8 faculty) involved in scholarship activities of their students. Data saturation guided the number of participants. Data Collection and Analysis: Interviews occurred via phone using a semi-structured interview guide. All interviews were audio recorded and transcribed verbatim. Data were analyzed by a three-person research team and coded into themes and categories based on a consensus

process. Researchers independently coded the data and discussed emergent themes and categories to formulate a consensus codebook that appropriately represented the data. Credibility was established by utilizing multiple researchers, an external auditor, and member checks. Results: Two major themes were identified within the data; mechanisms of scholarship and perceptions surrounding the inclusion of scholarship. Participants reported students engaged in a variety of mechanisms of scholarship including traditional experimental research and evidence based practice scholarship activities (e.g., critically appraised synthesis of the available evidence). Some programs incorporated singular scholarship experiences (e.g., assist with data collection) while other programs integrated purposeful and sequential scholarship activities throughout the curriculum. Future scholarship endeavors, upon transition to a master's degree program, included a traditional "thesis" process as well as practice-based, point-of-care research that might better integrate clinical practice and the research process. Student engagement in scholarship was perceived as valuable by participants who noted the challenge of getting buyin from their stakeholders, including students and preceptors. Some participants felt that the term "research" held a negative connotation with stakeholders, making it difficult for them to instill the value and relevance of scholarly clinical practice. When an institutional culture embraced scholarship and research, particularly at the undergraduate level, participants reported feeling more satisfied in extending the scholarship experiences across the entire curriculum. Conclusions: Participants perceived scholarship as a valuable part of professional preparation. Mechanisms of current scholarship integration and future intentions vary between programs. Future research should explore best practices for integration of student scholarship in professional health care education programs, including athletic training.

Program Directors' Perceived Barriers and Resources Necessary to Conduct Student Scholarship Within a Professional Athletic Training Program: A Report From the Athletic Training Clinical Education Network

Welch Bacon CE, Cavallario JM, Walker SE, Van Lunen BL, Lindley TR, Eberman LE: Athletic Training Clinical Education Network, Boston, MA; A.T. Still University, Mesa, AZ; Old Dominion University, Mesa, AZ; Old Dominion University, Norfolk, VA; Ball State University, Muncie, IN; Northwestern University, Evanston, IL; Indiana State University, Terre Haute, IN

Context: As professional athletic training programs transition to the master's level, it is important that educators consider how scholarship will be integrated throughout the curriculum. While various approaches to embed student scholarship may be available, external variables, such as institutional requirements and available resources, may impact how scholarship is interwoven through a professional program. **Objective:** To explore program directors' perceptions of resources necessary and barriers to implementing student scholarship within a professional program. Design: Consensual qualitative research. Setting: Individual phone interviews. Patients or Other Participants: 17 professional athletic training program directors representing 12 professional bachelor's programs, 3 professional master's programs, and 2 institutions with both (11 females, 6 males; age = 45 ± 7 y; years as an administrator = 13 ± 7 y; public institution = 1, private institution = 6). Programs reported an average of 3 ± 1 core faculty (range = 1-5 faculty) supporting 37 ± 21 students (range = 3-96 students), with 3 ± 2 faculty (range = 1-8 faculty) involved in scholarship activities of their students. Data saturation guided the number of participants. Data Collection and Analysis: One semi-structured phone interview was conducted with each participant. Following transcription, a 3-person research team coded the data into themes and categories. Each researcher independently coded the data, and then the team met to reach a final consensus ensuring accuracy and representativeness of the data. Triangulation of the data was ensured by the use of multiple researchers, participant member-checking, and the use of an external auditor. Results: Two themes emerged: 1) challenges to scholarship and engagement and 2) needed resources for scholarship engagement. Challenges to scholarship engagement was characterized by participants who described a lack of a scholarship-embracing culture among athletic training faculty, students, and preceptors. Participants reported more challenges integrating scholarship in the curriculum, and an inability to model the important role of scholarship in clinical practice due to a perception that students and preceptors didn't value research, making collaborative projects difficult. The needed resources for scholarship engagement theme was characterized by participants who described the need for release time or dedicated load to engage in and mentor student scholarship. They also described a need for faculty with particular content knowledge or expertise who could effectively advise student on their topics. Finally, participants highlighted the need for publically available examples of how others have successfully incorporated scholarly experiences in a professional program. Conclusions: A supportive culture with commitment from stakeholders may help students see value and relevance in the integration of scholarship into their clinical practice. Institutional resources, such as release time and faculty with content or methodological expertise, may be necessary to incorporate student scholarship into a program. Publically available resources regarding student engagement in scholarship should be developed and shared with members of the athletic training profession.

Free Communications, Rapid Fire Oral Presentations: Caring for the Million Dollar Arm

Thursday, June 28, 2018, 7:00AM-8:00AM, Room 220–222; Moderator: Charles Thigpen, PhD, ATC, PT, ATI

Comparison of Myofascial Release Techniques on Pectoralis Minor Length, Glenohumeral Total Arc of Motion, and Skin Temperature: A Pilot Study Rivera MJ, Eberman LE, Games KE, Powden CJ: Indiana State University, Terre Haute, IN

Context: Graston® Technique (GT) and self-myofascial release (SMR) are often used to promote blood flow and increase ROM. The pectoralis minor (PM) is an important postural muscle that may benefit from the effects of these myofascial techniques. Objective: To examine the effects of GT and SMR on pectoralis minor length (PML), glenohumeral total arc of motion (TAM), and skin temperature. Design: Cohort. Setting: Laboratory. Patients or Other Participants: Twenty-six healthy participants (19 female, 7 males, 20.9 ± 2.24 yrs, height = 170.52 ± 8.66 cm, weight = 72.45 ± 12.32 kg) with PML measurement of <7.44% of their body height participated. Interventions: Participants were randomized to an intervention group (GT = 12, SMR = 14). During the GT intervention participants were prone in 90° of elbow flexion and shoulder abduction. Graston® tools were applied for 5 minutes to the PM. Initially long strokes were used followed by PM release via the axillary. SMR involved participants rolling a tennis ball from the 4th rib to the coracoid process continuously for five sets of one minute. Participants completed three intervention sessions separated by 48 hours each. Main Outcome Measures: Outcome measures were collected before and after each intervention session (Pre1, Post1, Pre2, Post2, Pre3, Post3) and at 1-week follow-up (follow-up). PML was measured by tape measure from the 4th rib to coracoid process and normalized to height. TAM was the amount of motion from maximal internal rotation to maximal external rotation assessed by a digital inclinometer.

Skin temperature was measured using an infrared surface thermometer. Three trials of PML and TAM were collected at each time point and averaged for analysis. Separate intervention by time ANOVAs examined differences for each outcomes measure. Bonferroni post hoc analyses were completed when indicated. Significance was set a-prio*ri* at $p \leq 0.05$. **Results:** No significant intervention by time interactions were identified for PML, TAM, or temperature ($p \ge 0.349$). Overall time main effects were found for PML (p = 0.024) and temperature (p < 0.001). There was a significant increase in PML at follow-up (p = 0.028, 7.01 $\pm 0.31\%$) compared to Post2 ($6.82 \pm 0.36\%$). There were significant increases in temperature at Post1 (p < 0.001, 33.84 $\pm 0.94^{\circ}$), Post2 (p = 0.008, 33.37 $\pm 0.92^{\circ}$), and Post3 (p < 0.001, 33.39 $\pm 1.17^{\circ}$) compared to Pre1 $(32.43 \pm 0.99^\circ)$; Post2 was increased compared to Pre2 (p = 0.003, $32.60 \pm 0.80^{\circ}$), Pre3 (p < 0.001, $32.63 \pm$ 0.98°), and follow-up (p = 0.007, 32.28 $\pm 1.05^{\circ}$); Post3 was increased compared to Pre3 (p = 0.007) and follow-up (p =0.007). No other significant post hoc analyses for time were significant (p > p)0.051). No significant time main effect were identified for TAM (p = 0.404). No significant intervention main effect for PML (p = 0.537, GT = $6.83 \pm 0.48\%$, SMR = $6.91 \pm 0.44\%$), TAM (P = 0.686, $GT = 107.27 \pm 20.23^{\circ}$, SMR = 105.10 \pm 18.73°), or temperature (P = 0.895, $GT = 32.97 \pm 1.00^{\circ}$, $SMR = 32.93 \pm$ 0.92°). Conclusions: Application of GT and SMR to the pec minor did not result in increases in PML or TAM. Regardless of intervention, skin temperature increased following application. Clinicians should consider using complementary interventions when addressing PML or ROM restrictions.

The Effects of a Shoulder Strengthening Program on Scapular Positioning in Collegiate Swimmers Paulson G, Selkow NM, Begalle RL: Illinois State University, Normal, IL; Daemen College, Amherst, NY

Context: Shoulder injuries are one of the most common complaints among competitive swimmers. A leading cause of shoulder pathology includes scapular dyskinesis that can result in a decrease of subacromial space. This decrease in space can lead to impingement and shoulder pain. To date, there is no effective shoulder intervention program designed to correct the altered scapular kinematics specifically seen in swimmers. **Objective:** Shoulder injuries are one of the most common complaints among competitive swimmers. A leading cause of shoulder pathology includes scapular dyskinesis that can result in a decrease of subacromial space. This decrease in space can lead to impingement and shoulder pain. To date, there is no effective shoulder intervention program designed to correct the altered scapular kinematics specifically seen in swimmers. Design: Controlled laboratory study. Setting: Athletic Training Laboratory. Patients or Other Participants: Twentyeight asymptomatic collegiate swimmers (age 20.0 ± 2.0 years). Participants were excluded if they had a diagnosed shoulder injury in the past three months, a history of shoulder surgery in the past year, shoulder pain during the intervention program, or could not comply with the intervention program by missing more than two intervention sessions. Interventions: The intervention group (Division I collegiate swim team) completed 8 strengthening exercises that specifically targeted the LT and SA muscles. The program was completed 3x/week for 4 weeks and included 3 sets of 10 repetitions of the following exercises: prone horizontal abduction with
external rotation, prone Ys, standing shoulder flexion in the scapular plane 0-120°, side-lying shoulder external rotation, side-lying shoulder forward flexion, SA wall slides, scapular punches, and inferior glides. The control group (Division III collegiate swim team) did not complete the strengthening exercises and were asked to maintain their normal routine. Separate ANCOVAs with baseline values as the covariate were performed for each dependent variable to assess differences between groups following the 4-week intervention program. Main Outcome Measures: Pretest and posttest measurements of subacromial space distance measured via diagnostic ultrasound (mm), scapular upward rotation at 0°, 60°, 90°, and 120° of shoulder abduction in scaption using a digital inclinometer, and forward shoulder posture using a double square (mm) were collected in both the control and intervention groups on both shoulders. Results: There were no significant between-group differences observed in forward shoulder posture (p > .298). There was a significant difference observed in upward rotation of the scapula, but only at 90° and in the left arm (p = .035) with an effect size of 1.10 (.16-2.04). No other angles were significant (p > .061). There was a significant difference in subacromial space seen in the right arm (p = .001)with an effect size of 1.88 (.83-2.93), but not the left (p = .797). <u>Conclusions:</u> The current intervention program was not effective in decreasing forward shoulder posture or increasing upward rotation when compared with a control group. However, it was successful in increasing the subacromial space. This program may serve as framework for future prevention programs to improve subacromial space.

The Effects of Volitional Preemptive Abdominal Contraction on Upper Extremity Function During Common Rehabilitation Exercises Scott RA, Yang HS, James CR, Sawyer S, Sizer PS: Texas Tech University Health Sciences Center, Lubbock, TX

Context: Volitional preemptive abdominal contraction (VPAC) is commonly used during resisted shoulder exercises. It is not known how VPAC, performed through an abdominal bracing maneuver, affects shoulder muscle function during resisted shoulder exercise. **Objective:** To identify how VPAC performance during upper extremity movement affected the EMG amplitude and latencies of selected parascapular and glenohumeral muscles when subjects performed commonly used upper extremity movements. Design: A within-subjects, multifactorial, repeated measures design. Setting: A clinical biomechanics research laboratory. Patients or Other Participants: A total of 22 healthy subjects (10 women and 12 men) were recruited from a sample of convenience. The mean age of subjects was 24.55 + 2.84 years. The mean weight and height of subjects was 71.67 + 16.66 kg and 172.06 + 12.75 cm, respectively. With a desired power of 80%, estimated effect size index of f = 0.25, and desired $\alpha = 0.05$, the estimated sample size was a minimum of 21 subjects (G*Power version 3.1.9.2). Interventions: Subjects performed arm elevation in scaption and D1 shoulder flexion (D1F) patterns with and without resistance and VPAC. Electromyography (EMG) was used to record signals from the anterior deltoid (AD), posterior deltoid (PD), upper trapezius (UT), lower trapezium (LT), and serratus anterior (SA). Kinematic data were collected using an 8-camera Vicon system. Elbow movement was recorded. A Shapiro-Wilk test revealed that the amplitude and latency variables were not normally distributed. Wilcoxon signed-rank tests were conducted to identify significant muscle amplitude differences and significant muscle latency differences between the no-VPAC versus VPAC conditions for each of the tested muscles during each movement direction. Main Outcome Measures: EMG was used for muscle contraction amplitudes and onset timing analysis for the AD, PD, UT, LT, and SA. Muscle activation amplitudes were quantified by calculating root mean squared EMG. Shoulder muscle relative onset timing was quantified in reference to kinematic elbow movement initiation. Wilcoxon signed-rank tests were conducted to analyze the data. **Results:** The VPAC significantly increased SA amplitude during D1F (mean = 21.06(15.70), Z = 756.00, p < .001, r = 0.57) and scaption (mean = 56.18 (40.10), Z = 930.00, p < .001, r = 0.77), and UT amplitude in the scaption direction (mean = 89.80 (108.79), Z = 758.00.p < .001, r= 0.51). During D1F, the VPAC significantly decreased muscle onset latencies for the AD (mean = -0.75 (1.02), Z = 71.00, p < .001, r = -0.70), PD (mean = -0.64 (.72), Z = 267.00, p = .008, r = -0.40), UT (mean = -0.54 (.78), Z = 208.00, p = .001, r = -0.51), LT (mean = -0.64 (1.15), Z = 261.00, p = .006, r =-0.41), and SA (mean = -0.83 (1.15), Z = 180.00, p = .001, r = -0.52). During scaption, the VPAC significantly decreased muscle onset latencies for the AD (mean = -0.79 (1.26), Z = 80.50, p < .001, r = -0.65), PD (mean = -0.64)(1.50), Z = 262.00, p = .007, r = -0.41),UT (mean = -0.60 (.77), Z = 164.00, p < .001, r = -0.58), LT (mean = -0.69)(.90), Z = 168.00, p < .001, r = -0.58),and SA (mean = -0.97 (1.20), Z = 37.00, p < .001, r = -0.81). <u>Conclusions:</u> The VPAC only affected the amplitude of parascapular muscles that had the greatest scapular stabilizing roles during the particular open chained movement. The VPAC decreased muscle latencies in all muscles. These neuromuscular changes may enhance stability of the shoulder during D1F and scaption exercises.

The Effects of Loading Parameters and Elbow Flexion Angle on Medial Elbow Joint Space

Pexa BS, Ryan ED, Myers JB: University of North Carolina, Chapel Hill, NC; Tampa Bay Rays Baseball Organization, St Petersburg, FL

Context: The ulnar collateral ligament's (UCL) primary role is to limit medial elbow joint space (MEJS) during valgus stress. The valgus torques placed on the UCL during pitching are higher than previously demonstrated failure thresholds. Wrist and finger flexor muscle activity can provide a varus moment to limit MEJS, but this has yet to be determined in vivo across different elbow flexion angles. Objective: To determine MEJS changes at rest, under valgus stress, and under valgus stress with wrist/ finger contraction (grip) conditions at 0, 30, 60, and 90 degrees of elbow flexion. **Design:** Descriptive Laboratory Study Setting: University Laboratory Patients or Other Participants: 21 healthy college aged males (age: 21.2 ± 1.5 years, height: 182.4 ± 8.2 cm, weight: $79.8 \pm$ 17.8 kg) Interventions: Participants laid supine with their shoulder abducted to 90 degrees and the elbow flexed to 0, 30, 60, and 90 degrees in a random order with the forearm in full supination. At each elbow angle, medial elbow joints were imaged using ultrasonography during three separate conditions: at rest (unloaded), under valgus load with 2kg cuff weight (loaded), and under valgus load with maximal grip contraction (loaded-contracted). Main **Outcome Measures:** Medial elbow joint images were reduced to attain the MEJS defined as the distance from the trochlea to the sublime tubercle. MEJS values have previously established high reliability and precision in our laboratory (ICC₂₁ = 0.92, SEM = 0.32mm). A two-way 3x4 within subjects ANOVA was used to assess the change in MEJS between the different elbow flexion angles and loading conditions. Significance was set to $\alpha < 0.05$ and Bonferroni corrections were made for post-hoc testing. Results: There was a significant interaction between the loading condition and elbow flexion angle $(F_{6,120} = 3.095, p = 0.007)$. At 0 degrees of elbow flexion, MEJS was significantly higher in the loaded condition (4.20 \pm 1.05 mm) than the unloaded (3.71 ± 0.98) mm, p = 0.024) and contracted (3.59 ± 0.83 mm, p = 0.002) conditions. At the 30 degree elbow angle, the loaded condition $(5.10 \pm 1.12 \text{ mm})$ was significantly higher than the contracted $(3.83 \pm 0.99 \text{ mm}, \text{ p})$ < 0.001) and unloaded (4.31 ± 1.28 mm, p < 0.001) condition, and the contracted condition was significantly lower than the unloaded condition (p = 0.027). At 60 and 90 degrees of elbow flexion. MEJS was significantly higher in the loaded condition (60: 3.76 ± 1.15 mm; 90: 4.16 ± 1.27 mm) compared to the unloaded (60:4.44 \pm $1.21 \text{ mm p} < 0.001; 90:3.34 \pm 0.95 \text{ mm, p}$ < 0.001) and loaded-contracted condition $(60:3.82 \pm 1.20 \text{ mm}, p = 0.010; 90: 3.17)$ \pm 0.91 mm, p < 0.001). Conclusions: The activation of upper extremity musculature decreases the medial elbow joint space and demonstrates a potential protective mechanism against valgus stress at all elbow flexion angles. The finger and wrist flexors should be targeted with preventative exercise to assist in protecting the UCL. Additionally, valgus stress tests should be performed across different elbow flexion angles, as there are likely different bony congruencies that may contribute to changes in elbow joint space. Future research should address how fatigue affects the protective capabilities of the forearm musculature.

Surface Electromyography of the Elbow Musculature During Progressive Rehabilitative Exercises

Lipinski CL, Donovan L, McLoughlin TJ, Armstrong CW, Ingersoll CD, Norte GE: University of Toledo, Toledo, OH; The Steadman Clinic, Vail, CO; University of North Carolina at Charlotte, Charlotte, NC

Context: Ulnar collateral ligament (UCL) injuries remain increasingly common among overhead athletes. The flexor carpi ulnaris (FCU) and flexor digitorum superficialis (FDS) are reported to provide dynamic stabilization to the medial elbow during throwing, thereby protecting the UCL. However, it remains unclear how these muscles function during progressive exercises used in rehabilitation. Identifying a stepwise exercise progression will inform clinicians on how to optimize rehabilitation. **Objective:** To compare FCU and FDS surface electromyographic (sEMG) activity during four progressive exercises. Design: Crossover. Setting: Laboratory. Patients or Other Participants: Sixteen healthy adult males (age: 22.0 ± 2.5 years, height: 180.7 ± 7.8 cm, mass: 87.1 ± 14.1 kg) with at least three years of pitching experience volunteered. Interventions: Participants completed four exercises in a counterbalanced order: plyometric reverse throw (PLYO), long-toss at 50% speed (LT₅₀), long-toss at 75% speed (LT_{75}) , and pitch (PITCH) during a single session. Main Outcome Measures: Peak normalized sEMG amplitude (% MVIC) and percentage change in sEMG amplitude between progressive exercises (PLYO-LT₅₀, LT₅₀-LT₇₅, and LT₇₅-PITCH) was measured for each muscle. Separate ANOVAs were used to assess the influence of exercise on muscle activation, and the percentage change in muscle activation between exercises. Mean sEMG amplitudes were evaluated on a continuous scale to determine the phase of peak activation during throwing for each exercise. All sEMG data were synchronized with kinematic data, and evaluated from late cocking (peak external rotation) to ball release (0-100%). Results: Peak FCU amplitude significantly differed between exercises, indicating greater activation during the PITCH compared to LT_{50} (251.2 ± 96.1 vs. 156.2 ± 68.2%, P = .002), and during LT₇₅ compared to LT_{50} (221.3 ± 88.0 vs. 156.2 ± 68.2%, P = .031). Peak FDS amplitude did not differ between exercises. Percentage change in peak FCU and FDS amplitude significantly differed between progressive exercises, indicating that the change in activation from LT₅₀ to LT₇₅ was greater than the change from PLYO to LT_{50} for the FCU (93.7 ± 227.4 vs. $-16.2 \pm 33.3\%$, P = < .001) and FDS $(26.5 \pm 51.1 \text{ vs.} -3.3 \pm 27.6\%, P = .042).$ The PLYO and PITCH exercises increased activation most during the late throwing phase (66-100%), whereas LT_{50} and LT_{75} increased activation most during the middle phase (33-66%). Conclusions: Peak sEMG activation of the FCU did not increase in a stepwise manner with progressive rehabilitation exercises, and FDS remained unchanged. Each muscle demonstrated a disproportionate increase in activation during the second exercise progression $(LT_{so}-LT_{7s})$ compared the first (PLYO- LT_{50}). The phase of throwing in which peak activation occurred differed by exercise, which may have implications for rehabilitation. Collectively, these findings provide evidence that additional exercises may be required to achieve an appropriate stepwise progression relative to forearm muscle activation.

Tracking of Pitching Kinematics Using Wearable Sensors During a Simulated Game

Oyama S, Kuehne JT: Department of Kinesiology, Health, and Nutrition, University of Texas, San Antonio, TX

Context: Pitching-related upper extremity injuries are attributed to repetitive pitching beyond the physiological limit. While age-based pitch count guidelines are available to protect athletes from overuse injuries, the number of pitches that a pitcher can safely throw depends on many factors including developmental stage, conditioning, and cumulative fatigue. Tracking of pitching motion and detection of changes in technique using wearable sensors may allow us to identify the onset of fatigue and help prevent overuse injuries. **Objective:** To track throwing kinematics throughout a simulated baseball game using an inertial measurement unit (IMU). Design: Observational study. Setting: Baseball training facility. Patients or Other Participants: Twenty-three baseball pitchers (age = 15.3 ± 1.8 years, height $= 1.8 \pm 0.1$ m, mass $= 69.1 \pm 15.7$ kg, years of experience = 6.1 ± 2.3 years, right/left dominance = 20/3) participated. Interventions: The IMU sensors (128Hz) were secured onto participants' wrist, trunk, pelvis, and thigh (stride leg) to capture pitching kinematics while the participants pitched in a simulated game that consisted of sets of 15 pitches. The sets were repeated until the pitch count reached 120 (= 8sets) or the average ball velocity during a set decreased by 2mph from the first set. Main Outcome Measures: Trunk and pelvis rotation velocities were calculated from the gyroscope data. Forward and lateral flexion angles of the trunk and pelvis, and thigh elevation angle were calculated using the Madgwick AHRS algorithm. The peak trunk and pelvis rotation velocities, forward and lateral flexion angles of the trunk and pelvis, and thigh elevation angle at the instant of max arm-cocking (identified

using the wrist angular velocity data) were calculated for each pitch, and averaged across 15 pitches in each set. The baseline values were calculated as the averages from the first three sets. The change in kinematics was defined as a change in set average by more than two standard deviations from the baseline. The frequency of pitchers who exhibited kinematic changes during the simulated pitch was calculated. Results: The percent of pitchers who exhibited changes (increase or decrease) in kinematic variables are summarized in the table. Conclusions: The pattern of alteration in pitching kinematics that appears with prolonged pitching is highly variable between pitchers. The high variability represents a variety of ways in which the pitchers adjust their pitching technique. This poses a challenge in detecting onset of fatigue based on the kinematic data. Further study is needed to determine the feasibility of using wearable sensors to detect fatigue-induced changes in pitching kinematics.

rable. I creent of pitchers who exhibited changes in kinematic variables.							
	Increased	Decreased	Unchanged				
Pelvis forward flexion angle at arm-cocking	13.0%(3)	30.4%(7)	56.5%(13)				
Pelvis lateral flexion angle at arm-cocking	4.3%(1)	39.1%(9)	56.5%(13)				
Pelvis peak rotation velocity	30.4%(7)	13.0%(3)	56.5%(13)				
Trunk forward flexion angle at arm-cocking	34.8%(8)	34.8%(8)	56.5%(13)				
Trunk lateral flexion angle at arm-cocking	13.0%(3)	30.4%(7)	30.4%(7)				
Trunk peak rotation velocity	17.4%(4)	17.4%(4)	65.2%(15)				
Thigh elevation angle at arm-cocking	13.0%(3)	39.1%(9)	47.8%(11)				

Table: Percent of pitchers who exhibited changes in kinematic variables.

Fatigue of the Lower Trapezius Produces Decreased Acromial Humeral Distance

Timmons MK, Rigsby K, Konz S: Marshall University, Huntington, WV

Context: The lower trapezius muscle helps control scapular motion and can impact the width of subacromial space. Several authors have hypothesized that the position of the scapula changes with arm motion in order optimize the dimensions of the subacromial space. The lower trapezius muscle assists in producing scapular upward rotation and posterior tilt during arm elevation. Reduced low trapezius muscle function (reduced force development) is hypothesized to effect scapular kinematics leading to a decrease in the width of the subacromial. **Objective:** The purpose of this study was to test the effect of repeated contractions of the lower trapezius muscle on lower trapezius force and the width of the subacromial space. Design: Repeated measures Setting: research laboratory Patients or Other Participants: Thirty participants (170.9 \pm 9.1cm, 70.5 \pm 13.7Kg, 21.8 \pm 1.7 years, 15 female, 15 male) were included in this investigation. Interventions: Ultrasound images were collected using a Mindray M5 Ultrasound scanner. The transducer was placed over the most anterior aspect of the lateral acromion in order to image the acromial humeral outlet. The acromial humeral distance, was measured with the participants arm at their side and while at 45° of arm elevation. Measurements of lower trapezius strength were made using a microFET2 handheld dynamometer. Lower trapezius strength was determined using a break test, maximal lower trapezius strength was determined at the force level when scapular motion was observed. Lower trapezius strength was measured before and during the fatigue protocol. The lower trapezius fatigue protocol consisted participants laying prone on a table with their arm elevated to 120°, participants were instructed to elevate their arms off the

table (the"Y" exercise). Participants performed sets of 15 repetitions. Lower trapezius strength was assessed following each set until participants produced 80% of their maximal lower trapezius force. Ultrasound images were repeated following the fatigue protocol. Main Outcome Measures: Acromial Humeral Distance Results: The lower trapezius force decreased 20.5% (mean = 6.5 ± 4.5 N). The acromial humeral distance decreased after the fatigue protocol (difference = $.46 \pm .10$ mm, $F_{(1,31)}$ = 20.005, P < .001). The acromial humeral distance at 0° was not statistically different pre to post fatigue (difference $= .19 \pm .10$ mm, t = 1.905, P = .066); while the acromial humeral distance at 45° arm elevation showed a decrease after the fatigue protocol (difference $= .72 \pm .17$ mm, t = 4.106, P < .001). Conclusions: The results of this investigation support the hypothesis that the reduce function of the low trapezius results in decreased acromial humeral distance measurement. This result suggests that fatigue of the lower trapezius might contribute to the mechanisms leading to rotator cuff injury. Strengthening exercises for the lower trapezius might help patients maintain the width of their subacromial space during arm elevation.

Prospective Examination of the Relationship Between Training Volume and Shoulder Pain During the Training Season in Competitive Adolescent Swimmers

Hibberd EE, Berkoff DJ, Kucera KL, Laudner KG, Yu B, Myers JB: University of Alabama, Tuscaloosa, AL; University of North Carolina at Chapel Hill, Chapel Hill, NC; Illinois State University, Normal, IL; Tampa Bay Rays, Tampa Bay, Saint Petersburg, FL

Context: During the training season, competitive swimmers perform a large volume of yardage with high intensity practices in order to gain strength and power. The repetitive stress during swimming training, increasing the risk for the development of swimmer's shoulder, a general term for overuse shoulder pain and injury. Despite the high reporting of injuries during the training season, participation, pain and injury incidence in competitive adolescent swimmers has not been extensively evaluated in the literature. **Objective:** The purpose of this study was to prospectively evaluate participation factors, pain scores, and shoulder injury during the swimming training season, as well as determine relationships that exist between changes in these variables. Design: Cohort repeated-measures design Setting: Field Laboratory at local high schools and swimming pools. Patients or Other Participants: 45 adolescent competitive swimmers that were not currently experiencing any shoulder, neck, or back pain that limited their participation in sports activity were included in the study. Interventions: All participants were evaluated 2 times: prior to the start of the swimming training season and 12 weeks following the baseline testing before taper. At each session, participants completed a participation survey and 4 pain scores. Main Outcome Measures: Total yardage during swim training and changes in the following shoulder pain scales between the assessments: Oxford Shoulder Scale (OSS), Shoulder Pain and Disability Index (SPADI), and Penn Shoulder Scale (PENN). Results: Over the course of the training season, up to 71% of the adolescent swimmers reported experiencing mild shoulder pain, with some swimmers reporting moderate and severe pain. Swimmers completed an average of 477,419 ± 103,829 yards during the course of the 12-weeks of swim training. This yardage volume positively correlated to changes in PENN Function Scores (r = 0.32, p = 0.03), PENN Satisfaction Scores (r = 0.33, p = 0.03) and PENN total scores (r = 0.33, p = 0.04) over the 12-weeks of swim training. There were no significant correlations between total yardage during the training season and changes in the OSS and SPADI (p> 0.05). Conclusions: Over the course of the training season, a high percentage of swimmers reported pain with moderate disability and significant relationships were observed between total yardage performed and PENN scores, which indicates training volume is a contributor to the development of swimmer's shoulder. Future research should focus on understanding other participation factors such as stroke biomechanics, training intensity, equipment use, and rest and recovery that may also significantly influence the development of shoulder pain and injury in competitive adolescent swimmers. In addition, the development of a swimming specific scale is needed to better understand the effects of the unique demands of swim training on pain, disability, and function.

Shoulder Best Practices Forum: Return to Sport for Upper Extremity Athletes: Are There Any Good Procedures Out There?

Thursday, June 28, 2018, 8:15AM-9:15AM, Room 220–222; Moderator: Timothy Uhl, PhD, PT, ATC Discussants: Aaron Sciascia, PhD, ATC, PES; Natalie Myers, PhD, ATC

Free Communications, Rapid Fire Oral Presentations: Quad Function Following Anterior Cruciate Ligament Injury and Reconstruction

Thursday, June 28, 2018, 9:30AM-10:45AM, Room 220-222; Moderator: Christopher Ingersoll, PhD, ATC

Quadriceps Function in ACL Reconstructed Patients: A Principal Component Analysis Norte GE, Hertel J, Saliba SA, Diduch DR, Hart JM: University of Virginia, Charlottesville, VA; University of Toledo, Toledo, OH

Context: Context: Assessment of physical function for patients after ACL reconstruction (ACLR) is complex and warrants the use of diverse evaluation strategies. To maximize the efficiency of assessment and improve clinical outcomes, there is a need to identify tests that provide the most meaningful information. By establishing the diagnostic and predictive abilities of assessment tools to discriminate between patients with and without ACLR, clinicians can begin to evaluate the utility of each, and work towards an evidence-based assessment paradigm. **Objective:** To (1) investigate underlying constructs of quadriceps muscle function that uniquely describe patients after ACLR, (2) establish clinical thresholds for measures able to discriminate between patients with and without ACLR, and (3) identify a preliminary prediction model for patient status. Design: Cross-sectional. Setting: Laboratory. Patients or Other Participants: 72 patients with a primary, unilateral ACLR (32 males/40 females, age = 26.0 ± 9.3 years, height = 172.6 \pm 11.2 cm, mass = 75.6 \pm 17.7 kg, time since surgery = 46.5 ± 58.0 months), and 30 healthy individuals (12 males/18 females, age = 22.7 ± 4.6 years, height = 174.8 ± 11.8 cm, mass = 75.1 ± 16.2 kg) volunteered. Interventions: Quadriceps function was assessed bilaterally during one session. Main Outcome Measures: Isokinetic strength (peak torque [Nm/ kg], total work [J/kg], average power [W/kg]) at 90°/second, maximal voluntary isometric contraction (MVIC) torque (Nm/kg), central activation ratio (CAR,%), Hoffmann reflex (H/M ratio), and active motor threshold (AMT,%) were measured. Separate principal component analyses were conducted for the involved limb, contralateral limb, and limb symmetry indices. Receiver operating characteristic curve analyses were used to establish clinical thresholds that maximized the ability of retained variables within each component to discriminate patient status (ACLR vs. healthy). Binary logistic regression was used to predict patient status using the final combination of variables with the greatest discriminatory value from each retained component. Accuracy of classification, sensitivity, specificity, positive likelihood (LR+) and negative likelihood (LR-) ratios were calculated. Results: Three principal components of peripheral, central, and combined (peripheral and central) muscle function were identified, explaining 70.7-80.5% of cumulative variance among measures of quadriceps function. Involved limb total knee extensor work at 90°/ second (≥18.4 J/kg), CAR (≥94.7%), and AMT (\geq 40.0%) were the strongest predictors of patient status, and correctly classified 83.5% of patients with ACLR (sensitivity = 91.4, specificity = 57.1, LR += 2.13, LR -= 0.15, P < .001). Conclusions: Individual constructs of peripheral, central, and combined quadriceps muscle function uniquely describe patients after ACLR. Measures recorded from the involved limb yielded the highest LR+ and lowest LR-. Total knee extensor work at 90°/second, CAR, and AMT consistently explained a significant portion of variance in measures of quadriceps function, demonstrated acceptable to excellent discriminatory value, and predicted patient status with 72.8-83.5% accuracy. The presented tests and clinical thresholds appear to provide a sensitive test battery for patient status and produce a moderate effect on decreasing the probability of being classified as having an ACLR.

Quadriceps Cross-Sectional Area, Not Neural Activity, Is Associated With Improved Self-Reported Function After ACLR Burland JP, Lepley LK, Davi SM, Lepley AS: University of Connecticut, Storrs, CT

Context: Quadriceps weakness is common following anterior cruciate ligament reconstruction (ACLR) and can result from alterations in muscle morphology and both central and peripheral neural pathways. Quadriceps strength is a strong predictor of self-reported function after ACLR, however individual contribution of these underlying factors of quadriceps weakness to deficits in patient-reported outcomes is unknown. Understanding these relationships is clinically important, as the counteractive approach clinicians should employ to maximize muscle function and improve self-reported outcomes is unclear. **Objective:** Examine whether quadriceps strength, neural excitability (corticospinal, spinal-reflexive, muscle activation) and quadriceps cross-sectional area (CSA) influence self-reported function after ACLR. Design: Descriptive laboratory study. Design: Cross-sectional. Setting: Research laboratory. Patients or Other Participants: Ten individuals with a history of unilateral ACLR volunteered (age: 22 ± 2 y; height: 166.4 ± 7.1 cm; mass: 65.6 ± 12.1 kg). Interventions: Quadriceps strength, muscle activation, corticospinal excitability, spinal-reflex excitability, and CSA were assessed during a single testing session in the injured limb of all participants (years post-surgery: 5.9 ± 1.7 y). Main Outcome Measures: Quadriceps strength and quadriceps activation were assessed using maximal voluntary isometric contractions normalized to body mass (MVIC) and the central activation ratio (CAR). Quadriceps spinal-reflexive excitability was assessed via Hoffmann-reflexes normalized to

maximal muscle responses (H:M). Corticospinal excitability was evaluated with active motor thresholds (AMT) and motor evoked potentials at 120% of AMT (MEP) elicited through transcranial magnetic stimulation. Peak CSA of vastus medialis (VM), intermedius (VI), lateralis (VL) and rectus femoris (RF) muscles were obtained and measured using MRI. Selfreported function was measured using the International Knee Documentation Committee (IKDC) subjective knee form. Separate initial bivariate Pearson product moment correlations and stepwise hierarchical multiple linear regression models were used to determine the association between quadriceps muscle outcomes and self-reported function. Results: IKDC was strongly and positively associated with MVIC (r = 0.795, p = 0.006) and peak CSA of the VI (r = 0.738, p = 0.037), VL (r = 0.714, p = 0.047) and VM (r = 0.714, p = 0.04). RF CSA and measures of neural activity were not significantly associated with IKDC scores (p > 0.05). The overall regression model using MVIC, VM, VL and VI CSA predicted 91.6% of the variance in IKDC scores ($R^2 = 0.916$, P = 0.05; IKDC = $6.64_{MVIC} + 0.28_{VI} +$ 3.05_{VL} - 3.84_{VM} + 52.78). MVIC alone accounted for 64% (R² = 0.64, P = 0.01) of the variance in IKDC, with the addition of VM CSA accounting for a significant increase of 25.2% ($\Delta R^2 = 0.252$, P = 0.05) in the prediction capability of the model. VI and VL CSA contributed an insignificant 2.4% to the model $(\Delta R^2 = 0.024, P > 0.05)$. <u>Conclusions:</u> Quadriceps strength and CSA (driven by VM CSA) were strongly associated with IKDC scores and predicted 91.6% of the variance in self-reported function. These data indicate that muscle morphology, and not neural excitability, influences self-reported function in patients who are on average five years removed from surgery. Clinicians should focus on maximizing morphological outcomes in these patients to improve self-reported function.

Underlying Contributors to Quadriceps Strength in Anterior Cruciate Ligament Reconstructed Patients: Morphological and Neurological Adaptations Lepley AS, Grooms DR, Burland JP, Davi SM, Lepley LK: University of Connecticut, Storrs, CT; Ohio University, Athens, OH

Context: Quadriceps weakness following anterior cruciate ligament reconstruction (ACLR) has been strongly correlated with physical performance, risk of re-injury, and osteoarthritis development. Unfortunately, strength deficits continue to exceed 20% of the non-operative limb at return to activity and persist for upwards of 15-years post-surgery. The inability of the current standard of care to restore strength indicates a gap in our understanding of the mechanisms contributing to quadriceps weakness after ACLR. Patients with ACLR experience deficits in both neural activity and muscle morphology that contribute to strength deficits. However, the interaction of neural and morphological contributions to muscle strength has not been quantified. **Objective:** Examine the contributions of quadriceps morphological and neural function on quadriceps strength in ACLR patients. Design: Descriptive laboratory study. Setting: Research laboratory. Patients or Other **Participants:** Eight patients with a history of unilateral ACLR (6F/2M; $22.5 \pm$ 2.3 yrs; 163.83 ± 5.91 cm; 62.4 ± 12.2 kg; years post-surgery: 5.9 ± 2.1) volunteered. Interventions: Injured limb quadriceps muscle strength, corticospinal excitability, spinal-reflexive excitability, motor cortex activation, and cross sectional area (CSA) were collected during a single testing session. Main Outcome Measures: Quadriceps strength was assessed via maximal voluntary isometric contractions (MVIC) normalized to body mass (Nm/kg) and performed at 90° of knee flexion. Corticospinal excitability was evaluated by active motor thresholds (AMT) elicited using transcranial magnetic

stimulation. Hoffmann-reflexes normalized to maximal muscle responses (H:M) were used to measure spinal-reflexive excitability. Functional magnetic resonance imaging was used to quantify motor cortex activation $(M1_{m})$ by assessing peak voxel signal intensity during unilateral knee extension-flexion using a 3T Siemens MRI. Total quadriceps CSA was obtained and measured using the same MRI. AMT, H:M and M1_{act} outcomes were combined using a principal component analysis to represent a comprehensive neural function outcome. Initial Spearman rho correlations were performed to determine the association between quadriceps CSA, the combined neural outcome, and MVIC. A stepwise hierarchal linear regression was performed to examine the amount of variance in MVIC that could be individually explained by CSA and the combined neural outcome. Alpha level was set *a priori* at P < 0.05. **<u>Results</u>**: Quadriceps CSA (r = 0.76, P =0.02) and the combined neural outcome (r = 0.73, P = 0.03) were significantly correlated with MVIC. The overall regression model predicted 68.6% of the variance in MVIC ($R^2 = 0.686$, P = 0.05; $MVIC = 0.001_{CSA} + 0.316_{Neural} + 2.28).$ CSA accounted for 48% ($R^2 = 0.48$, P =(0.05) of the variance in MVIC, with the addition of the neural outcome accounting for a significant increase of 19.8% $(\Delta R^2 = 0.19, P = 0.05)$ in the model's prediction capability. Conclusions: Quadriceps CSA and neural function significantly predict muscle strength in patients with ACLR. Targeted interventions, aimed at improving morphological and neural outcomes would be beneficial for the restoration of quadriceps strength following ACL. This information will help guide future evidence-based clinical trials which will expand our understanding of muscle function post ACLR.

Quadriceps Strength Assessment as a Screening Tool for Loading Symmetry Following Anterior Cruciate Ligament Reconstruction: A Preliminary Investigation

Goto S, Hannon JP, Grondin AN, Besand KB, Lindley HN, Bothwell JM, Garrison JC: Texas Health Sports Medicine, Fort Worth, TX; Texas Christian University, Fort Worth, TX

Context: Quadriceps strength is used as return to sport (RTS) criteria for individuals following anterior cruciate ligament reconstruction (ACL-R). Deficits in quadriceps strength is often associated with greater asymmetric loading and could potentially lead to second ACL injury. It is unclear if quadriceps strength during the early stages of rehabilitation and at time of RTS can be used to identify loading asymmetry in adolescent populations at time of RTS. **Objective:** To examine the ability of quadriceps strength in identifying asymmetric loading during a jump-landing task in an adolescent males and females. Design: Cohort study. Setting: Clinical Research Laboratory. Patients or Other Participants: A total of sixty participants with unilateral ACL-R who completed biomechanical assessment at 12 weeks after surgery and at a time of return to sport (RTS) following ACL-R volunteered (Male: N = 25, Age = 15.85 ± 1.16 yrs, Ht = 178.09 ± 7.34 cm, Mass $= 78.15 \pm 14.81$ Kg; Female: N = 35, Age = 15.47 ± 1.10 yrs, Ht = 163.88 \pm 7.58 cm, Mass = 65.32 \pm 1.24 Kg). Interventions: Vertical ground reaction forces (vGRF) were assessed using two force plates while participants performed three separate jump-landing (JL) tasks at time of RTS. Isokinetic strength of the quadriceps at 60 deg/sec was assessed from the involved (INV) limb at 12 weeks after surgery (QUADS-12) and at RTS (QUADS-RTS). Main Outcome Measures: Bilateral peak vGRF was collected during the loading phase of the JL task, normalized to the body weight and averaged across three trials. Peak vGRF Limb symmetry index (LSI) was calculated ((INV limb/ contralateral limb)*100), and classified as "LSI \geq 90" and "LSI < 90". Peak torque of the quadriceps was normalized to body weight and averaged across five trials. Separate area under the curve (AUC) values were calculated for male and female using receiver operating characteristic (ROC) curve analysis to determine the ability of QUADS-12 and QUADS-RTS to predict peak vGRF-LSI at RTS. If AUC was greater than or equal to 0.70, the assessment would be considered as a useful tool to identify peak vGRF-LSI and preceded to determine cutoff value to maximize sensitivity (Sn) and specificity (Sp). Results: QUADS-RTS of female adolescents demonstrated as a reliable measurement to predict vGRF symmetry at RTS with a cutoff value of 1.32 BW⁻¹ (AUC = 0.75, 95% CI = 0.58, 0.92, Sn = 0.67, Sp = 0.72). The AUC for other measurement presented as under 0.7: QUADS-12wk of the female adolescents (AUC = 0.62, 95% CI = 0.41, 0.83), male adolescents' OUADS-12wk (AUC = 0.59, 95% CI = 0.35, 0.82), and QUADS-RTS (AUC = 0.55, 95% CI = 0.29, 0.77). Conclusions: This preliminary data suggests that the QUADS-RTS may be useful to identify loading symmetry during a JL task at RTS and can be used as one of the screening tools for RTS following ACL-R in female adolescent populations. The QUADS-RTS (male) and QUADS-12 (males and females) may not identify symmetrical loading, thus other clinical measurement should be considered.

Knee Extension Strength and Quadriceps Activation After Anterior Cruciate Ligament Reconstruction: A Systematic-Review and Meta-Analysis Lisee C, Lepley AS, Birchmeier T, O'Hagan K, Kuenze C: Michigan State University, East Lansing, MI; University of Connecticut, Storrs, CT

Context: After anterior cruciate ligament reconstruction(ACLR), individuals experience central and peripheral alterations that negatively impact different aspects of quadriceps function. Altered quadriceps function is associated with short-term and long-term negative consequences including increased decreased rates of return to activities, increased re-injury risk, and elevated risk of developing osteoarthritis. Objective: To compare quadriceps function in the involved limb of individuals with ACLR to their contralateral limb and to un-injured individuals. The secondary purpose was to assess the influence of sex and graft source on quadriceps function in this population. Data Sources: A database search including Web of Science, SportDISCUS, PubMed (Medline), CINHAL (EBSCO) and Cochrane Library was conducted on July 13, 2017 using the search terms: TOPIC:((ACLR OR ACL Reconstruction) AND (quadriceps strength OR quadriceps activation OR knee extension strength OR knee extension torque)). The search was limited to articles published in English after January 2000. Study Selection: Articles were included in the analysis if they included participants with primary, unilateral ACLR, and evaluated isometric knee extension strength normalized to body mass and quadriceps central activation ratio(CAR) via the superimposed burst technique. Data Extraction: Two reviewers extracted means, standard deviations and sample sizes from relevant articles. Methodological quality of the included studies was assessed by two reviewers using the modified Downs and Black scale. If the reviewers disagreed on an item score, a third reviewer decided the final item score. Magnitude of between limb and between group differences were assessed using a random effects model meta-analysis approach to calculate combined, pooled effect sizes (ES) and 95% confidence intervals. Data Synthesis: The titles and abstracts of 2,024 articles were reviewed and 28 articles were included for analysis. Methodological quality ranged from low to high quality (10 low, 8 moderate, 10 high). Individuals with ACLR demonstrated lower involved limb knee extension strength (ES = -0.76 LB = -0.98, UB = -0.53) and CAR (ES = -0.84, LB = -1.18, UB = -0.50) compared to controls. The contralateral limb in individuals with ACLRs demonstrated lower CAR (ES = -0.73, LB = -1.39, UB = -0.07), but not strength (ES = -0.24, LB = -0.68, UB = -0.19) compared to controls. The involved limb in individuals after ACLRs demonstrated lower knee extension strength (ES = -0.78, LB = -0.99, UB = -0.58), but not CAR (ES = -0.15 LB = -0.37, UB = 0.07) compared to the contralateral limb. Only one study reported quadriceps strength sex differences, two studies reported CAR sex differences and no studies directly compared quadriceps function between graft types. Conclusions: Central and peripheral factors influencing quadriceps dysfunction are multifactorial and persist for years after rehabilitation. Individuals with ACLR have impaired quadriceps function including involved limb quadriceps weakness and bilateral quadriceps activation deficits. Unilateral assessment of quadriceps function may help guide evidence-based rehabilitation to improve outcomes. A gap exists in the literature regarding effects of sex and graft type on quadriceps function and should be considered in future research.

The Relationship Between Joint Position Sense and Quadriceps Function Following Anterior Cruciate Ligament Reconstruction Johnston CD, Goodwin JS, Pietrosimone B, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Diminished quadriceps strength, rate of torque development (RTD), and voluntary activation are common following anterior cruciate ligament reconstruction (ACLR). Impairments in quadriceps motor function may result in diminished capacity to attenuate energy at the knee during walking, which may result in aberrant loading directed to joint tissues that is hypothesized to contribute to posttraumatic osteoarthritis (PTOA) onset. In addition to impairments in motor function, ACLR patients demonstrate impaired proprioception, potentially also resulting in aberrant loading and future PTOA onset. It remains unknown if motor function impairments are related to impaired proprioception following ACLR. **Objective:** To determine the association between quadriceps function and joint position sense (JPS) following ACLR. Design: Crosssectional Setting: Laboratory Patients or Other Participants: Thirty-four individuals (26 females; 8 males) with a unilateral ACLR (25 \pm 14 months post-ACLR) volunteered for this study. All participants were at least 6 months removed from ACLR and cleared to participate in unrestricted physical activity. Interventions: JPS was assessed with participants supine on a sliding platform inclined 75° from vertical to minimize joint loading attributable to gravity. Participants began in full knee extension and slid the platform downward by flexing the knee to a target angle (20°, 25°, or 30° randomized each trial), maintained the target angle for 5s, returned full extension, and then attempted to replicate the target angle. Knee joint angles were captured via an electromagnetic motion capture

system. Quadriceps function was assessed via maximal voluntary isometric contractions (MVIC) during which an electrical stimulus was superimposed on the muscle. Main Outcome Measures: JPS was calculated as the difference between the target angle and the reproduced angle (°), and averaged across 5 trials. Peak torque, RTD (slope of torque vs. time curve), and central activation ratio (CAR; ratio of peak voluntary torque to peak torque from superimposed electrical stimulation) were averaged across 2 MVIC trials. Associations between each index of quadriceps function and JPS were evaluated via Pearson Product Moment correlations (a=0.05). Results: JPS error $(2.9 \pm 1.2^{\circ})$ was negatively associated with CAR $(82 \pm 11\%)$ (r =-0.443; p = 0.009), but was not associated with any other index of quadriceps function. Conclusions: Our hypothesis that poorer JPS would be associated with poorer quadriceps function was partially supported by our data. Lower CAR (i.e. poorer quadriceps voluntary activation capacity) was associated with greater JPS errors (i.e. poorer proprioception). Partial deafferentation at the knee may contribute to proprioceptive deficits in the lower extremity, and is also a contributor to quadriceps dysfunction. Proprioceptive deficits potentially lead to greater compressive joint loading, as the sense of instability likely leads to excessive muscular co-activation, stiffened knee gait, and elevated ground reaction forces. Improving JPS may improve quadriceps activation and mitigate joint loading during walking, potentially reducing the risk of PTOA.

Elucidating the Underlying Architectural and Neural Mechanisms of Strength Loss That Influence Patient Reported Outcomes After ACL Reconstruction

Davi SM, Lepley AS, Burland JP, Earp JE, Lepley LK: University of Connecticut, Storrs, CT; University of Rhode Island, Kingston, RI

Context: Protracted reductions in quadriceps muscle strength after anterior cruciate ligament reconstruction (ACLR) contribute to a reduced quality of life. Historically, the measurement of quadriceps muscle weakness after ACLR has been limited to gross strength measurements. However, these methods cannot elucidate the underlying architectural and neural mechanisms of strength loss. Defining the underlying mechanisms of strength loss is critical for understanding modifiable factors of quadriceps strength that influence patient reported outcomes. **Objective:** To simultaneously, non-invasively, assess quadriceps muscle architecture and neurological activity during a maximal voluntary isometric contraction (MVIC) to identify their relationship with patient reported outcomes after ACLR. Design: Crosssectional. Setting: Research laboratory. Patients or Other Participants: Participants with history of ACLR (n $= 5m/6f; 22.3 \pm 2.0 \text{ yr}; 169.3 \pm 11.9$ cm; 66.9 ± 12.8 kg; 64.1 ± 28.6 months since surgery) took part in testing. Interventions: Participants performed a MVIC using an isometric dynamometer with a superimposed burst while muscle architecture of the vastus lateralis was recorded using ultrasound. Main Outcome Measures: Quadriceps strength was defined as peak torque relative to body mass. Neural activity was assessed using the central activation ratio (CAR). Quadriceps muscle architecture was quantified using ultrasound to measure fascicle length (F_1) , fascicle angle (F_a) and the architectural gear ratio (AGR [ratio between change in muscle length to change in fascicle length]). Patient reported outcomes were assessed using the Knee Injury and Osteoarthritis Outcome Score Quality of Life subscale (KOOS-QOL). Pearson product moment correlations were used to determine the association between quadriceps architecture characteristics and CAR and KOOS-QOL. Results: KOOS-QOL was positively and strongly associated with F_{1} (r = 0.898; p = 0.039) and the AGR $(\mathbf{r} = 0.954; \mathbf{p} = 0.012)$, but not F₁ (r = -0.811, p = 0.099). KOOS QOL was not associated with CAR (r = -0.052, p =0.882). Conclusions: Muscle architecture was associated with patient reported outcomes, where greater muscle F. and AGR were associated with a better quality of life. Larger F, and AGR have been shown to shift the force-length curve to regions that improve muscle function, which may optimize muscle contraction during activity and allow for greater self-perceived function. Conversely, neural characteristics of muscle were not associated with patient reported outcomes, indicating that protracted changes in volitional muscle activation may not influence patient well-being. Collectively these data suggest that rehabilitation strategies focused on positively influencing patient muscle structure, namely exercises that mechanically stimulate muscle architecture adaptations, will likely improve patient reported outcomes.

Investigating the Underlying Neurological Factors That Regulate Quadriceps Muscle Activation After ACL Reconstruction Lepley LK, Davi SM, Woxholdt CK, Burland JP, Lepley AS: University of Connecticut, Storrs, CT

Context: Quadriceps dysfunction that accompanies anterior cruciate ligament reconstruction (ACLR) is among the most extensively studied example of muscular dysfunction after traumatic joint injury. From a neural perspective, quadriceps dysfunction manifests as a decline in volitional muscle activation and is often quantified using laboratory methods such as the central activation ratio (CAR). The shortcoming of the CAR is that this method only accounts for discrete values in the isometric torque produced prior to the maximal voluntary isometric contraction. In order to better understand the underlying neurological factors that regulate muscle activation, researchers must employ technologies capable of examining alterations in neural activity that precede the production of peak torque. **Objective:** To assess alterations in quadriceps neural activity during CAR testing in individuals with a history of ACLR. Design: Cross-sectional. Setting: Research laboratory. Patients or Other Participants: Ten individuals with a history of unilateral ACLR volunteered (age: 22.4 ± 1.95 ; height: 166.4 ± 7.1 cm; mass: 65.6 ± 12.1 kg). Interventions: Quadriceps neural activity was assessed during a single testing session in the ACLR limb of all participants (years post-surgery: 5.9 ± 1.7 yrs). Main Outcome Measures: Quadriceps voluntary muscle activation was assessed using superimposed burst technique and quantified using the CAR. Simultaneously, quadriceps vastus lateralis (VL) and vastus medialis (VM) electromyographical (EMG) activity were measured during CAR testing to quantify changes in muscle firing rate, muscle recruitment, and system chaos using

EMG measures of median frequency, peak muscle activity, and sample entropy, respectively. Multiple linear regressions were used to determine the association between EMG measures and the CAR. **Results:** VL sample entropy was strongly and positively associated with the CAR ($R^2 = 0.537$, p = 0.016). Median frequency of the VL and VM (VL: $R^2 = 0.083$, p = 0.420; VM: $R^2 =$ 0.120, p = 0.327), peak muscle activity of the VL and VM (VL: $R^2 = 0.009$, p = 0.792; VM: $R^2 = 0.007$, p = 0.827) and sample entropy of the VM ($R^2 = 0.304$, p = 0.098) were not associated with the CAR. Conclusions: Conclusions: Historically, the changes in neural signaling associated with the CAR were thought to originate from a lack of muscle recruitment or a reduction in firing rate. However, our EMG data indicates that sample entropy of the VL, a mathematical algorithm that measures chaos (i.e. the lack of repeatability of a sinewave signal) was the only neurological factor significantly associated with the CAR. These data clinically imply that erratic motor control behavior of the VL during knee extension tasks is related to a failure to volitionally control the quadriceps muscle after ACLR.

Immediate Effects of Patellar Tendon Vibration on Quadriceps Strength in ACL Reconstructed Knees

Goetschius J, Hertel J, Saliba SA, Brockmeier SF, Hart JM: Adrian College, Adrian, MI; University of Virginia, Charlottesville, VA

Context: Quadriceps muscle dysfunction is a common and persistent consequence of anterior cruciate ligament reconstruction (ACLR) that has been associated with chronic knee-related disability. Tendon and muscle vibration has been used to evaluate sensorimotor impairments and to enhance muscle function in individuals with knee injury and quadriceps dysfunction. Objective: To evaluate the immediate effects of patellar tendon vibration on quadriceps strength in ACLR and healthy control knees. **Design:** Controlled Laboratory Study Setting: Research Laboratory Patients or Other Participants: A convenience sample of fifty-one individuals with a history of primary, unilateral ACLR were assigned to the ACLR group (n = 51, 37 female, 15 male, 22.8 ± 4.6 years, 68.3 ± 11.3 kg, $1.72 \pm .09$ m, 4.4 ± 3.5 years post-surgery) and nineteen healthy individuals with no history of knee joint injury were in the control group (n = 19, 12)female, 7 male, 22.2 ± 3.3 years, $69.5 \pm$ 13.2 kg, 1.71 ± .14 m). Interventions: All participants received 20-minutes of percussion vibration applied to the mid-portion of the patellar tendon at a 50 Hz frequency, 5 mm displacement, and ~30 N forces using a commercially available soft tissue massager. Three knee extension maximum voluntary isometric contractions (MVIC) were performed at 90° knee flexion at baseline and immediately post-vibration. Main Outcome Measures: The primary outcome, quadriceps strength, was quantified using the average mass normalized knee extension torque (Nm/ kg) from the three MVIC trials at baseline and post-vibration. Effects of vibration on quadriceps strength and group differences in quadriceps strength at baseline and post-vibration were analyzed using Wilcoxon sign ranks and Mann-Whitney U tests, respectively. Central tendencies were presented as median [interquartile range]. Cohen's-d effects-size [95% confidence interval (CI)] and mean percent-change [95% CI] were calculated for the baseline to post-vibration change in each group. **Results:** The ACLR group experienced an increase (P < .001, d = 0.51 [.11,]).90], 20.9% [15.5, 26.2]) in quadriceps strength from baseline (1.5 [1.1, 1.8] Nm/kg) to post-vibration (1.8 [1.4, 2.1] Nm/kg). The control group experienced an increase (P < .001, d = 0.63 [-.02, d = 0.63]1.28], 26.2% [16.6, 26.2]) in quadriceps strength from baseline (1.7 [1.3, 2.1] Nm/kg) to post-vibration (2.1 [1.7, 2.5] Nm/kg). At baseline, there was no difference in quadriceps strength between groups (P = .11). Post-vibration quadriceps strength was greater in the control group than the ACLR group (P =.03). Conclusions: We observed a 21% average increase in quadriceps strength in the ACLR knees and a 26% average increase in control knees immediately following a single bout of patellar tendon vibration. In the ACL group, effects size and 95% CI suggest that vibration had a moderate effect on quadriceps strength that may be clinically meaningful. Applying vibration prior to therapeutic exercises may provide a potential strategy to enhance muscle strength in ACLR knees; however, a 20-minute protocol may not be clinically feasible and requires further research.

Free Communications, Rapid Fire Oral Presentations: Quality of Life in Intercollegiate and Interscholastic Athletes

Thursday, June 28, 2018, 5:15PM-6:30PM, Room 220–222; Moderator: Tamara Valovich McLeod, PhD, ATC, FNATA

The Associations Among Sex, Contact, Concussion History and Preseason Emotion Dysregulation Measures in NCAA Collegiate Student-Athletes Fraser MA, Green AL: Texas State University, San Marcos, TX

Context: Currently only depression and anxiety have been investigated in collegiate athletes. Aggression and impulsivity have been associated with sex, contact, and concussion history in high school athletes, but not collegiate athletes. In addition, sensation seeking is a measure of risk which has been found to be elevated in extreme sport athletes and with injury-risk, but has yet to be studied in a collegiate population. **Objective:** To determine the associations among sex, contact, concussion history and preseason emotion dysregulation measures in collegiate student-athletes. Design: Crosssectional study. Setting: Research laboratory. Patients or Other Participants: 446 Division I collegiate student-athletes (19.3 ± 1.30) . Interventions: Sex (M/F), concussion history (Y/N), and contact level. Sports were categorized into contact as high (football), low (baseball, basketball, cheer, soccer, softball, pole vault, volleyball) and no (cross country, golf, dance, tennis, track and field). Main Outcome Measures: Preseason emotion dysregulation measures of depression (Patient Health Questionnaire-9), anxiety (Generalized Anxiety Disorder-7), aggression (Buss Perry Aggression Questionnaire), impulsivity (Barrett Impulsiveness Scale-11) and sensation seeking (Arnett Inventory of Sensation Seeking) were collected. One-way analysis of variance was used for all analyses (p = 0.05). **Results:** Preseason data were collected for 446 collegiate athletes (n = 244 females). Females reported significantly higher anxiety (B = -0.894, 95% CI: -1.547, -0.241, p = 0.007) and significantly lower impulsivity (B = 2.011, 95% CI: 0.128, 3.893, p = 0.04), aggression (B = 9.800, 95% CI: 6.800,

12.800, p < 0.0001) and sensation seeking (B = 2.958, 95% CI: 1.717, 4.199, p < 0.0001). Athletes with a concussion history reported significantly higher depression (B = 0.858, 95% CI: 0.242, 1.473, p = 0.006), anxiety (B = 0.768, 95% CI: 0.016, 1.521, p = 0.04), and aggression (B = 4.230, 95% CI: 0.654, 7.805, p = 0.02). High contact sports reported significantly higher depression than low contact sports (B = -0.828, 95% CI: -1.536, -0.122). High contact sports reported significantly higher aggression compared to low (B = -9.536, 95% CI: -13.531, -5.541) and no (B = -10.505, 95% CI: -14.424, -6.586) contact sports. No other significant differences were found. Conclusions: In univariate analyses, sex, concussion history, and contact level were associated with emotion dysregulation data in Division I collegiate athletes. Being female was associate with higher anxiety and lower impulsivity, aggression and sensation seeking compared to being male. Division I college athletes with a history of concussion reported significantly higher depression, anxiety, and aggression. High contact sport athletes reported higher depression, and aggression compared to low contact athletes and higher aggression compared to no contact sport athletes. It is not surprising that our high contact sport (football) would report higher aggression than the low and no contact sports due to the nature of the sport and that all football players were male. Understanding the differences between sex, contact and concussion history may be beneficial to athletic trainers when treating concussed athletes, particularly if baseline measures do not exist. Longitudinal studies investigating the causation of these differences and potential alterations over time should be conducted.

The Epidemiology of Sport-Related Psychological Issues in Collegiate and Secondary School Student-Athletes

Dalton SL, Wasserman EB, Collins CL: Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

Context: Mental health of student-athletes is just as important as physical health. However, psychological issues are relatively rare compared to musculoskeletal injuries and often present with no obvious, outward signs, making diagnosis and management difficult. Little is known about the incidence of sport-related psychological issues in collegiate and secondary school student-athletes and how these may differ by competition level. **Objective:** To describe psychological issues reported by athletic trainers (ATs) in collegiate and secondary school sports. Descriptive epidemiology Setting: Data from the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) and National Athletic Treatment Injury and Outcomes Network (NATION). Patients or Other Participants: Men and women collegiate student-athletes from 25 sports during the 2009/10-2015/16 academic years; boys and girls secondary school student-athletes from 27 sports during the 2011/12-2013/14 academic years. Interventions: ATs reported psychological issues occurring during athlete-exposures (AEs). Main Outcome Measures: Injury rates per 10,000 AEs and rate ratios (RRs) were reported with 95% confidence intervals (CIs), along with characteristics of psychological issues. Results: Of 38,153 injuries reported to the NCAA-ISP, 56 (0.15%) were psychological issues for an overall rate of 0.10/10,000 AEs (95% CI: 0.07-0.13). Psychological issues were most commonly depression/fatigue/ overstress (n = 33, 58.9%), followed by anxiety (n = 12, 21.4%). Women had a higher rate of psychological issues

(0.11/10,000 AEs; 95% CI: 0.07-0.16) than men (0.09/10,000 AEs; 95% CI: 0.06-0.12). Nearly half resulted in no time loss from participation (n =25, 44.6%). However, 4 (7.1%) and 3 (5.4%) psychological issues resulted in time loss greater than 30 days and out for the remainder of the season, respectively. Of 46,891 injuries reported to NATION, 14 (0.03%) were psychological issues for an overall rate of 0.03/10,000 AEs (95% CI: 0.01-0.04). The most common diagnosis was anxiety (n = 4, 28.6%). Girls had a higher rate of psychological issues (0.04/10,000 AEs; 95% CI: 0.01-0.07) than boys (0.02/10,000 AEs; 95% CI: 0.00-0.03). Half resulted in no time loss (n = 7, 50.0%), while 1 (7.1%) restricted participation for greater than 30 days. The rate of psychological issues in secondary schools was 73% lower than in college (RR = 0.27, 95% CI: 0.15-0.49). For both collegiate (n = 16; 28.6%) and secondary schools (n = 3;21.4%), football had the highest number of reported psychological issues. Conclusions: Overall, a higher rate of psychological issues were reported at the collegiate level than the secondary school level. This may be due to increased demand in athletic commitment at the collegiate level, but could also be due to higher availability of mental health services at the collegiate level. While many student-athletes did not miss any participation time, it is important to further examine psychological issues in which student-athletes are missing significant time. Psychological issues are relatively rare; however, it is important for athletic trainers to partake in athlete mental health continuing education to improve preparedness.

The Influence of Depressive Symptoms on Substance Abuse in a Sample of Collegiate Athletes Amrani KA, Oglesby LW, Gallucci

AR: Baylor University, Waco, TX

Experiencing Context: depressive symptoms (DS) has been shown to increase rates of substance abuse (SA) among college students. Conversely, studies of college students have found that participation in varsity athletics is a protective factor against SA. Collegiate athletics provides a unique environment where factors such as DS and athlete status (AS) can influence SA rates and patterns. The effects of DS and AS on SA is not well-documented, but warrants further examination. **Objective:** Identify and describe the SA patterns among college students and the influence of AS and DS on this behavior. Design: Cross-sectional study. Setting: A self-administered, paper-and-pencil survey was distributed to college students in classrooms and athletic team meeting settings. Patients or Other Participants: The sample was composed of 570 undergraduate students $(age = 19.6 \pm 1.4 \text{ years}; gender = 63\%)$ female) from a large, private university in the Southwestern region of the US. The response rate was 92% (570 of 616 students recruited). Interventions: Researchers developed a 38-item survey of previously-validated instruments assessing the variables of interest. The survey included the revised version of the Center for Epidemiological Studies Depression Scale (CESD-R) and questions from the Monitoring the Future Study regarding the abuse and misuse of several substances. Participants indicated the levels of organized college athletics that they had participated in during the previous 12 months. Participants were considered student-athletes if they selected the "Varsity (Division I)" response option. Additional demographic questions were included in the survey. Main Outcome Measures: The primary outcome variables of interest were usage rates of several substances (e.g.

alcohol, cigarettes, marijuana, pain killers). Multiple regression analyses were conducted to evaluate the effect of AS and DS on SA. Responses on the DS scale were totaled, recoded into high and low symptom groups based on documented cutoff scores, and entered into the models. Results: Fifteen percent of the sample identified themselves as student-athletes. Student-athletes reported similar substance use patterns in the previous month when compared to student-nonathletes. When accounting for DS as a moderating factor, AS was a significant predictor of monthly marijuana use in the multivariate model (B = .336, p < .05). Gender was also a predictor of monthly marijuana use in this sample (B = -.301, p < .05). Significant differences in other SA variables were not identified. Conclusions: When including DS, athletic participation still appeared to be a protective factor against the abuse of most substances (e.g. alcohol, prescription painkillers, cigarettes). Contrary to previous findings in the literature, student-athletes reported monthly marijuana use at a significantly greater rate than student-nonathletes. Given the limited sample size in this study, the potential changes in marijuana use during or after experiences of depressive symptoms should be explored further.

The Impact of Sport-Related Concussions on the Health-Related Quality of Life in High School Athletes

Roberts EJ, Soyk MG, Kliethermes SA, Schwarz AM, Niewold NK, Gallenberger MA, Pfaller AY, McGuine TA: University of Wisconsin, Madison, WI

Context: Athletes who have sustained a sport-related concussion (SRC) have lower self-reported health-related quality of life (HRQoL) immediately following their injury. However, limited research exists to measure the impact of SRCs on HRQoL in the months following the injury. **Objective:** To determine the impact of SRC injuries on HRQoL in high school athletes over a three month timeframe. Design: Prospective cohort study. Setting: Data were collected at 29 Wisconsin high schools during the 2016/17 and 2017/18 academic years. Patients or Other Participants: A convenience sample of 2,414 healthy (able to fully participate) high school athletes (males = 1,521, females = 893; age = 15.9 ± 1.1 years) completed a baseline questionnaire. Interventions: Subjects completed a baseline questionnaire (paper, in-person), which included the Pediatric Quality of Life (PedsQL) questionnaire. Post-SRC data were collected at 1) seven days post-SRC, 2) unrestricted return to sport (URS), and 3) three months post-SRC. Main Outcome Measures: Dependent variables included subscale scores reported as least-square means and standard errors (SE) for physical function (PF) and psychosocial function (PSF) and total PedsQL score (PedsTS), scored 0 to 100 with a lower score indicating lower HROoL. Descriptive statistics (median, [25th,75th IQR], range) were used to describe the data. Linear mixed effects models with random intercepts were used to estimate the association of HRQoL scores between the baseline and post-SRC time points and assessed at p < 0.05. **Results:** One hundred (36) females, 64 males) subjects (4.1%) sustained a SRC. The SRCs were sustained

most often during football (46%) basketball (16%) soccer (10%) and volleyball (9%) with a median of 14 [10.75, 20] days (range = 5 to 63) missed from their sport. Eighty-one (81%) subjects completed post-SRC surveys through three months post-injury. No difference by sex over time (p = 0.39) was detected. PF scores were significantly lower (p = 0.03) seven days, but were significantly higher at URS (p = 0.005) and at three months post-SRC (p = 0.004), [baseline = 93.13 (0.96), seven days = 90.21 (0.96), URS = 96.75 (0.97), threemonths = 97.29 (1.17)]. PSF scores were not different (p = 0.91), but higher (p < 0.001) at URS and three months (p < 0.001)< 0.001), [baseline = 91.76 (0.73), seven days = 91.87 (0.73), URS = 97.39(0.74), three months = 96.56 (0.88)]. PedsTS scores were not different (p =0.60) at seven days, but higher at URS (p < 0.001) and three months (p < 0.001), [baseline = 91.77 (0.74), seven days = 91.28 (0.74), URS = 97.13 (0.75), three months = 96.79 (0.90)]. Conclusions: Secondary school student-athletes saw their HROoL diminish during the first seven days, but then recover in the weeks and months following an SRC. Clinicians should recognize the impact of SRC's on HRQoL and therefore monitor patient's status post-injury.

The Impact of Sport Related Concussion on Depression in Male and Female High School Athletes

Soyk M, Roberts E, Kliethermes S, Schwarz A, Niewold N, Gallenberger M, Pfaller A, McGuine TA: University of Wisconsin, Madison, WI

Context: Sport Related Concussion (SRC) injuries have been associated with an increased risk for short term symptoms of depression in high school athletes. However, limited research exists to prospectively measure the impact of SRCs on depression in the months following the injury. **Objective:** To determine the association of SRCs on levels of depression in healthy (able to fully participate in sport) high school student-athletes in the weeks and months following their injury. Design: Prospective cohort study. Setting: Data was collected at 29 Wisconsin high schools during the 2016/17 and 2017/18 academic years. Patients or Other Participants: A convenience sample of 2,414 healthy, high school student-athletes (females n = 893, males n = 1,521, mean age = 15.9 + 1.1 years) were enrolled in the study and completed a baseline questionnaire. Interventions: Subjects completed a baseline survey including the Patient Health Questionnaire (PHQ-9) to measure depression. The PHQ-9 contains nine questions scored 0 - 3 per question (total score range = 0 - 27). A higher score indicates a higher level of depression. Post SRC data collection was performed at time points that included: 7 days post SRC, unrestricted return to sport (URS), and 3 months post SRC. Main Outcome Measures: Dependent variables included the PHQ-9 score reported as Least-Square Means and Standard Errors (SE). Descriptive statistics (Median, [25th,75th IQR], Range) were used to describe the data. Linear mixed effects models with random intercepts were used to estimate the association of PHQ-9 scores between the baseline and post SRC time points and were assessed at p < 0.05. Results: Eighty-one (28 females, 53

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males) of the subjects sustained an SRC that caused them to miss a median of 14 days [10.75, 20] (range = 5 to 63) from their sport. Females had significantly higher scores compared to baseline at 7 days post SRC (p = 0.002), but lower at URS (p = 0.016) and 3 months post (p = 0.006), [Female baseline = 2.31 (0.43), 7 days = 4.0 (0.43), URS= 1.0 (0.43), 3 months = 0.64 (0.51)].There was no difference in the scores for males at 7 days post SRC (p < 0.26) or at 3 months (p = 0.31), but scores were significantly lower than baseline at URS (p = 0.05) [Male Baseline = 1.51 (0.31), 7 days = 1.96 (0.31), URS= 0.74 (0.32), 3 months = 1.06 (0.38)].**Conclusions:** Female and male athletes reported slightly different levels of depression both at baseline and after sustaining an SRC. Males and females had lower levels of depression compared to baseline data by the time they returned to their sport and at 3 months following their injury. Females, however, had a significantly higher level of depression 7 days following SRC. Sports medicine providers need to be aware of these short-term fluctuations in depression levels when treating athletes who sustain an SRC.

The Relationship Between Cognitive Function and Quality of Life in Collegiate Athletes Green SL, Register-Mihalik JK, Bradney DA, Bowman TG: Lynchburg College, Lynchburg, VA; University of North Carolina, Chapel Hill, NC

Context: Overall quality of life may affect baseline concussion measures. An understanding of the relationship between various quality of life metrics and concussion baseline measures is important for clinical interpretation of these baseline measures. **Objective:** To determine the relationship between quality of life subscales and cognitive function in collegiate athletes. Design: Cross sectional study. Setting: Participants' measures of quality of life and computerized cognitive testing prior to the start of the athletic season in a computer lab. Patients or Other Participants: A total of 71 females and 86 males volunteered to participate in the study. The participants consisted of soccer (n = 72) and lacrosse (n = 83) athletes. The athletes were 19.12 ± 1.14 years old, 161.24 ± 0.15 cm tall, and weighed 72.82 ± 11.77 kg. Interventions: PROMIS-29 subscale scores (Anxiety, Depression, Fatigue, Pain Interference, Pain Intensity, Physical Function, Sleep Disturbance, and Social Roles), and NeuroQOL1.0 (Fatigue), and NeuroQOL2.0 (Cognitive Function) composite scores served as the independent variables. Main **Outcome Measures:** Concussion Vital Signs (CVS) composite scores (Verbal Memory, Visual Memory, Executive Function, and Reaction Time) served as the dependent variables. We used multiple linear regression to determine if there was a relationship between quality of life and cognitive function (CVS composite scores). **Results:** Quality of life has an effect on cognitive function in the following categories: verbal memory, visual memory, and reaction time. We found a significant regression equation for Verbal Memory $(F_{3153} = 3.34, P = 0.02, R^2 = 0.06)$

using PROMIS-29 subsets: Physical Function (P = 0.05), Sleep Disturbance (P = 0.02), and NeuroQOL Cognitive Function (P = 0.03). We found a significant equation for Visual Memory $(F_{2154} = 3.82,, P = 0.02, R^2 = 0.05)$ using PROMIS-29 subsets: Anxiety (P = (0.01) and Fatigue (P = 0.03). We found a significant equation for Reaction Time $(F_{7,147} = 2.13, P = 0.04, R^2 = 0.09)$ using PROMIS-29 subsets: Physical Function (P = 0.06), Depression (P = 0.08), Fatigue (P = 0.61), Sleep Disturbance (P = 0.11), Social Roles (P < 0.01), Pain Interference (P = 0.25), and NeuroQOL Fatigue (P = 0.40). We did not find a significant equation for Executive Function $(F_{1,156} = 1.69, P = 0.52, R^2 = 0.05)$ using PROMIS-29 subsets. Conclusions: Reduced quality of life has negative effects on baseline concussion test scores. Understanding the effect quality of life has on the athlete's cognitive function is important when baseline testing athletes. These data support the utility of quality of life metrics at baseline to aid in interpretation and clinical utility of baseline assessment measures.

The Relationship Between Depression Symptoms, Pain and Athletic Identity in Division II NCAA Athletes at Preseason Bodine LE, Keenan LC, Bear DJ, Daltry RM: West Chester University of Pennsylvania, West Chester, PA

Context: Most individuals diagnosed with depression first experience symptoms in their young adult years, putting college students at an increased risk. Pain has also been found to be related to depression symptoms; however, the experience of pain and depression symptoms may be unique in the athletic population and has not yet been studied. There has been a positive relationship found between depression symptoms and athletic identity; however, the literature is limited. The relationship between depression symptoms, pain and athletic identity has yet to be studied. **Objective:** To examine the relationship between depression symptoms, pain, and athletic identity in collegiate student-athletes. Design: Cross-sectional study. Setting: NCAA Division II public university. Patients or Other Participants: Ninety-one male (n = 49, 53.8%) and female (n =42, 46.2%) student-athletes across 4 sports including Women's Volleyball (n = 18, 19.8%), Women's Rugby (n = 24, 26.4%), Men's Swimming and Diving (n = 22, 24.2%), and Men's Soccer (n =27, 29.7%). Interventions: Participants completed three surveys on electronic tablets during preseason physicals. Measures included the Patient Health Questionnaire-9 (PHQ-9), a previously validated, brief depression symptom screen, the Numeric Rating Scale (NRS) measuring self-reported pain on a 0-10 scale, and the Athletic Identity Measurement Scale (AIMS), a seven-item Likert-scale quantifying the extent to which participants identified as athletes. Main Outcome Measures: Dependent variables included total PHQ-9 scores, AIMS scores and NRS scores. Descriptive statistics (mean \pm SD) were calculated and Pearson's correlation coefficients were used to

examine relationships between dependent variables. A priori alpha level was set at p < 0.05. **Results:** The mean PHQ-9 score was 2.43 ± 3.138 , the mean NRS score was 0.81 ± 2.113 , and the mean AIMS score was $38.52 \pm$ 7.644. A significant but weak positive correlation was found between depression symptoms and pain (r = .304, p = .003) and between athletic identity and depression symptoms (r = .258, p = .013). No significant association was found between athletic identity and pain (r = .018, p = .867). Conclusions: Our data supports that student-athletes experiencing pain may experience more depression symptoms. Those student-athletes with a high athletic identity may also experience more depression symptoms. Ultimately, athletic training and sports medicine professionals should observe or screen student-athletes for depression symptoms, especially those expressing pain and who identify highly with the athletic role.

Effects of Gender and Sports-Related Concussion History on Self-Reported Baseline Measures of Health-Related Quality of Life and Symptomology

Walton SR, Broshek DK, Goodkin HP, Broglio SP, Resch JE: University of Virginia, Charlottesville, VA; University of Michigan, Ann Arbor, MI

Context: Health-related quality of life (HRQoL) measures are recommended for individual management of patients with sports-related concussion (SRC). Post-injury HRQoL is related to self-reported symptoms (SS) in pediatric student-athletes. While baseline SS endorsement in these patients may differ based on gender and history of multiple SRCs, little is known about the effects of gender and SRC history on HRQoL at baseline. **Objective:** To explore the effects of gender and SRC history on baseline HRQoL and SS in high school student-athletes. Descriptive Study. Setting: Laboratory. Patients or Other Participants: 189 high school student athletes; 100 females aged 16.0 + 1.32 years, 25 (25%) with a history of SRC (range 1-3), and 89 males aged 16.1 + 1.30 years, 23 (25.8%) with history of SRC (range 1-2). Interventions: Participants were administered the Patient Health Questionnaire-9 (PHQ-9), PedsQL[™] 4.0 Short Form (PedsQL), the Revised Head Injury Scale (HIS-r) and the Post-Concussion Symptom Scale (PCSS) prior to the start of their respective sport season. Main Outcome Measures: Mann-Whitney U tests were used to compare the PHQ-9 total score, PedsOL total score, PedsOL individual function scores (physical, emotional, social and school), HIS-r total duration, HIS-r total severity, PCSS symptom score, and PCSS total symptom severity between genders (male vs. female), SRC history (yes vs. no), between genders stratified by history of SRC (i.e. males with no SRC history vs. females with no SRC history), and within gender based on history of SRC (i.e. females with SRC history vs. females without). Cohen's d effect sizes were calculated for significant differences. All analyses were performed with α =0.05. **Results:** Overall, females reported significantly higher values for the PHQ-9 total (p = 0.038; mean difference = 1.08; d = 0.55), PedsQL emotional (p = 0.024; mean difference = 0.96; d = 0.49), HIS-r total duration (p = 0.036; mean difference = 2.91; d= 0.64), HIS-r total severity (p = 0.002; mean difference = 2.63; d = 0.64), PCSS symptom score (p = 0.006; mean difference = 0.92; d = 0.47) and PCSS total symptom severity (p = 0.006; mean difference = 2.08; d = 0.75) compared to males. Among participants without history of SRC, females endorsed greater symptom burden than males for HIS-r total duration (p = 0.026; mean difference = 3.72; d = 1.66) HIS-r total severity (p = 0.007; mean difference = 3.34; d = 2.05), PCSS symptom score (p = 0.016; mean difference = 1.1; d =.91), and PCSS total symptom severity (p = 0.012; mean difference = 2.78; d =1.53). Females with history of SRC endorsed greater PHQ-9 total compared to males with history of SRC (p = 0.036; mean difference = 1.68; d = 1.08). No additional significant differences were observed. Conclusions: Our data reflect higher baseline SS and HRQoL burden in high school females compared to their male counterparts. SRC history did not influence SS or HRQoL, even when stratified by gender, which is contrary to previous literature. Preinjury SS and HRQoL burden may affect post-injury outcomes and therefore each patient should be managed individually. This study was funded by the National Athletic Trainers' Association Foundation.

Free Communications, Oral Presentations: Characteristics of Cartilage Following Anterior Cruciate Ligament Reconstruction

Friday, June 29, 2018, 7:00AM-7:45AM, Room 220-222; Moderator: Randy Schmitz, PhD, ATC, FNATA

Ultrasonographic Assessment of Acute Femoral Cartilage Deformation Following Walking and Running in Individuals With an Anterior Cruciate Ligament Reconstruction

Harkey M, Zhang M, Blackburn JT, Davis H, Driban JB, Pietrosimone B: Tufts Medical Center, Boston, MA; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Monitoring cartilage health in individuals with an anterior cruciate ligament reconstruction (ACLR) is critical for detecting early deleterious changes indicative of posttraumatic osteoarthritis development. The magnitude of acute cartilage deformation following walking and running may provide clinically meaningful information regarding the resiliency of cartilage to common activities that cyclically load the knee. Ultrasonography (US) is a valid and clinically accessible imaging modality to assess femoral cartilage deformation. However, no study has utilized US to assess femoral cartilage deformation following cyclical loading in individuals with an ACLR. **Objective:** To determine differences in acute femoral cartilage deformation following walking, running, and sitting conditions in individuals with an ACLR. Design: Cross-over. Setting: Research Laboratory. Patients or Other **Participants:** Eighteen participants with a unilateral ACLR (72% Female, age = 20.2 ± 2.1 yr, height = $168.5 \pm$ 7.6 cm, mass = 71.0 ± 17.0 kg, $39.5 \pm$ 26.8 months post ACLR) volunteered to participate. Interventions: An anterior femoral cartilage US assessment at 140° of knee flexion was performed in the ACLR limb before and after three 30-minute loading conditions: 1) walking at a self-selected speed; 2) running at a self-selected speed; 3) sitting in full extension (i.e. control). The conditions were separated by at least one week and the condition order was randomized. Main Outcome Measures: ImageJ Software was used to segment the cross-sectional area of femoral cartilage. A custom MATLAB program was used to identify and quantify the thickness of the medial (inter-session ICC_{μ} = 0.98), central (ICC_{2k} = 0.97), and lateral (ICC_{2k} = 0.98) femoral regions. The central region was defined as the middle 1/4th of the cartilage centered on the apex of the intercondylar notch. We utilized a novel average cartilage thickness (mm) measure calculated as the area of the cartilage divided by the length of the cartilage surface for each region. Acute

cartilage deformation was quantified as the average thickness percent change (%D) from pre to post loading for each femoral region. Three one-way analysis of variance models with repeated measures were used to compare the cartilage deformation between the three loading conditions for each femoral region. Post hoc paired samples *t*-tests were used following a significant main effect to determine which loading conditions were significantly different. Results: In all three femoral regions, significantly greater deformation was detected following walking and running compared to sitting (Table). Walking and running deformation did not differ for any of the regions (Table). Conclusions: All regions of femoral cartilage underwent greater cartilage deformation following 30 minutes of walking or running compared with the sitting condition. Individuals with ACLR appear to present with greater central and lateral femoral deformation following walking and running compared with previously reported deformation following walking in healthy individuals [central (%D) = -0.2; lateral (%D) = -4.2]. Further work is needed to determine if greater cartilage deformation associates with a decline in cartilage health following ACLR.

Table. Acute Femoral Cartilage Deformation Following Loading Conditions	

Femoral Region	Condition	Mean	SD	ANOVA	Compared to Sitting		Compared to Running	
					t ₁₇	Р	t ₁₇	Р
Medial (%Δ)	Walking	-8.7*	6.8	E 27.1.	6.1	< 0.001	-0.5	0.654
	Running	-7.7*	5.5	$F_{1,17}=37.1;$ P < 0.01	-6.9	< 0.001		
	Sitting	1.2	3.5	1 <0.01				
Central (%∆)	Walking	-8.3*	8.5	F 75.	2.7	0.014	-0.4	0.663
	Running	-7.2*	7.2	$F_{1,17}=7.5;$ P=0.01	-3.4	0.003		
	Sitting	0.4	6.4	1 -0.01				
Lateral (%Δ)	Walking	-8.8*	7.2	E 017	4.7	< 0.001	-1.4	0.19
	Running	-7.0*	7.7	$F_{1,17}=21.7;$	-3.9	0.001		
	Sitting	2.8	7.1	1 <0.01				

*Significantly different than sitting condition ($P \le 0.05$)

Frontal Plane Knee Mechanics During Gait Are Associated With Femoral Cartilage Thickness in Females After ACL Reconstruction

Pamukoff DN, Moffit TJ, Vakula MN, Garcia SA, Holmes S, Montgomery MM: Department of Kinesiology, California State University, Fullerton, CA; Department of Kinesiology and Health Science, Utah State University, Logan, UT

Context: Individuals with ACL reconstruction (ACLR) are at greater risk for knee osteoarthritis due to alterations in gait biomechanics. The external knee adduction moment (KAM) is used as a surrogate for medial compartment joint loading, and predicts OA incidence and progression. Articular cartilage is commonly assessed using magnetic resonance imaging, but this method lacks portability and is cost-prohibitive. **Objective:** To examine the association between frontal plane knee mechanics during gait and femoral cartilage thickness, measured via ultrasound imaging, in individuals with ACLR. Design: Cross-Sectional. Setting: Biomechanics Laboratory. Patients or Other Participants: 25 females with primary unilateral ACLR (age = 21.8 ± 2.7 years; body mass index = $24.8 \pm$ 4.2; time since ACLR = 50.5 ± 14.9 months; 14 patellar tendon; 8 hamstring tendon; 3 allograft; Proportion with concomitant meniscal injury = 58%; Knee Documentation International Committee Score = 85.1 ± 9.3) participated in this study. Interventions: Ultrasonography was used to assess cartilage thickness at the medial femoral condyle in 140° of knee flexion following a 30-minute resting period in a non-weight bearing supine position. Participants completed 5 walking trials at a self-selected speed along a 10m runway and struck consecutive force plates while 3-dimensional kinematics (240Hz) and kinetics (2400Hz) were recorded. Main Outcome Measures: Kinematic variables included the peak knee adduction angle (KAA) during the stance phase, and frontal plane knee angle at heel contact. Kinetic variables included both KAM peaks (KAM1 and KAM 2), and the KAM angular impulse during the stance phase. Joint kinetics were normalized to body weight (BW) and height. Partial correlation accounting for speed and time since ACLR was used to assess the association between gait mechanics and cartilage thickness $(\alpha = 0.05)$. **<u>Results:</u>** Larger KAA (r = -0.45, p = 0.02) and larger KAM1 (r = -0.37, p = 0.04) were associated with thinner medial femoral cartilage. No association was found between medial cartilage thickness and the frontal plane knee angle at heel contact (r = -0.31, p = 0.08), KAM2 (r = -0.33, p = 0.07) or KAM impulse (r = -0.25, p = 0.13). Conclusions: Findings indicate that frontal plane knee mechanics during gait are associated with femoral cartilage thickness in females with ACLR. Large KAA and KAM1 contribute to greater medial compartment joint loading, which may contribute to knee OA incidence and progression. Ultrasound imaging may provide a non-invasive and portable method for imaging the femoral cartilage. Future longitudinal studies are needed to examine the association between frontal plane knee mechanics during gait and ultrasound measures of femoral cartilage thickness following ACLR.

Manipulating Peak Vertical Ground Reaction Force During Walking Influences Cartilage Oligomeric Matrix Protein in Individuals With Anterior Cruciate Ligament Reconstruction

Luc-Harkey BA, Franz JR, Hackney AC, Blackburn JT, Padua DA, Schwartz TA, Pietrosimone B: Brigham and Women's Hospital, Boston, MA; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: The complex interaction between aberrant mechanical loading and altered tissue metabolism that occurs following anterior cruciate ligament reconstruction (ACLR) is hypothesized to contribute to the development of posttraumatic knee osteoarthritis. It is currently unknown if acutely manipulating mechanical loading during walking is capable of influencing tissue metabolism in individuals with ACLR. Assessing changes in serum cartilage oligomeric matrix protein (COMP), a biomarker of cartilage breakdown, following the acute manipulation of peak vertical ground reaction force (vGRF) during walking may identify therapeutic targets that maintain homeostatic tissue metabolism following ACLR. **Objective:** To compare COMP_{CHANGE} following 20 minutes of walking while using visual real-time biofeedback (RTBF) to elicit bouts of high-loading (increased vGRF), low-loading (decreased vGRF), and symmetrical loading (symmetric vGRF between limbs) compared to control loading (participant's usual loading) in individuals with ACLR. Design: Cross-over study. Setting: Research laboratory. Patients or Other Participants: Thirty individuals with primary, unilateral ACLR (70% female; age = 20.4 ± 2.9 years; BMI = $24.4 \pm$ 4.3 kg/m²; 47.8 \pm 26.9 months following ACLR). Interventions: Participants completed four separate sessions involving 20 minutes of walking on a force-measuring treadmill during one of four loading conditions. Loading

conditions consisted of a control (participant's usual loading) followed by a randomized sequence of 3 experimental loading conditions prescribed using visual RTBF. Experimental loading conditions consisted of 1) walking with a 5% increase in vGRF (high-loading), 2) walking with a 5% decrease in vGRF (low-loading), and 3) walking with symmetric vGRF between the ACLR and contralateral limbs (symmetrical loading). Main Outcome Measures: Whole blood samples were collected immediately prior to $(\text{COMP}_{\text{PRE}})$ and following (COMP_{POST}) each 20-minute loading condition, and serum COMP was analyzed using a commercially available enzyme linked immunosorbent assay. COMP_{CHANGE} (COMP_{POST} - COMP_{PRE}) was calculated within each loading condition for analysis. One subgroup was identified from our entire cohort, which included only participants demonstrating an increase in serum COMP following the control condition $(COMP_{CHANGE} > 0)$ ng/mL). A general linear mixed model was used to compare COMP_{CHANGE} between each experimental loading condition (symmetrical loading, high-loading, low-loading) with control loading while adjusting for COMP_{PRE}. Post hoc comparisons were performed with the Dunnett-Hsu adjustment ($\alpha \leq 0.05$). Statistical analyses were conducted for the entire cohort and for the subgroup. Results: In the entire cohort, COMP_{CHANGE} was not different across experimental loading conditions compared to control loading $(n = 30; F_{329} = 1.34, P = 0.282)$. Within the subgroup demonstrating an increase in COMP following control loading (n = 22), COMP_{CHANGE} was significantly less during high-loading (mean \pm SD; 1.95 \pm 24.22 ng/mL, t_{21} = -3.53, P = 0.005) and symmetrical loading $(9.93 \pm 21.45 \text{ ng/})$ mL; $t_{21} = -2.86$, P = 0.025) compared to control loading $(25.79 \pm 21.40 \text{ ng/mL})$. **Conclusions:** Increasing vGRF during walking results in less serum COMP response in individuals with ACLR, suggesting that higher loading may be beneficial for joint tissue metabolism in those who demonstrate an increase in serum COMP with usual walking.

Friday, June 29, 2018, 8:00AM-9:00AM, Room 220-222; Moderator: Susan Yeargin, PhD, ATC

Influence of Graded Dehydration on Neuromuscular Control During Prolonged Exercise in the Heat

Adams WM, Vandermark LW, Scarneo SE, Belval LN, Lee EC, DiStefano LJ, Armstrong LE, Casa DJ: University of Connecticut, Storrs, CT; University of North Carolina at Greensboro, Greensboro, NC; University of Arkansas, Fayetteville, AR

Context: Exercise-induced hypohydration (3-5% body mass loss during 90 min exercise) in a hot environment impairs neuromuscular control. However, the proportional impact of exercise duration and different hydration levels on neuromuscular control remains undefined. **Objective:** To investigate the effects of graded exercise-induced hypohydration on neuromuscular control and lower extremity injury risk 1 hour (h) and 24h following prolonged exercise in a hot environment. Design: Randomized, cross-over design. Setting: Controlled laboratory. Patients or Other Participants: Eleven healthy, recreationally active males (mean \pm SD: age, 22 \pm 3 y; height, 178 ± 6 cm; VO_{2max}, 54.7 \pm 5.5 ml·kg⁻¹·min⁻¹; body fat, $11.6 \pm 3.9\%$). Interventions: Participants completed three randomized exercise sessions: euhydrated arrival + fluid replacement (EUR), euhydrated arrival + no fluid (EUD), and hypohydrated arrival + no fluid (HYD) in hot conditions (ambient temperature, $35.3 \pm 0.6^{\circ}$ C; relative humidity, $31.3 \pm 2.0\%$). Participants completed 3h of exercise (6 x 30 min cycles: 8 min, 40% VO_{2max}, 8min, 60% VO_{2max}, 8 min, 40% VO_{2max} , 6min passive rest) and 60 min passive rest before returning for 24h follow-up. Main Outcome Measures: Body mass was recorded for calculation of percent body mass loss (%BML) at 24h prior to exercise (PRE_{24}) , pre-exercise (PRE_{FX}) , after passive rest (POST_{EX}), and 24h following exercise (POST₂₄) in all trials. Rectal temperature (T_{REC}) was recorded

at PRE_{FX} and POST_{FX}. Neuromuscular control (Landing Error Scoring System (LESS) and Balance Error Scoring System (BESS)) was tested at PRE_{EX} , POST_{EX}, and POST₂₄. Statistical differences were assessed using separate mixed design (condition x trial x time) ANOVA with Tukey post hoc tests. Logistic regression was used to identify variables predictive of decreased risk of lower extremity injury (LESS score < 5). Results: %BML was greater in HYD at PRE_{FX} (1.8 ± 0.6%) and $POST_{EX}$ $(5.6 \pm 0.6\%)$ than in EUD (-0.8 ± 1.2%, $3.8 \pm 1.2\%$) and EUR (-0.7 ± 1.1%, 0.4 \pm 1.0%) (p < 0.001). %BML in EUD was greater than EUR only at POST_{EX} (p < 0.001). All groups were rehydrated by $POST_{24}$ (p > 0.05). At $POST_{EX}$, T_{REC} was significantly higher in HYD (38.08 $\pm 0.22^{\circ}$ C) than EUD (MD [95% CI]; $0.30 \pm 0.09^{\circ}$ C [0.07, 0.53], p = 0.007) and EUR $(0.57 \pm 0.0.09^{\circ} \text{ C} [0.34, 0.79],$ p < 0.001). There were no differences in LESS scores between EUD, EUR, and HYD at POST_{FX} (EUD, EUR, HYD; 4.5 \pm 1.9, 4.8 \pm 3.2, 3.1 \pm 1.9) or POST₂₄ $(3.4 \pm 2.2, 2.9 \pm 1.9, 4.8 \pm 2.7)$ when compared to PRE_{FX} (3.7 ± 2.7, 4.2 ± 1.4, 5.3 ± 2.2) respectively (p > 0.05). Balance was unaffected by exercise-induced hypohydration at POST_{EX} and $POST_{24}$ (p > 0.05). Logistic regression analyses revealed that there was a 2.1 times greater likelihood LESS score \geq 5 at POST₂₄ when prolonged exercise in the heat induced a greater level of dehydration (p < 0.05). <u>Conclusions:</u> Exercise-induced hypohydration up to 5.6% body mass loss did not adversely affect neuromuscular control after an acute (1h) or prolonged (24h) bout of recovery. Future research investigating the effects of chronic (day-to-day) hypohydration on neuromuscular control and risk of injury is warranted.

Perceived Relative Advantage of Intravenous Rehydration Being a Standard Protocol for Certified Athletic Trainers

Wise SL, Kravey JK, Weatherby NL, Binkley HM: Middle Tennessee State University, Murfreesboro, TN

Context: Many heat related illnesses can be prevented by maintaining proper hydration and having trained personnel, such as Athletic trainers, onsite during athletic events. While oral hydration is the standard, recent interest has been in the use of intravenous (IV) methods of rehydration. **Objective:** To examine the perception and perceived advantage of IV usage of rehydration by Athletic trainers and if they would favor a change in protocol to the traditional treatment. Design: Cross-sectional survey. Setting: National Athletic Trainers Association (NATA) membership. Patients or Other Participants: An online survey was administered to 1000 randomly selected certified Athletic Trainers who were members of the NATA. A total of 310 (31%) of surveys were returned with a participant average of 12.73 years of athletic training experience. Interventions: Participants completed an online survey through Free Online Surveys. Main Outcome Measures: Participants completed a 13-question survey consisting of questions regarding heat-related illness and EMS, current protocol, and whether they believe IV use should become a standard protocol for rehydration methods. Results: A majority of Athletic trainers (69.03%) would agree to adopt IV use as a proficiency in the educational framework and practice. A Chi-square analysis noted no significance of those having EMS assistance and support of IV use (p = 0.645). However, a significant value of p < .001 was found for the variable indicating the years of experience. It demonstrates that the more years of experience that a Certified Athletic Trainer has, the more likely they would be to support the adoption of IV use for

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treating heat-related illnesses (O.R. = 1.052). <u>Conclusions:</u> While oral hydration is the standard protocol for Athletic trainers in helping to prevent heat-related illnesses, the majority of Athletic trainers perceive an advantage to using IV fluids for rehydration and believe it should be adopted as a proficiency.

Field Validation of Sweat Sodium Analysis Via Portable Ion-Selective Electrode Analyzer in Athletes During Exercise in the Field

Barnes KA, Baker LB, Reimel AJ, Ungaro CT, Pahnke MD; Gatorade Sports Science Institute, PepsiCo, Inc, Barrington, IL

Context: Replacing electrolytes lost during prolonged sweating in the heat is important in preventing fluid/electrolyte imbalances. However, sweat sodium concentration ([Na⁺]) is highly variable. Therefore, having a field based method to measure athlete's sweat [Na⁺] can help athletes create individualized electrolyte replacement plans. **Objective:** To determine the validity of a field-based method of extracting and analyzing sweat [Na⁺]. Design: This study compared sweat extraction and [Na⁺] analysis methods from sweat collected during exercise in a hot, humid environment (30°C, 65% humidity). Setting: Sweat [Na⁺] was analyzed in the field and in the laboratory via a compact Na⁺ analyzer (Horiba B-722) versus the reference laboratory technique (ion chromatography; IC). Thirty-seven elite triathletes (28 males, 9 females) rode their bike on a stationary trainer (CompuTrainer[™], RacerMate, Inc.) outdoors (under a tent) at a self-selected race pace. After a warm up, athlete's forearm and upper back were cleaned and dried, and then two absorbent patches (labeled "field" and "lab") were applied to each site, and removed upon sufficient saturation based on visual inspection. **Interventions:** "Field" patches (n = 74) were placed into the barrel of a 5 mL syringe and the sweat was immediately plunged into a cryovial, the sweat was then analyzed for [Na⁺] on-site with the Horiba device; remaining sweat in the "field" cryovial was refrigerated for laboratory analysis. "Lab" patches (n = 74)were removed, placed into a filter tube, and refrigerated until shipment for laboratory analysis. All remaining sweat samples were shipped to the laboratory and 2 weeks after collection "lab"

patches were centrifuged and, along with the remaining sweat from "field" patches, were analyzed via IC. After IC analysis, remaining sweat was analyzed with the Horiba device in the laboratory. Main Outcome Measures: Paired t-tests were used to determine mean differences in sweat [Na⁺], while coefficient of variation (CV) were calculated to assess variation between methods. **Results:** The main comparison, Syringe Field Horiba versus Centrifuge IC had a mean difference and CV of 4.8 ± 9.0 mM (p < 0.001) and 10.9%, respectively. The mean differences and CV's for the other comparisons were as follows: Syringe Field Horiba versus Syringe Lab Horiba (error due to field testing) 5.8 ± 4.0 mM and 8.6%, Syringe Lab Horiba versus Syringe IC (error due to Horiba) -1.5 ± 3.5 mM and 3.2%, and Syringe IC versus Centrifuge IC (error due to syringe) -0.1 ± 8.0 mM and 8.4%, respectively. Conclusions: Most of the measurement error with the Syringe Field Horiba method was due to differences between field and laboratory results (perhaps due to shipping or time lag between collection and analysis); the error due to syringe extraction and Horiba Na⁺ analysis was minimal. These results suggest that syringe extraction followed by Horiba analysis may be a useful, inexpensive field method to assess sweat [Na⁺].

Sweat Rate and Intestinal Temperature Response During 2 Hr of Running When Drinking to Thirst Versus Drinking to a Generic Schedule

Fowkes Godek S, Worley ML, McGinty S, Morrison KE: The HEAT Institute at West Chester University, West Chester, PA

Context: Dehydration is often thought to cause decreased sweat rate and increased core temperature. Outdated fluid replacement guidelines includes specific parameters for scheduled drinking to avoid dehydration. However, recent consensus statements and position stands suggest that drinking to thirst minimizes dehydration and prevents overdrinking which is known to cause hyponatremia. Objective: To investigate the temperature and sweat responses during 2hr of running in a thermoneutral environment when drinking to thirst(Thirst) versus drinking to a generic schedule (Scheduled). We expected no differences in intestinal temperature or sweat rate regardless of fluid intake, but differences in weight loss/gain. Design: A randomized crossover study. Setting: Data was collected in climate-controlled chamber in a University laboratory. Patients or Other Participants: Ten trained endurance runners (6 male and 4 female) with age = 36.7 ± 10.3 yrs, height = 174.8 ± 7 cm, weight = 71.4 \pm 11.8 kg, %body fat = 15.6 \pm 6%, and $VO2max = 57.7 \pm 7.8 \text{ ml/kg/min volun-}$ teered and completed both experimental trials. Interventions: Baseline data was collected 2 weeks prior to the first experimental trial. The Thirst versus Scheduled trials were randomized and completed 7 days apart. Participants ran at 60% VO2max for 2hr in a climatic-controlled chamber (21°C and 40%RH). Subjects drank when they felt a deep-seated desire for water in the Thirst trial. Scheduled water intake included: 600 mL 2hr pre-trial, 300 mL 20 min pre-trial, and 300 mL every 10 min during running. Body weight was measured on a calibrated scale and urine samples were obtained pre-trial and post-trial. Fluid intake (Fluids) and

urine produced (Uvol) were measured. Sweat loss was calculated (?Body weight + Fluids - Uvol), and sweat rate = sweat loss/time. Intestinal temperature (CoreTemp,HQI) was recorded every 15 min. Repeated measures GLM was used for temperature analysis over time and correlated t-tests were used for other dependent variables, with p < .05 for significance. Main Outcome Measures: Intestinal temperature, sweat loss, sweat rate, fluid intake, ∆body weight, fluids replaced (%), and dehydration (%) or overhydration (%). Results: Environmental conditions and pre-trial hydration (USG in Thirst = 1.009 ± 0.005 and Scheduled = 1.007 ± 0.006) were not different. Intestinal temperature was not different between trials ($F_{1,18} = 0.614$, P = .44) nor was sweat rate $(1.06 \pm 0.23 \text{ L/hr ver-})$ sus 1.02 ± 0.17 L/hr) or sweat losses $(1.97 \pm 0.45 \text{ L versus } 1.88 \pm 0.53 \text{ L}).$ Differences existed between Thirst and Scheduled in fluid intake (0.553 ± 0.41) L versus 3.2 ± 0.42 L), Δ body weight $(-1.62 \pm 0.51 \text{ kg versus} + 0.58 \pm 0.66 \text{ kg})$ kg), and fluid replaced ($25.7 \pm 17.4\%$ versus $125.2 \pm 26\%$. Dehydration in Thirst (-2.24 \pm 0.5%, range = -1.23 to -2.87%) was different from overhydration in Scheduled (+0.8 \pm 0.88% range = -0.84% to +2.2%), all p > .001. Conclusions: Results show that drinking to thirst did not affect intestinal temperature or sweat rate during 2hr of exercise in a thermoneutral climate compared to scheduled drinking. Importantly, drinking to a generic schedule did promote weight gain, and overhydration by 1-2% in most subjects, which has been shown to cause hyponatremia. Unless individual sweat rate is known, drinking to thirst is the safest strategy as suggested by the 2017 NATA Position Statement on Fluid Replacement.

A Comparison of the Physiological Effects of Drinking to Thirst Versus Drinking to a Generic Schedule During 2 Hours of Running in Thermoneutral Conditions Worley ML, Fowkes Godek S, Morrison KE, McGinty S, Klock A, Reed M: The HEAT Institute at West Chester University, West Chester, PA

Context: The 2000 NATA fluid replacement position statement includes guidelines for scheduled drinking to avoid losing greater than 1-2% body weight. A recent consensus statement suggests that drinking to thirst is more appropriate. **Objective:** To investigate the physiological effects of drinking to thirst versus drinking to a schedule during 2 hr of continuous running in a thermoneutral environment. We hypothesized that drinking water to a generic schedule could promote weight gain and decreased blood sodium (Na+). **Design:** A randomized crossover study. Setting: University laboratory using a climate controlled chamber. Patients or Other Participants: Eight male and five female trained endurance runners (age = 33.6 ± 10.7 yrs, height = 172.9 ± 7.6 cm, weight = 70.2 ± 11.4 kg, %body fat = 15.0 ± 5.9 %, VO2max = 58.4 ± 9.0 ml/kg/min) voluntarily completed both experimental trials. Interventions: Baseline data was collected within 2 weeks of the first experimental trial. The experimental trials (Thirst versus Scheduled) were completed 7 days apart. Participants ran on a treadmill at 60%VO2max for 2 hr in a climatic chamber (21°C and 40% RH). Scheduled drinking was as follows: 600mL 2 hr pre-trial, 300mL 20min pre-trial, and 300mL every 10min during running. In the Thirst trial subjects drank when they felt a deep-seated desire for water. Body weight was determined on a calibrated digital scale and urine samples were obtained pre and post exercise. Blood samples were taken via lancet technique at the following time periods: pre-trial, mid-trial, post-trial and 20min post-trial. These samples were immediately analyzed for electrolytes via ion-selective electrode. Sweat loss was calculated as change in body weight adjusted for fluid intake and urine volume. Correlated t-tests were used and p < .05 was determined apriori. Main Outcome Measures: Blood electrolytes (Na⁺, Cl⁻ and K⁺), Δ body weight (kg), fluid intake (L) and sweat loss (L). Results: Environmental conditions and pre-trial hydration $(Thirst = 318.4 \pm 191.6 \text{ mOsm/kg} and$ Scheduled = $260.6 \pm 195.4 \text{ mOsm/kg}$), as well as blood electrolytes were not different. Blood Na+ was different between Thirst and Scheduled mid-trial $(141.6 \pm 2.1 \text{ versus } 137.9 \pm 2.4 \text{ mmol/L}.$ P < .001), post-trial (142.7 ± 2.6 versus $135.7 \pm 2.5 \text{ mmol/L}, \text{ P} < .001$), and 20 min post-trial (142.7 \pm 2.5 versus $136.6 \pm 3.1 \text{ mmol/L}, P < .001$), as was chloride (Cl⁻) mid-trial (103.9 \pm 2.5 versus $101.8 \pm 2.3 \text{ mmol/L}, P < .001$), post-trial $(104.7 \pm 2.5 \text{ versus } 99.3 \pm 2.5$ mmol/L, P < .001), and 20 min post-trial $(104.7 \pm 3.0 \text{ versus } 100.2 \pm 3.4$ mmol/L, P < .001). Blood Na⁺ post-trial in Scheduled ranged from 130-140 mmol/L. Blood potassium (K⁺) was not different at any time. Body weight was different between Thirst (-1.6 \pm 0.5 kg, P < .001) versus Scheduled (0.4 ± 0.7 kg, P < .001). Fluid intake was lower in Thirst $(0.58 \pm 0.42 \text{ L}, \text{P} < .001)$ versus Scheduled $(3.26 \pm 0.72 \text{ L}, P < .001)$, but sweat losses were not different between Thirst $(1.95 \pm 0.46 \text{ L})$ versus Scheduled $(1.84 \pm 0.70 \text{ L})$. Conclusions: Results show that drinking to a generic schedule promotes body weight gain and a decline in blood Na⁺, whereas all subjects drinking to thirst resulted in blood Na⁺ within the normal range (135-145mmol/L). This study supports the 2017 NATA Fluid Replacement Position Statement that suggests consuming fluids based on individual sweat losses, or drinking to thirst.

100% Orange Juice Consumption on Gastrointestinal Distress, Thirst, Palatability, and Mood After Exercise in the Heat Kelly MR, Emerson DM, Landes EJ, Barnes ER, Gallagher PM: University of Kansas, Lawrence, KS

Context: Compared to carbohydrate electrolyte beverages (CEB) commonly consumed by physically active individuals, the composition of 100% orange juice (OJ) is similar in carbohydrate content, has less sodium, and more potassium and vitamins. There is limited research investigating 100% OJ as a post-exercise fluid replacement option. **Objective:** To examine OJ, water (W), and CEB on gastrointestinal (GI) distress, palatability, thirst, and mood disturbance. Design: Randomized, controlled, single-blind design. Setting: Research laboratory. Patients or Other Participants: Twenty-six moderately endurance trained volunteers (20 male, 6 female, age: 22.1 ± 3.3 yrs; weight: 72.9 ± 10.0 kg; height: 174.3 ± 7.9 cm; VO2max: 48.8 ± 7.3 mL/kg/min) completed this study. Interventions: On 5 consecutive days, euhydrated (plasma osmolality < 290 mOsm/L) participants cycled 80 min at 70% VO2max in a hot, humid environment $(30.1 \pm 0.2^{\circ} \text{ C}, 51.6)$ \pm 4.0% relative humidity). After exercise, participants consumed 237 mL (8 oz) of OJ or commercially available orange flavored W or CEB. Participants then rested 1 hour in an ambient environment. Main Outcome Measures: GI distress (GI symptom index, modified GI symptom index), mood disturbance (Profile of Mood States [POMS]), and perceived thirst and palatability (9-point scale) measures were taken pre-, during-, post-, and 1 hour post-80 min of cycling. Fluid volume (Fvol) and core temperature (Tc; rectal thermometer) were measured to control for potential effects on GI distress. Descriptive statistics for all dependent variables were calculated. Demographic differences were assessed using one-way ANOVA. GI data were analyzed using frequency

and wilcoxin signed rank tests. Tc, Fvol, POMS, thirst, and palatability were analyzed using 3 (condition) x 3 (time) and 3 (condition) x 4 (days) repeated measures Significance level was set at P < 0.05 for all analyses. **Results:** We found no statistically significant differences between experimental conditions for GI distress, POMS, thirst, palatability, Fvol or Tc. Likewise, there were no significant differences at any time point (pre- to 1-hour post) for POMS, GI distress, palatability or Fvol. Pre-beverage thirst (4.6 ± 2.2) was significantly higher than 15 min post-beverage ingestion $(3.6 \pm 1.9, P < .001)$, 30 min post- (3.1) \pm 1.6, P < .001), and 45 min post- (2.7 \pm 1.4, P < .001). Thirst was also significantly different between 15 min and 30 min post- (P = .002), 15 and 45 min post- (P < .001), and 30 to 45 min post-ingestion (P < .001). Conclusions: Consuming 8 oz of OJ on multiple days after moderately intense cycling in the heat did not increase GI distress symptoms, alter mood, or affect thirst and palatability differently than drinking W or CEB. 100% OJ is a viable rehydration beverage in individuals starting and ending exercise euhydrated. Funded by the Florida Department of Citrus (#STE0075600).

Racial Differences in Renin and Aldosterone and Their Relationship to Sweat and Urine Electrolyte Losses in Male Collegiate Athletes During Pre-season Practices McGinty S, Fowkes-Godek S, Worley M, Godek T, Owens J, Adesina O, LaSorda M, Morrison K: HEAT Institute, West Chester University, West Chester, PA; Aria 3B Orthopedics, Philadelphia, PA

Context: Racial differences in the Renin-Angiotensin-Aldosterone system (RAAS) have been implicated in the racial disparity in prevalence of hypertension in Americans. The RAAS is the primary mechanism for sodium conservation (and potassium excretion) during exercise. Objective: To investigate racial differences in the RAAS and their relationship to sweat and urine electrolyte losses during exercise. Design: Casecontrol cohort. Setting: Data was collected before the first pre-season practice and during football and soccer practice on day 10 of practices. Patients or Other Participants: Eight Caucasian (Age: 21.6 \pm 1.2 yrs, Height: 182.8 \pm 5.0 cm, Mass: 98.6 ± 21.6 kg, BSA: 212.9 ± 37.3 cm²) and 8 African-American (Age: 21.0 ± 1.1 yrs, Height: 177.5 ± 7.5 cm, Mass: 89.1 \pm 21.8 kg, BSA: 198.7 \pm 37.3 cm²) male division II collegiate football and soccer players volunteered. Caucasian and African-American subjects reported that they, and both biological parents, identify as either Caucasian or African-American. Groups contained 6 football and 2 soccer players and did not differ in physical characteristics. Interventions: A venous blood sample (8mL) was drawn before the first pre-season practice (baseline) and pre-practice on day 10 of practices when players were acclimatized. Serum and plasma were prepared and frozen until assayed. Sweat loss was calculated as Δ body weight (kg) adjusted for fluid intake (L) and total urine volume produced (L). Forearm and low-back sweat samples were collected using standard procedures. Sweat and urine electrolyte concentrations (mmol/L) were analyzed by ion-selective electrodes, and total electrolyte losses(mg) were calculated. Main Outcome Measures: Plasma renin, serum aldosterone, sweat and urine sodium, potassium, and chloride concentrations, sweat and urine volumes, and calculated electrolyte losses. We used independent t-tests to assess group differences, and multiple correlations to assess relationships between both pre-practice aldosterone and renin with urine and sweat sodium, potassium, and chloride concentrations, and total sodium, potassium, and chloride losses within each racial group. Results: Significant differences were found in renin at baseline (Caucasian: 1.22 ± 0.56 ng/dL/hr, African-American: 0.57 ± 0.22 ng/dL/hr, P = 0.013) and at pre-practice (Caucasian: 1.30 ± 0.51 ng/ dL/hr, African-American: 0.77 ± 0.34 ng/ dL/hr, P = 0.042). Additional differences were found in concentrations of urine sodium (Caucasian: 48.8 ± 33.7 mmol/L, African-American: $97.7 \pm 40.1 \text{ mmol/L}$, P = 0.029) and chloride (Caucasian: 95.2) ± 49.7 mmol/L, African-American: 151.5 \pm 42.7 mmol/L, P = 0.039). Moderate to high correlations were found in African-American players between pre-practice renin and the concentration of urine sodium (r = -0.80, P = 0.02) and potassium (r = 0.74, P = 0.03) with chloride approaching significance (r = -0.67, P =0.07). Similar correlations were found in African-American players between renin and sweat sodium (r = 0.74, P = 0.03) and chloride (r = 0.75, P = 0.03). Whereas in Caucasians, significant correlations were found for pre-practice aldosterone and potassium concentrations in both urine (r = 0.71, P = 0.05) and sweat (r = 0.84, P = 0.01). Conclusions: Significant correlations found in one race between renin or aldosterone and sweat or urine electrolyte concentration that were insignificant in the other suggest a potential racial difference in the influence of these hormones on the mechanism by which electrolytes are lost and may need to be replaced in African-American versus Caucasian athletes.

Sweat Electrolyte Concentrations and Sweat Rates of Athletes With and Without a History of Muscle Cramps

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Context: Exercise-associated muscle cramps (EAMC) are thought to be caused by dehydration and/or electrolyte losses. Prior investigations of fluid and sweat electrolyte losses in crampers and non-crampers were limited to small samples (n < 14) of American football athletes. **Objective:** Determine if athletes with a self-reported lifetime history of EAMC had higher sweat rates, sweat sodium concentrations ([Na+] sw), sweat potassium concentrations ([K+]sw), and sweat chloride concentrations ([Cl-]sw) than athletes without an EAMC history. Design: Multicenter, cross-sectional. Setting: Field study. Patients or Other Participants: 204 males completed testing: American football (n = 110), baseball (n = 17), basketball (n = 31), track and field (n =28), and wrestling (n = 18). 146 females completed testing: basketball (n = 36), field hockey (n = 18), gymnastics (n =10), soccer (n = 36), softball (n = 22), tennis (n = 9), and volleyball (n = 15). Interventions: Pre-exercise, athletes were weighed and sterile sweat patches were applied to the posterior forearms. Athletes completed 20-150 minutes of conditioning or sport-specific practice. Sweat patches were collected, centrifuged, and analyzed for electrolyte concentrations. Post-exercise, athletes dried themselves and were weighed. Athletes were grouped by self-reported EAMC history, sport, and gender. Main Outcome Measures: Sweat was analyzed for [Na+]sw, [K+]sw, and [Cl-]sw. Sweat rates were calculated from body mass changes and normalized using body surface area (BSA). Descriptive statistics (means \pm SD) were calculated. Two-way ANOVAs

(sport and EAMC history) with Tukey-Kramer post-hoc tests identified differences in electrolyte concentrations and sweat rates/BSA within each gender ($\alpha = .05$). **Results:** For both genders, no interaction between sport and EAMC history occurred for sweat rate/ BSA (F6,132 < 1.5, P > .18), [Na+] sw (F5,105 < .9, P > .51), and [Cl-] sw (F4,58 < .8, P > .51). For [K+]sw, no interaction (F4,182 = .6, P = .69) or main effect of EAMC history (F1,182 = .3, P = .57) occurred for the male athletes. However, we observed an interaction for [K+]sw in the female athletes (F5,105 = 13.5, P < .001). Males with an EAMC history (n = 153; $.64 \pm .28$ L/h/m2) had similar sweat rates/BSA as males without EAMC (n = 51; .59 \pm .20 L/h/m2; F1,194 = .01, P = .96). Females with an EAMC history (n =92; $.47 \pm .22$ L/h/m2) had similar sweat rates/BSA as females without EAMC (n = 54; .46 \pm .21 L/h/m2; F1,132 = 1.1, P = .29). Males with an EAMC history (n = 145; 43.9 \pm 14 mmol/L) had similar [Na+]sw as males without EAMC (n = 46; 46.5 \pm 11 mmol/L; F1,181 = .4, P = .55). Females with a history of EAMC $(n = 74; 35.2 \pm 12 \text{ mmol/L})$ had similar [Na+]sw as females without EAMC (n $=43;38.5\pm11$ mmol/L; F1,105 = 1.6, P = .2). Males with an EAMC history (n = 145; $52 \pm 21 \text{ mmol/L}$) had similar [Cl-] sw as males without EAMC (n = 47; 52 \pm 18 mmol/L; F1,182 = .01, P = .94). Females with an EAMC history (n = 38; $46 \pm 19 \text{ mmol/L}$) had similar [Cl-]sw as females without EAMC (n = 30; 44 ± 19 mmol/L; F1,58 = .01, P = .94). Softball athletes without an EAMC history had higher [K+]sw $(3.9 \pm .4 \text{ mmol/L})$ than softball athletes with EAMC ($3.6 \pm .5$ mmol/L, P < .05). Conclusions: EAMC may not be related to fluid or electrolyte losses. Clinicians should individualize rehydration plans because fluid and electrolyte losses vary between sports and genders.

Knee Best Practices Forum: The Evolution of Return to Sport Criteria After Anterior Cruciate Ligament Reconstruction: A Progression Toward a Multidimensional Approach

Friday, June 29, 2018, 10:45AM-11:45AM, Room 220–222; Moderator: David Bell, PhD, ATC Discussants: Brian Pietrosimone, PhD, ATC; Conrad Gabler, PhD, ATC

Free Communications, Rapid Fire Oral Presentations: Organizational and Professional Issues in the Secondary School Setting

Friday, June 29, 2018, 12:00PM-1:00PM, Room 220-222; Moderator: Kelly Pagnotta, PhD, ATC, PES

Athletic Trainer Services in the Secondary School Setting: The ATLAS Project

Huggins RA, Attanasio SA, Cooper GL, Harper RC, Huemme KL, Morris RF, Pike AM, Peterson BC, Pryor RR, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Penn Trafford High School, Harrison City, PA; Palo Verde High School, Tucson, AZ; Dutchtown High School, Geismar, LA; Central California Sport Sciences Institute, California State University, Fresno, CA

Context: Previous research determined that 67% of public (PUB) and private (PVT) secondary schools have access to athletic trainer (AT) services. Furthermore, 35% were employed full-time (FT), while 30% were employed part-time (PT). This sample represents 52% of the 20,388 secondary schools nationwide with athletics programs. The precise population-based statistic is yet to be determined. **Objective:** To determine the level of AT services in PUB and PVT secondary schools with athletics programs in the United States (US)

and by NATA district to expand upon previous findings from smaller samples. Design: Longitudinal, cross sectional study. Setting: PUB and PVT secondary schools with athletics programs in the US. Patients or Other Participants: Data from 99% (n = 20,114/20,388) PUB and PVT secondary schools were obtained. Interventions: Data were acquired and continually updated from September of 2012 through November of 2017 via one or more of the follow methods; completion of an online survey-based questionnaire by the secondary school AT, direct phone call or email to school administration or AT, or cross-referencing from current secondary school AT and athletics directories provided to the researchers or was publicly available online. Main Outcome Measures: Descriptive statistics depict FT, PT and no AT services data for PUB, PVT, and combined (PUB+PVT) by NATA district. FT services were defined as all of the following: AT services provided to only 1 school, >5 days per week, >30 hours per week, and >10 months per year. PT services were defined as anything less than FT. Results: Of the 20,114 schools with athletics programs whose AT services were obtained, 67% (n = 13,373) received AT

services while 33% (n = 6,741) received no AT services. Of those schools with AT services, 51% received FT medical care (n = 6,848) while 49% (n = 6,525)received PT medical care. PUB schools (n = 15,923) received 36%, 33% and 31%, while PVT schools (n = 4,191)received 27%, 28% and 45%, for FT, PT, and no AT, respectively. Secondary schools in NATA Districts 2, 3, 6 and 9 received the greatest percentage of FT services and also comprised the lowest percentage of schools without an AT. Furthermore, District 2 had the highest percentage of schools with AT services (78%) (Table 1). Conclusions: The national percentage of schools that have AT services and the percentage of schools with FT and PT services, were similar to previous reports with reduced sample sizes. Of greatest concern is the one third of secondary schools who have athletics without appropriate medical care, which is largely due to the lack of AT services in the PVT school setting. These data depict the largest and most updated representation of AT services in the secondary school setting and can serve to promote improvement of medical care provided to secondary school athletes.

Level of AT Services by NATA District										
	1	2	3	4	5	6	7	8	9	10
FT (n, %)	342,	1133,	794,	1247,	469,	835,	330,	376,	1104,	218,
	31%	52%	45%	32%	19%	49%	33%	22%	35%	19%
PT (n, %)	390,	561,	423,	1350,	910,	416,	266,	626,	1272,	311,
	35%	26%	24%	35%	37%	25%	26%	36%	40%	27%
None (n, %)	374,	497,	547,	1271,	1077,	444,	416,	716,	784,	615,
	34%	22%	31%	33%	44%	26%	41%	42%	25%	53%
Total (n)	1106	2191	1764	3868	2456	1695	1012	1718	3160	1144

FT= full time; PT= part time, reported % is based on column total.

Secondary School Athletic Trainers' Influential Factors and Barriers to Implementation of the Executive Summary Consensus Recommendations on the Appropriate Care of Spine Injured Athletes

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Context: Sport-related spine injuries require efficient management by healthcare professionals. Athletic trainers (ATs) are often the first to respond to secondary school athletes with a suspected spine injury, which makes it essential that they provide care according to best-practice guidelines. Understanding secondary school ATs use of current spine injury recommendations, including the NATA Executive Summary Recommendations for the Appropriate Care of Spine Injured Athletes (ES-Spine), is important when considering support strategies to encourage use of best-practice recommendations. **Objective:** To describe the implementation patterns and influential factors and barriers of secondary school ATs who do and do not implement the ES-Spine. Design: Cross-sectional. Setting: Qualtrics survey. Patients or Other Participants: 2,630 participants from a sample of 27,528 ATs the survey (access rate = 9.6%). 951 of those were secondary school ATs (362 males, 583 females, 6 preferred not to answer, age = 34.14 ± 10.91 years) and completed at least one part of the survey and were included. Interventions: Participants were solicited via email to complete the Athletic Trainers' Beliefs, Attitudes, and Implementation Strategies on Appropriate Care of Spine Injured Athletes (BAISAC-Spine) survey. The BAISAC-Spine consisted of several multipart questions that assessed ATs' knowledge, comfort, ease, success, influential factors, and barriers related to implementation of the ES-Spine Main Outcome Measures: Surveys responses are reported (frequencies and percentages). **Results:** The majority of secondary school ATs indicated they fully (31%, n = 104/334) or partially (53%, n = 177/334) implemented the recommendations. Secondary school ATs who indicated they fully or partially implemented the recommendations found implementation to be easy (86.0%), comfortable (88.9%), and successful (91.3%). The majority of secondary school ATs indicated that they develop emergency action plans (EAPs) in conjunction with EMS (61.8%, n = 457/739), activate EAPs in accordance with injury severity (98.8%, n = 702/710), apply rigid devices prior to athlete transport (83.3%, n = 515/669), use immobilization devices for transport (83.3%, n = 536/643), and developed a transport plan for emergency situations (59.0%, n = 369/625). Over half of ATs indicated they did not conduct a timeout prior to athletic events (59.8%, n =435/728), remove protective equipment prior to transport (53.5%, n = 371/694), use three trained rescuers for equipment removal (64.5%, n = 437/677) or use an 8-person lift for moving patients (71.2%, n = 448/629). The most common influential factors for implementation were related to being a priority, professional responsibility/best-practice, and EMS support. The most common barriers were related to insufficient trained staff, personnel, and education/ training. Conclusions: The majority of secondary school ATs are either fully or partially implementing current recommendations for care of spine injured patients. However, more trained staff and greater education and training are needed to overcome barriers to implementation for some recommendations. Purposeful efforts are needed to assist secondary school ATs with successfully implementing practice guidelines, including those related to the spine-injured athlete.

Implementation of Emergency **Action Plan Policies in** Secondary School Athletics Without Previous Athletic **Training Services** Scarneo SE, Hosokawa Y, Pike AM, Attanasio S, Endres B, Burland JP, Register-Mihalik J, Stearns RL, DiStefano LJ, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Emergency action plans (EAP) for secondary schools (SS) athletics play a critical role in ensuring readiness to adequately and efficiently respond to emergency situations. Recent reports suggest that SS with an athletic trainer (AT) are more likely to have a venue-specific EAP. **Objective:** Describe the extent of EAP adoption, along with the current readiness to act, in SS that recently hired an AT within the past 6 months. Design: Descriptive study. Setting: SS athletics. Patients or Other Participants: AT and athletics directors (AD) from 55 SS who received a NFL Foundation Athletic Trainer Grant Pilot Program were included. The goal of the program was to award funding to SS with minimal or no access to AT services. . Interventions: The AD and recently hired AT for each school (total potential n = 110) were asked to complete an online survey through Qualtrics prior to the start of the fall 2017 season. Eleven recommendations for meeting minimum best practices for EAPs were derived from the "NATA Position Statement: Emergency Planning in Athletics". Survey questions were structured following the Precaution-Adoption Process Model (PAPM), a health behavior model that examines respondent's readiness to act (i.e., EAP policy adoption for the secondary school setting). Main Outcome Measures: Frequencies were tabulated for each recommendation and presented

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as a dichotomized representative sample of the responding schools. Seperated McNemar's tests evaluated disagreement between AT and AD responses. Results for participant's readiness to act (PAPM scale) are also presented. Results: The response rate of the survey was 41.81% (AD, n = 23; AT, n = 23). Fourteen SS had both AT and AD responses, 21 schools had only AT (n =9) or AD (n = 9) response. Of the overall responses, 23.7% of AT and 21.7% of AD stated they did not have an EAP for athletics prior to the fall season. McNemar's test determined there was a significant disagreement in the proportion of AD responses compared to AT responses for EAP implementation (p = 0.02) and rehearsal of EAP (p = 0.02). When compared to AT, AD were more likely to report that schools had already been implementing the individual components of EAP adoption for longer than 6 months (AD: 40.7%; AT: 36.61%). In schools that did not adopt an EAP or individual components of EAP, 29.4% of AT responded they were planning on implementing the components in the next 6 months. Conclusions: Over 20% of AT and AD respondents from SS report not having an EAP, demonstrating a need for improved emergency planning. SS ADs were more likely to report that their EAP for athletic emergencies was adequate, despite the low PAPM scale reported by the newly hired ATs. Future research should longitudinally investigate the change in EAP policy adoption in schools with recently hired ATs.

Relationship Between Athletic Trainers Employed in the High School Setting and Emergency Department Visits for Sport and Recreation Related Injuries in Florida

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Context: The employment of athletic trainers(ATs) in the high school setting has widely been promoted as a public health issue. It has been proposed that in addition to improving student-athlete safety, having direct access to a health care provider in the school setting may reduce youth seeking care in more costly, less efficient facilities such as emergency departments (EDs). Objective: To determine the relationship between the number ATs in the high school setting and the amount of emergency department visits for unintentional sports and recreation related injuries (SRIs). A negative correlation was hypothesized. Design: Cross-sectional Setting: Epidemiological review of Florida statewide medical records Patients or Other Participants: Florida youth aged 13-18. Interventions: ED discharge data from the Florida Agency for Health Care Administration for the period of July 1, 2014 to June 30, 2015 was analyzed to identify emergency department visits that did not result in admission for SRIs among youth aged 13-18. SRIs were summed for each county by county of residence of the SRI patient. The number of athletic trainers practicing in high school settings in the state of Florida was determined by querying the Athletic Training Locations And Services (ATLAS) database. The athletic trainer status for each school in the state of Florida was extracted. For those schools listed as having a "Part Time Athletic Trainer" or "Full Time Athletic Trainer" the number and type of athletic trainers serving the school were determined and the county in which the school was located was identified. Each full-time athletic trainer was counted as one high school level athletic trainer. Part-time ATs were credited as 0.5 of an AT. For each county the number of ATs was summed to calculate AT full-time-equivalents (AT-FTEs) per county. Main Outcome Measures: SRI frequency counts for injury type. A Spearman Rho correlation was used to evaluate the relationship between SRIs and AT-FTEs for each county. Results: There were 37,942 ED visits with SRI codes associated with the primary or secondary diagnosis. The five most common types of SRIs were sprains/strains (13,936), fractures (7,242), superficial wounds/contusions (7,802), unspecified injuries (4,692), and open wounds (3,193). Between SRIs (median = 202; range 18-5,429) and AT-FTEs (median = 2; range 0-48) by county a moderate positive correlation (r = 0.54, p < 0.001; df = 65) was observed. <u>Conclusions:</u> The observed positive association failed to support our hypothesis. In this sample, as the number of ATs in the high school setting increased so did SRIs for youth aged 13-18. These findings may be confounded by the greater presence of ATs in large population centers where there are more sports and recreation opportunities, and therefore, more exposures to potential injury. Further research is necessary to better understand the observed relationship.

Are California High Schools Putting Student-Athletes at Risk? A Look at Medical Care Around the State

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Context: Athletic trainers (ATs) prevent and treat sport-related and catastrophic injuries due to physical activity. However, not all secondary schools hire ATs or have appropriate emergency equipment to use in potentially catastrophic situations. **Objective:** The objective is to determine athletic training services and emergency equipment available in California secondary schools. Design: Cross-sectional study. Setting: California secondary schools. Patients or Other Participants: 278 (16.2%) of all 1,719 California secondary schools contacted responded to our survey. Interventions: A structured phone survey determined differences in medical services and emergency planning and equipment provided to public and private secondary schools in California. The number of schools with non-medical personnel providing athletic training services was quantified. Main Outcome Measures: Data on medical services and emergency planning and equipment for student-athletes were collected for public and private secondary schools. Data are presented as means ± standard deviations and percentages. Results: Only 35% (87/251) of schools hired an AT, accounting for 52% (N = 54,763) of student-athletes. Approximately half (51%, 143/278) of schools reported having sports medicine personnel, including both certified ATs and other individuals. Although ADs thought 93% (108/116) of these individuals were ATs, only 75% (87/116) were found in the Board of Certification database. Twenty-one ADs were unaware that their sports medicine personnel were not ATs, affecting 15,180

student-athletes. The percent of schools with an AT was similar between public and private schools (p = 0.974) despite public schools having more athletes (542 ± 382) than private schools $(197 \pm 227, p < 0.001)$. 10% (27/278) of all schools allowed students to provide sports medicine services without AT supervision. While 87% (243/278) of schools had at least one automated external defibrillator (AED) on site, only 87% (201/232) of schools with an AED would have one accessible during an emergency. Conclusions: Nearly two-thirds of California secondary schools lack appropriate medical staff. California has dramatically fewer schools with an AT than the nationwide average of 70% of public and 58% of private secondary schools.

Athletic Training Student Aide Task Allowance in the Secondary School Setting

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Context: Athletic training student aides (ATSA) are minors in high school that participate in an athletic training experience under the supervision of secondary school athletic trainers (SSAT). While being an ATSA exposes students to athletic training, the legal and ethical risks associated with a minor providing healthcare can be very high, especially without supervision. The NATA published an official statement on the proper supervision of ATSAs, explicitly stating that interpreting referrals, performing evaluations, selecting interventions, planning care, and independently providing care during travel are not permitted by ATSAs. **Objective:** To identify the task allowance of ATSAs by SSATs. Design: Cross-sectional. Setting: Web-based survey. Patients or Other Participants: SSATs (n = 3,567) from the ATLAS database were recruited and 614 participants (age = 39 ± 11 years, years credentialed = 12 \pm 9 years) completed the study (23%) access rate, 75% completion rate). Most participants worked in a public secondary school (n = 490/614, 79.8%) predominately from the states of Texas (n = 83/614, 13.5%), Pennsylvania (n = 31/614, 5.0%), and South Carolina (n = 31/614, 5.0%). Most participants did not have teaching responsibilities (n = 361/614, 58.8%) and worked as the only SSAT (n = 362/614, 59.0%). Interventions: An online survey was developed to reflect the NATA official statements for task allowance and supervision of ATSAs. Demographic data was collected via the ATLAS survey of the SSAT using the school name, and matched with their confidential task allowance survey. The instrument was pilot tested for face validity by three practicing SSATs prior to distribution. Data were collected for one month. Main Outcome Measures: Dependent variables included requirements of the ATSA, personal perceptions of SSATs, and the task allowance of the ATSA based on supervision (direct, indirect, restricted). Partial data were used for all analyses. Results: SSATs (n = 470/614, 76.5%) reported having ATSAs involved in their clinical practice. Participants did not require CPR/ AED (n = 223/470, 47.5%), first aid (n = 213/470, 45.3%), blood-borne pathogen (n = 169/470, 35.9%), and HIPAA/ FERPA (n = 144/470, 30.6%) training. The ATSA was listed as a member of the emergency personnel team who practiced the emergency action plan infrequently (n = 64, 13.6%). Most of the participants followed best practice guidelines set forth by the profession for ATSA task allowance. Perceptions of ATSAs identified that SSATs with and without current ATSAs felt the experience promotes their ability to mentor/teach (with = 423/4701, 90.0%, without = 117/144, 81.3%), while not feeling like it devalued the profession (with = 17/470, 3.6%, without = 16/144,11.1%). In addition, participants without ATSAs stated the reason for not allowing these students in their clinical practice was due to time demands (n =57/144, 39.6%) and legal/ethical principles (n = 41/144, 28.5%). Conclusions: Although SSATs are following best practice recommendations for task allowance, whereby they are providing supervision to ATSAs. However, 100% compliance was not met, thus increasing risks to patients and the profession. SSATs should improve training and preparedness for the ATSAs involved in their clinical practice.

Table 1. Task Allowance Reported by the SSAT. Participants responded whether the ATSA could perform the task based on the headings. Data includes the frequency of task allowance. Bold, italicized data are the correct choice based on best practice recommendations.

		Only with	Not	Direct +	
	Autonomously	Direct	Permitted	Indirect	Missing
		Supervision	to Perform	Supervision	
Set up and break down of sideline	385, 81.9%	60, 12.8%	11, 2.3%	11, 2.3%	3, 0.6%
equipment	-		(00.00.00)		
Perform a concussion evaluation for	0, 0%	28, 6.0%	439, 93.4%	0, 0%	3, 0.6%
an athlete	EE 44 70/	404 40 6%	205 42 69/	40.040/	0.4.00/
Recognize an athlete with heat	55, 11.7%	191, 40.0%	205, 43.6%	10, 2.1%	9, 1.9%
Perform an orthopedic evaluation of	1 0 2%	5/ 11 5%	105 86 2%	0.0%	10 2 1%
an injured athlete	1, 0.270	54, 11.576	405, 00.270	0, 070	10, 2.170
Make and apply ice bags	223. 47.4%	201. 42.8%	26. 5.5%	18. 3.8%	2.0.4%
Tapa pap injured athletes for	65 12 9%	208 11 20/	190 29 20/	10 2 10/	7 1 5%
preventative measures prior to or	05, 15.076	200, 44.37	100, 30.37	10, 2.170	7, 1.576
during athletic activity					
Practice taping on other student	187. 39.8%	225. 47.9%	27. 5.7%	30, 6,4%	1.0.2%
aides	,	,		00,0170	.,/.
Hydration specialization	202, 43.0%	156, 33.2%	86, 18.3%	17, 3.6%	9, 1.9%
Clear an athlete to return to the	0, 0%	2, 0.4%	465, 98.9%	0, 0%	3, 0.6%
game after being hurt					
Tape an injured athlete's ankle	14, 3.0%	130, 27.7%	311, 66.2%	6, 1.3%	9, 1.9%
Make up rehabilitation exercises for	0,0%	111, 23.6%	348, 74.3%	1, 0.2%	9, 1.9%
an injured athlete					
Travel to away games	60, 12.8%	300, 63.8%	94, 20.0%	8, 1.7%	8, 1.7%
Stocking kits, taping tables, shelves,	285, 60.6%	123, 26.2%	26, 5.5%	32, 6.8%	4, 0.9%
etc.					
Give a student-athlete over the	2, 0.4%	21, 4.5%	443, 94.3%	0, 0%	4, 0.9%
counter (OTC) medicine					
Serve as "eyes and ears" at an	157, 33.4%	85, 18.1%	208, 44.3%	14, 3.0%	6, 1.3%
athletic event using a walkie-talkie to					
communicate to the ATC located at					
File patient records	62 13 2%	156 33 2%	240 51 1%	1 0 9%	8 1 7%
	02, 10.270	100, 00.270	270, 70.7%	4, 0.370	0, 1.770
Perform e-stim or ultrasound on an	2, 0.4%	90, 19.2%	370, 78.7%	1, 0.2%	7, 1.5%
Borform wound care (bandages	102 21 0%	249 52 9%	00 10 2%	25 5 20/	4 0 0%
stopping blood etc.)	103, 21.970	240, 32.07	90, 19.270	25, 5.576	4, 0.376
Stretching players	83, 17.7%	277, 58.9%	83, 17.4%	19, 4.0%	8, 1.7%
Talk to parents of an injured athlete	0.0%	5 1 1%	A62 08 3%	0.0%	3.0.6%
about their child's injury	0, 070	5, 1.176	402, 30.370	0, 070	5, 0.070
Interpret referrals from other	0, 0%	8, 1.7%	459, 97.7%	0, 0%	3, 0.6%
healthcare providers				-	
Enforcing athlete sign-in procedures	219, 46.6%	157, 32.1%	63, 13.4%	32, 6.8%	5, 1.1%
Enter injury data into an EMR	19, 4.0%	98, 20.9%	337, 71.7%	9, 1.9%	7, 1.5%
system					

Barriers and Facilitators of Implementing Emergency Action Plans in Oregon High Schools

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Context: Best practice recommendations suggest that schools have venue specific emergency action plans (EAPs) in place for sports related emergencies. Despite this call, previous studies have provided mixed results on EAP implementation. Athletic trainers (ATs) are well positioned to help schools develop and implement EAPs given their expertise in risk minimization and emergency preparedness. However, ATs' perceptions of what has helped and hindered their capacity to develop and implement EAPs in their school is unknown. **Objective:** Identify ATs' perceived barriers and facilitators to implementation of EAPs in their schools. Design: Cross-sectional. Setting: Online survey. Patients or Other Participants: High school ATs in Oregon identified by the Oregon ATs' Society (n = 113)were invited to participate. Fifty ATs fully completed the survey (response rate = 44%). Interventions: An online survey instrument was developed based on recommendations from the NATA position statement on emergency planning in athletics. ATs were asked to identify: 1) whether their school had an EAP, 2) if their school had athletic venue specific EAPs, 3) what had helped the school develop the EAP(s), and 4) if the school had an EAP, what challenges the school faced when developing their EAP(s). Main Outcome Measures: Point estimates and 95% confidence intervals for EAP implementation and barriers and facilitators to EAP development. Results: All but two schools, 96% (95% confidence interval 87-99%), had an EAP. Of the schools with an EAP, 88% (75-94%) reported also having venue specific EAPs. ATs at 40% (28-54%) of the schools reported no challenges in developing EAPs. For schools noting challenges implementing EAPs, 50% (33-67%) identified lack of trained personnel to develop the EAP and 47% (33-67%) reported the lack of perceived need for EAPs as primary barriers. Twenty-three percent (12-41%) noted other barriers including administrative issues. Of schools with an EAP, 81% (68-90%) said personnel with knowledge of how to develop EAPs helped, 54% (40-67%) noted templates of EAPs, and 50% (36-64%) stated an Oregon School Activities Association (OSAA) policy requiring an EAP facilitated development. Conclusions: The percentage of schools that reported EAP implementation was greater than previous studies - indicating positive steps in emergency preparedness. Of the ATs reporting challenges with EAP development, the primary barriers were lack of personnel to develop EAPs and lack of perceived need. When asked what has helped the school develop EAPs, the vast majority of ATs reported someone with knowledge of EAP development. Access to EAP templates and the OSAA EAP mandate were also noted as facilitators. Taken together, the results indicate the need to help schools identify trained personnel to develop the EAPs, continued education on the importance of EAPs, and resources such as EAP templates. State athletic association policy changes may also help schools develop EAPs.
A Novel Concussion Specific Patient Reported Outcome Measure

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Context: Variation in concussion symptomatology and recovery time necessitates a multi-faceted approach to concussion assessment and return to activity (RTA). One way to implement an evidence-based approach is through patient reported outcome measures (PROMs). PROMs allow patients to report the status of their injury from their perspective (e.g., emotional health). Currently there is no concussion specific PROM. **Objective:** To analyze the psychometric properties of a novel Concussion-Specific Patient Reported Outcome Measure (CS-PROM). Design: Survey. Setting: Division II University Athletic Training Room. Patients or Other Participants: Twenty-two concussed NCAA athletes from seven different sports (15 males, 7 females). Interventions: The novel CS-PROM was an author derived 13-item survey utilizing a 5-point Likert scale (0 = never, 5 = always). Questions were developed based off current concussion management best practice guidelines. These recommendations provide counsel on how to acquire further information regarding the athlete's perceived limitations with his/her social life, academics, emotional feelings, sleeping problems, and motor functions. Participants were administered three PROMs [CS-PROM, Hospital Anxiety and Depression Scale (HADS), Disablement in the Physically Active Scale (DPAS)] at initial evaluation, sign and symptom (s/s) free, and at RTA. Main Outcome Measures: A principal component analysis (PCA) was conducted with varimax rotation to identify primary components for interpretation, where eigenvalues >1 were retained.

Internal consistency was determined with Cronbach a, and concurrent validity was assessed with Pearson's correlations. Results: The Kaiser-Meyer-Olkin measure verified mediocre sampling (KMO = .639). Bartlett's test of sphericity $[x^2(91)]$ = 231.76, p < 0.000 indicated that correlations between items were suited for PCA. PCA indicated that a three-factor structure was present. All items had a factor loading >0.549, and were categorized into three categories: functional (school work, social life, activities of daily life), rest (need breaks, sleep schedule is off), or emotional (angrier, lonely). The Cronbach a score at each time point was >0.918. Fair correlations were identified between CS-PROM, HADS (0.468, p = 0.028), and DPAS (0.621, p = 0.003) total scores at initial assessment. Strong correlation was shown between CS-PROM and HADS anxiety total (0.877, p = 0.010) at RTA, but no correlations were found at s/s free. Conclusions: This study demonstrated the CS-PROM is a reliable and valid instrument to assess the athlete's perspective of his/her concussion recovery. The PCA provided three main constructs, where clinicians should be evaluating function, rest, and emotion. Currently, there are no tools to evaluate rest and emotional stability outside of reported s/s, fortunately, the CS-PROM fills that gap. The CS-PROM also alleviates the need to use multiple PROMs, and is able to obtain pertinent information to identify how the athlete is feeling during their recovery. This information aids athletic trainers' decision-making process to ensure the clinical objective measures are comparable to how the patient is feeling from his/her viewpoint so he/ she is physically and mentally prepared for RTA.

Brain White Matter Alterations Associated With a Single Season of Competitive Football: A Comparison of Youth and High School Football

Myer GD, Barber Foss KD, Diekfuss JA, Leach J, DiCesare C, Dudley J, Yuan W: Cincinnati Children's Hospital, Cincinnati, OH

Context: While there is speculation that vounger brains are more susceptible to head impacts exposure, this hypothesis has not been objectively tested. Given the positive physical and emotional benefits enjoyed by an estimated 1.2 million youth tackle football participants annually, it is imperative to characterize head impact-related changes in brain health at the youth level. **Objective:** The purpose of this study was to compare the white matter (WM) integrity and total head impacts of a cohort of youth football players (YFB) relative to varsity high school football players (HS) over the course of one competitive season. Design: Prospective cohort. Setting: One season of YFB (grades 7 & 8) and one season of HS football (grades 10-12). Patients or Other Participants: A total of 12 YFB $(13.08 \pm 0.64 \text{ years})$ and 21 HS $(17.5 \pm$ 0.78 years) athletes participated in this study. Interventions: Participants completed one magnetic resonance imaging (MRI) session before their competitive season (preseason) and one MRI session following their competitive season (postseason). During the season, head impact was recorded using the GForce Tracker[™] accelerometer device affixed to the inside of each football helmet. Main Outcome Measures: Differences in whole brain axial diffusivity (AD), a measure of WM integrity based on diffusion tensor imaging, and total impacts, between HS and YFB at preseason and postseason. Tract based spatial statistics (TBSS) were used to test significance of the pre- to post-season DTI change in the two study groups. Results: The HS group experienced significantly more total head impacts compared to the YFB group (p < .001).In high school football athletes, significant pre- to post-season AD reduction (p < 0.05, corrected) was found in extensive WM areas (Figure 1, red-yellow regions). The percentage of

AD reduction within these significant area WM areas in the HS group (2.43 \pm 1.01%) was significantly greater than the YFB group $(0.37 \pm 1.27\%, t = 5.13, df$ = 31, p < 0.0001). Significant pre- to post-season AD reduction was also found in the YFB group (p < 0.05, corrected) but was limited in size of the regions (Figure 1, blue-light blue regions). Within these areas, the percentage of AD reduction in the YFB group $(3.35 \pm 1.58\%)$ was significantly greater than the HS group $(0.50 \pm 2.84\%, t = 3.71, df = 31,p =$ 0.0008). Conclusions: Significant pre- to post-season AD reduction was found in both YFB and HS study groups following one football season of repetitive head impacts. Counter to what has been previously postulated the, increased susceptibility in youth was not found as the area of WM with significant AD reduction was greater in the HS group. However, the contrast of percentage of AD reduction between the two groups was different in different WM regions. Future studies with larger sample size are needed to investigate the age dependence (e.g. myelination) and region specific vulnerability of WM to head impact exposure in contact sports.



Figure 1: Based on the TBSS analyses, significant pre- to post-season AD reduction in white matter was found in both HS group (Ared-yellow regions) and the YFB group (B-bluelight blue regions), respectively. All statistical significance was tested at p<0.05 with multiple comparison error corrected using the threshold-free cluster enhancement method in TBSS. The regions with significant AD reduction in the HS group (red-yellow regions) include corpus callosum, anterior and posterior limb of internal capsule, corona radiata, posterior thalamic radiation, external capsule, cingulum, and superior longitudinal fasciculus. Within this region, the percentage of AD reduction in the HS group was significantly greatly than the AD alteration in the YFB group within the same regions (See text). The regions with significant AD reduction in the YFB group (blue-light blue) were relatively much more limited in size, involving only the anterior and superior corona radiate (C). Within the regions of overlap, the AD alterations in the YFB group was significantly greater than the HS group.

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Diagnostic Accuracy of Ocular Tests for Assessing Concussion Deficits

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Context: Ocular motor and visual deficits occur in up to 65% of concussion patients. Assessments such as near point of convergence (NPC), the King-Devick Test (KDT), and stereoacuity can be performed to identify these deficits and ensure a more appropriate course of rehabilitation. However, the diagnostic accuracy of these assessments have yet to be thoroughly investigated. **Objective:** The purpose of this study was to determine diagnostic accuracy for NPC, KDT, and stereoacuity tests in concussed athletes. Design: A multicenter cross-sectional design was utilized. The independent variable was group (control vs. concussed). The dependent variables were ocular test scores (NPC, KDT, and stereoacuity tests). Setting: Athletic training facility. Patients or Other Participants: Subjects were recruited from several collegiate athletic programs. In total, 34 healthy, non-concussed control athletes (21 male, 13 female; 19 + 1.5 years)and 19 concussed athletes (11 male, 8 female; 20.42 + 1.5 years; 4 + 3.5 days since injury) participated in the study. Interventions: Control athletes completed the ocular tests during pre-season baseline testing. Athletes who sustained a concussion during the season underwent ocular assessment in addition to their normal concussion assessment battery. A concussion was diagnosed by a health care professional through the use of a signs and symptoms scale, BESS testing, and ImPACT testing. Main Outcome Measures: Both clinical and statistical cutoffs for all three tests were first established. Based on these cutoffs, sensitivity, specificity, positive likelihood ratios (PLR) and negative likelihood ratios (NLR) were determined for each assessment. Furthermore, receiver operating characteristic curves were calculated to help

determine the diagnostic accuracy of these assessments from area under the curve (AUC). The alpha level was set at p < .05 for all analyses. **Results:** NPC demonstrated a clinical cutoff of 6.8 cm and a statistical cutoff of 5.5 cm, which provided a sensitivity of 79% and specificity of 76%, a PLR of 3.0 and NLR of 0.47, and an AUC of 0.827. For the KDT, a clinical cutoff of 52.6 s and a statistical cutoff time of 49.5 s demonstrated a sensitivity of 58% and specificity of 72%, a PLR of 4.3 and NLR of 0.60, with an AUC of 0.658. Lastly, stereopsis had a clinical cutoff of 41.6 arc sec and a statistical cutoff of 28.5 arc sec, which produced a sensitivity of 65% and specificity of 54%, a PLR of 2.6 and NLR of 0.80, with a maximum AUC of 0.706. Conclusions: NPC, KDT, and stereoacuity assessments are altered by concussion and may be useful tools in the management of a sport-related concussion. Through use of these ocular tools, certain symptoms commonly missed in concussed athletes may be identified and tracked through rehabilitation.

Concussion Risk in Athletes Who Are Deaf or Hard-of-Hearing Compared to Athletes Who Are Hearing

Brancaleone MB, Clifton DR, Onate JA, Boucher LC: The Ohio State University, Columbus, OH; Jameson Crane Sports Medicine Institute, Columbus, OH

Context: Individuals who are deaf or hard-of-hearing (D/HoH) participate in collegiate athletics, but no evidence exists regarding epidemiology of concussion in this population. **Objective:** Compare the risk of concussion between athletes who are D/HoH and athletes who are hearing. We hypothesize that concussion risk will be similar between groups. **Design:** Descriptive epidemiology study. Setting: Data were collected from two Division III athletic programs. One institution is the world's only university designed to be barrier-free for students who are D/ HoH. Patients or Other Participants: 693 athletes who are D/HoH and 1284 athletes who are hearing were included in this study. Athletes participated in collegiate varsity football, soccer, basketball, baseball or softball during the 2012-2013 to the 2016-2017 academic years. Interventions: Concussion data were provided by the athletic training staff at each institution. Main Outcome Measures: Concussion risk was calculated by school and sex for each sport individually, for all sports combined, and for sex comparable sports combined (i.e. soccer, basketball, baseball, and softball). Injury risk ratios (IRR) with 95% confidence intervals (CI) were used to compare concussion risk between athletes who are D/HoH and athletes who are hearing for all sports combined, football, and sex comparable sports. IRR with 95% CI also were used to compare concussion risk between athletes who are D/HoH and athletes who are hearing for each sport by sex. IRR with 95% CI not including 1.00 were considered statistically significant. Results: A total of 30 athletes who are D/HoH and 104 athletes who are hearing suffered concussions during the study period. When examining all sports, athletes who are hearing had an increased injury risk compared to athletes who are D/HoH (IRR = 1.87, 95%CI: 1.26, 2.78). When examining only football, athletes who are hearing also had an increased injury risk compared to athletes who are D/HoH (IRR = 3.30, 95% CI: 1.71, 6.37). No difference in concussion risk was found between athletes who are D/HoH and athletes who are hearing when examining sex comparable sports. Concussion risk was higher for male athletes who are hearing than male athletes who are D/ HoH (IRR = 2.84, 95% CI: 1.62, 4.97). Concussion risk did not differ between female athletes who are D/HoH and female athletes who are hearing. There was no difference in concussion risk between women's soccer athletes who are D/HoH and athletes who are hearing. Conclusions: Athletes who are D/HoH in sex comparable sports may not have a higher risk of concussion than athletes who are hearing. Risk of concussion in football may be greater among athletes who are hearing compared to athletes who are D/HoH.

Practice Effects of a Clinical Concussion Assessment Battery Over an Ice Hockey Season DiFabio MS, Breedlove KM, Oldham JR, Buckley TA: University of Delaware, Newark, DE; University of Wisconsin, Eau Claire, WI

Context: Concussion evaluation inherently requires repeat administration of clinical tests in order to track recovery from baseline; however, this repetition may result in practice effects, and thus not truly reflect an neurologic individual's function. The commonly administered SAC and BESS have established practice effects, however, less is known about practice effects of other commonly utilized clinical concussion assessments. **Objective:** To compare scores from a multifaceted clinical concussion assessment battery over the course of a competitive season. Design: Longitudinal Setting: University Patients or Other Participants: 11 male ice hockey athletes (Age: 21.4 ± 1.0 years, ht: 1.8 ± 0.06 m, wt: $80.2 \pm$ 7.5 kg, concussion history: 0.7 ± 1.1) Interventions: Each participant performed four assessments monthly, for seven months: King-Devick (KD), Trail Making A (TMT-A) and B (TMT-B), Clinical Reaction Time (CT), and Tandem Gait (TG). Each test was performed in accordance with standard instructions in compliance with manufacturer's recommendations and/or consensus guidelines. Main Outcome Measures: Scores on the KD, TMT-A, TMT-B, CT, and TG, which were performed monthly from September-March. The KD outcome was the fastest time of the two trials without any errors. The TMT-A and TMT-B outcomes were the time to complete each trial. The CT outcome was the fastest ruler catch time of 8 trials. The TG outcome was the fastest completion time of four trials. A repeated measures ANOVA, with simple contrast, was performed to identify changes relative to baseline/first test performance. Results: The KD had a significant effect for Time (F = 4.839,

p = 0.03) with changes from baseline (39.3 + 5.2 s) beginning in month 3 (36.0 + 5.0 s) and all subsequent administrations were also significantly faster than baseline (p < 0.05). TMT-A had a significant effect for time (F = 5.653, p < 0.001), with changes from baseline $(25.1 \pm 7.7 \text{ s})$ beginning in month 4 $(17.2 \pm 3.5 \text{ s})$ and all subsequent administrations were also significantly faster than baseline (p < 0.05). TMT-B had a significant effect for time (F = 12.973, p < 0.001), with changes from baseline $(45.2 \pm 10.4 \text{ s})$ beginning in month 3 $(34.5 \pm 8.3 \text{ s})$ and all subsequent administrations were also significantly faster than baseline (p < 0.05). CT had a significant effect for time (F = 4.667, p = 0.024), with changes from baseline $(208.4 \pm 17.1 \text{ ms})$ beginning at month 3 (192.5 \pm 14.5 ms) and all subsequent administrations were also significantly faster than baseline (p < 0.05). TG had a significant effect for time (F = 4.90, p = 0.001), with changes from baseline $(10.5 \pm 1.5 \text{ s})$ beginning at month 6 (8.3 \pm 1.3 s); all subsequent administrations were also significantly better than baseline (p < 0.05). **Conclusions:** Repeat administration of these assessments resulted in a clear practice effect, with most showing practice effects beginning as early as 3 repeated administrations, despite there being a full month in between testing sessions. Clinicians should be aware that these commonly utilized concussion clinical tests show an early practice effect which may limit their clinical utility, thus reinforcing the recommendation for concussion to be a clinical diagnosis supported by objective neurological measures.

Free Communications, Rapid Fire Oral Presentations: Caring for the Football Athlete: Case Reports

Friday, June 29, 2018, 2:30PM-3:30PM, Room 220-222; Moderator: Rod Walters, DA, ATC

Epididymal Hematoma in a High School Football Player: A Level 4 Rare Events Case Study Rolow JM, Guerrero MJ, Snyder

MM: Western Carolina University, Cullowhee, NC; Garner Magnet High School, Garner, NC

Background: The patient was a 17 year-old male, high school football player that initially complained of right testicular pain. He reported to the athletic training student that his right testicle was bothering him after he was hit at practice the day before; patient reported MOI as being, "struck by someone's swinging hand at football practice." He was unable to practice because the pain increased with any movement. There was no past medical history to cause concern. The patient denied any hematuria and pain was in the lower abdomen along with the scrotum. The patient admitted to significant swelling of the right testicle and immense pain (quotient of 10/10). Differential Diagnosis: Differential diagnosis included the following: ruptured testicle, testicular torsion, testicular contusion, epididymitis, testicular fracture, testicular dislocation, and epididymal hematoma. Treatment: Patient was referred to his primary doctor at once for an evaluation. The patient was immediately referred to a local emergency room and imaging center for a diagnostic ultrasound due to the amount of increased swelling in the scrotum. The ultrasound showed enough swelling to suspect a rupture of the left testicle. The patient was transported to the nearest level 1 trauma center for scrotal exploration and repair of testicle. The patient was told there was a possibility of loss or decrease in function of testicle as well as possible orchiectomy (removal of a testicle). During the procedure, the surgeon drained the scrotum and found that the testicle was not ruptured; the injury was diagnosed as an epididymal hematoma in the inferior right pole. The patient was placed on oxycodone and ibuprofen to control pain and inflammation. The patient was on bed rest for the first week, icing every hour for 20 minutes. A jock strap with gauze was prescribed to be worn 24 hours a day for 3 week, except when showering. No other treatments were necessary and the patient returned to sport with no limitations after three weeks. Uniqueness: A single institutional review of a pediatric trauma registry stated that the incidence of testicular traumatic injuries was 0.1%, and only a quarter of those occurred secondary to sports participation. Results from a different retrospective research study indicated that early surgical intervention improved outcomes with testicular ruptures, severe scrotal hematoceles, severe intratesticular hematomas, and testicular torsions; surgery has no effect (positive or negative) with other injuries. Many testicular injuries are avoided with proper protection; however, the usage of genital protective equipment remains infrequent among young male athletes, even in high-risk sports. Conclusions: An epididymal hematoma is one of the many conditions that can arise from direct trauma to the testicle, if left untreated patients have a much high risk of having an orchiectomy, which is the removal of one or both testicles. Testicular injuries can occur easily without proper protection and that's why it is important that Athletic Trainers discuss the importance of personal protective equipment with their patients.

Acute Myositis Ossificans of a Division One Football Player: A Case Report

Rouah B, Joseph C: University of Central Florida, Orlando, FL

Background: The subject is a 22 y/o Division one football running back who sustained a left quadriceps contusion during the spring football game. He reported to the athletic training room (ATR) 21 days after the injury occurred, complaining of pain and soreness of his left proximal anterolateral thigh. The athlete was ambulatory without an antalgic gait. The athlete explained he attempted to work out in the days prior but had difficulty and pain doing so. Upon evaluation, a palpable mass was noted over the vastus lateralis muscle. There was a decrease in knee flexion range of motion (ROM) when compared bilaterally (90° compared to 130°). The athlete had no previous history of a quadriceps injury. It was also noted that the athlete's father developed myositis ossificans following hip replacement surgery in 2014. Differential Diagnosis: Quadriceps contusion, quadriceps strain, proximal quadriceps tendon strain, myositis ossificans. Treatment: After the initial evaluation, the athlete was diagnosed with a quadriceps contusion. He was treated conservatively with ROM exercises and therapeutic ultrasound. The athlete progressed well, increasing ROM while on a stationary bike. Seven days post diagnosis, the athlete returned to the ATR complaining of increased pain and decreased ROM. He was referred to the team orthopedist for further evaluation. X-ray imaging revealed a bony formation within the vastus lateralis muscle. This diagnosis was then confirmed via bone scan and CT imaging. The athlete was instructed to be non-weight bearing (NWB) and was started on Indomethacin (75 mg extended release, Q.D.) for one week. He was treated with ice multiple times a day. Following 7 days NWB, the athlete began ROM exercises and progressed while asymptomatic. The athlete was consistent with therapeutic ultrasound, GameReady treatment and ROM exercises. Ultimately, the athlete was medically disgualified 3 months post diagnosis due to the continued growth of the lesion and the nature of his position. Additionally, the athlete was in his final year of eligibility and the timing of the injury would have required that he miss the upcoming season. Uniqueness: Myositis ossificans occurs because of direct trauma and is likely associated with athletes of high contact sports and motor vehicle accidents. Roughly 20% of hematomas develop a complication and result in ossification within the muscle tissue. The average age of occurrence of myositis ossificans is between 20-40 years old. Lesions may resolve on their own if the muscle belly is the affected area. However, areas of muscle origin or insertion may cause functional deficits and be less likely to resolve. In this case, the lesion was located in the musculotendinous junction of the vastus lateralis muscle. Treatment options range from prescription medication to surgery, including post-surgical radiation. To allow for a surgical option, the lesion must completely mature and ossify. Even if the lesion is ossified, the risk of recurrence is roughly 67%. Conclusions: The athlete declined surgery due to the rate of recurrence and invasiveness of the procedure. Once diagnosed with myositis ossifcans, the athlete was treated with therapeutic ultrasound and Indomethacin (75 mg extended release Q.D.). The athlete progressed and increased ROM for six days without set back. The following week, he presented in considerable pain and with decreased ROM. At this point, it was important to limit motion and activity of the quadriceps muscle to reduce muscle calcification. The athlete has since regained full range of motion and has no limitations in ADL's. The risk of further muscle damage, timing of the injury and remaining eligibility was the reason for his disgualification. It is unknown, whether there is a congenital correlation that increased the athlete's likelihood of ossification. This area will require more research.

Post Compartment Syndrome Affects in a College Football Athlete

O'Neal-Belmont BJ, Felton SD, Craddock JC, Desmarteau TJ: Florida Gulf Coast University, Fort Myers, FL; Webber International University, Babson Park, FL

Background: Athlete was an 18-yearold freshman, 172.72 cm, 78 kg, male, NAIA football athlete. This athlete had a prior medical history of Acute Compartment Syndrome of his right quadriceps muscle approximately two years ago. The Compartment Syndrome was relieved through surgery shortly after the athlete experienced direct trauma to the muscle belly. Athlete completed his original rehabilitation prior to coming to the institution with no limitations or noted complications. Athlete reported to the athletic training room after weight lifting and complained of a sharp pain in his superior quadriceps muscle. He stated that he felt a pop and instant pain. Athlete does have a previous history of the calcified areas popping and releasing, which caused the athlete sever pain. In the weight room the athlete stated that when he felt the calcified tissue release he was descending into a split squat. The release was felt in the leading leg. Athlete has full Active ROM with pain due to the area being sore from the top calcified scar tissue being released. There was a clean palpable divot where it was released and it was evident that he did not tear his muscle because the edges were smooth and there was no drop off. There was also a sense of relief that followed the initial sharp pain after the scar tissue was released. Athlete had tight musculature that surrounded the quadriceps muscle group as well as the Adductor and Hamstring muscle groups. Along the scar of the incision the athlete had built up scar tissue that caused him pain. When athlete came into the Athletic Training room he was also evaluated by the head athletic trainer who confirmed that the musculature was not torn and that the calcified scar

tissue just released. Athlete's strength was tested in order to see if there were any deficits, which there were none. Differential Diagnosis: Calcified scar tissue released or torn quadriceps muscle Treatment: The athlete has begun conservative treatment in the process to diminish the calcified scar tissue. With the use of modalities such as the hydrocollator heat pack in the superior region of the quadriceps muscle and the use of ultrasound at 1MHz for 7 minutes with the warming head on and at an intensity of 2.0 watts/cm2. This was done in the attempt to heat up the scar tissue that surrounded the incision, which began to break down the buildup. We performed the ultrasound on either side of the incision scar to tackle both areas in need. To work on the athlete's flexion an Ace bandage was used in conjunction to force the athletes knee back into flexion. In order to work on the athletes tight surrounding musculature stretching techniques for both the quadriceps and hamstring muscle groups were done. Uniqueness: Compartment syndrome alone is a very unique injury that is not seen all the time and commonly misinterpreted initially as just a contusion. In this case the injury presented was from the post-surgical calcified buildup of scar tissue releasing. In this situation the athlete is completely rehabbed from the original Compartment Syndrome injury, but the calcified scar tissue has created pain for this athlete. Conclusions: This case study would be considered a Level 4: Rare Event Case Report and it highlighted the treatment of an athlete who suffered from Compartment Syndrome post-surgical calcium buildups that caused the athlete moderate pain. This was a single case review that followed the recovery and breakdown of the scar tissue.

Medical Disqualification of a Division I Football Player Chiu R, Warne A, Joseph C: University of Central Florida, Orlando, FL

Background: The athlete is a 19 year old, African American, male Division I football player. Both of his parents and his sister have Sickle Cell Trait. He played football through high school and noted previous physicians have cleared him for participation in sports. He had one hospital visit for idiopathic leg pain and dehydration at age 14 and was treated with intravenous fluids. During his Pre-Participation Examination at the University of Central Florida, he reported that he has sickle cell trait and tested positive on a Hemoglobin Solubility Test. A Hemoglobin Electrophoresis was ordered by the team physician, and the patient was not cleared pending his electrophoresis results. A few days later, he experienced unexplained lower leg pain after workouts on his own and admitted himself to a nearby hospital. Differential Diagnosis: Different forms of Sickle Cell Anemia (hemoglobin SS, SC, beta thalassemia), exertional rhabdomyolysis, deep vein thrombosis, musculoskeletal injury. Treatment: Lower leg x-rays at the hospital were negative for a fracture. He was later discharged from the hospital and instructed to follow up with his primary care physician. The Hemoglobin Electrophoresis revealed a hemoglobin concentration consistent with Hemoglobin SC Disease. The electrophoresis results revealed 48.8% of hemoglobin S, 45.3% of hemoglobin C, and 0% of hemoglobin A. The reference intervals for hemoglobin A should be between 94-98%, while both hemoglobin S and C levels are 0%, in individuals without a hemoglobinapthy. The high and approximately equal levels of hemoglobin S and C confirmed the diagnosis of Hemoglobin SC Disease. Symptoms and potential complications of Hemoglobin SC Disease are less severe than Sickle Cell Anemia, but more severe than Sickle Cell Trait.

The sickling nature of Hemoglobin SC Disease is almost four times faster than those with Sickle Cell Trait. Due to the life threatening potential of this disease, this student athlete was medically disqualified from participation in sports. He was then referred to a Hematologist for further recommendations, including possibility of hydroxyurea or folic acid treatment. Uniqueness: Both hemoglobin S and C genes are more prevalent in people of African, Caribbean, and South American descent and in much less frequency in individuals of Mediterranean and Middle Eastern descent. There are approximately 8-10% of African Americans in the United States who carry a hemoglobin S gene and about a 2-3% who carry the hemoglobin C gene. There are only an estimated .05% of African Americans in the US who carry both the hemoglobin S and C genes. This case is more unlikely because of the success our student athlete has achieved in becoming a three star collegiate recruit on a full scholarship. Conclusions: Hemoglobin SC Disease is a hemoglobinopathy that causes symptoms similar to those of Sickle Cell Anemia, but usually less severe. If an episode does occur, the rapid sickling nature of the disease poses a life threatening risk. On August 1, 2010, the National Collegiate Athletic (NCAA) Association implemented genetic screenings for all division I student athletes. Despite this policy, student athletes may sign a waiver declining confirmation of sickle cell status if he or she is provided education regarding the implications of exercising the waiver option. The Athletic Trainer and the NCAA should require all student athletes to go through a hemoglobin solubility test as part of their Pre-Participation Examination. If tested positive, a Hemoglobin Electrophoresis must be completed before clearance to participate. Student athletes should not be allowed to sign a waiver to opt out of sickle cell screening.

Traumatic Bilateral Patellar Tendon Rupture in a Collegiate Football Player

Bramblett JC, King A, Thrasher AB: Western Carolina University, Cullowhee, NC; North Carolina State University, Raleigh, NC

Background: The patient was a 22-yearold male (175 cm, 88.5 kg) NCAA Division I collegiate football running back that suffered a bilateral patellar tendon rupture during a game. Patient was tackled by the facemask and back of the jersey, and landed on his knees in a hyperflexed position. The patient immediately grabbed his knees and reported feeling a pop in both knees. There was no obvious deformity of the right knee but the left knee had obvious deformity. Motor function and distal pulse were within normal limits. Patient has no prior history of patellar tendinopathies or steroid use. Differential Diagnosis: Differential diagnosis included a rupture of the patellar tendons, tibiofemoral dislocation, anterior cruciate ligament tear, posterior cruciate ligament tear, and medial collateral ligament tear. Treatment: After on-field evaluation by the team physician, the left knee was placed into extension, reducing the deformity then the athlete was transported for imaging. He was then admitted to the hospital where he was taken for x-rays and an MRI, which showed the bilateral patellar tendon rupture. The day after his injury, he underwent surgical reconstruction of both patellar tendons. In the operating room, the patient was placed supine and placed under general anesthesia along with an abductor nerve block and thigh high tourniquets. While in surgery the physician observed that both tendons were torn from the distal pole of the patella as well as extensive medial and lateral retinacular tears to posterior medial and lateral corners. The knee was placed into full extension and the proximal stump was approximated to the distal pole of the patella. Medial and lateral retinacular tears were repaired. Approximation of the tears were good. Once the operation was completed, sterile dressing was place on both knees along with an ace wrap and polar care devices. The patient was placed in hinged braces and locked in full extension and transferred to a recovery room. The patient was locked into full extension for three weeks but was able to be unlocked for passive knee flexion and extension initially to 40 degrees. The rehabilitation for this patient is following a protocol developed by the University of Wisconsin Health Sports Rehabilitation. Phase I of this protocol includes passive range of motion (ROM) and isometric strengthening. Patient is weight bearing as tolerated with crutches. Phase II involves gait progression and increasing ROM to 90 degrees of knee flexion without active quadriceps action. Phase III includes increasing ROM, light closed kinetic chain exercises, and normalizing gait. Phase IV includes gaining full ROM, strengthening exercises, and progressing to functional exercises. Phase V involves sport specific and proprioception activities. At this time, the patient has progressed from a wheel chair to walking on crutches while still in the hinged braces and is in Phase I of the rehabilitation protocol. Uniqueness: While patellar tendon ruptures are not uncommon, bilateral simultaneous patellar tendon rupture is very rare. The majority of cases occur with predisposing conditions, such as systemic diseases (e.g., rheumatoid arthritits, lupus), patellar tendinopathy, or history of corticosteroid use. This patient did not have any predisposing factors. The incidence rate for patellar tendon ruptures is approximately 0.68%; however, there were only 50 bilateral cases in a review of the English and German literature without predisposing factors. Conclusions: Bilateral patellar tendon rupture is very rare and there are few documented cases. Due to low incidence rate, bilateral ruptures may be misdiagnosed. Athletic trainers should be aware of the possibility of this injury and predisposing factors. Athletic trainers should also be prepared to provide immediate care, post-operative treatment, and rehabilitation to ensure optimal recovery and return to play.

Leg Pain in a High School Football Athlete Terhune W, Mills H, Yonz C: University of Kentucky, Lexington, KY; Woodford County High School, Versailles, KY

Background: The athlete is a 16 year old male football athlete playing receiver/linebacker. He has no significant medical history. He presented to the athletic trainer with an obvious deformity about the knee after sustaining an impact from an opposing player when making a catch **Differential Diagnosis:** Ligament sprain, tibiofemoral dislocation, distal femur fracture Treatment: While making a catch the athlete was hit by an opposing player causing immediate pain and deformity. As the athletic trainer approached the athlete the deformity was obvious and noted immediately. The athlete's tights and uniform were cut away from the area to expose the deformity. At this time the distal capillary refill was confirmed. It was noted that the knee appeared deformed. The sports medicine orthopedic physician was called onto the field at this time. It was assessed that the athlete had a dislocated knee. The physician stated that EMS needed to be activated. While this was being done, the physician attempted to reduce the tibiofemoral joint. The physician was unable to reduce the deformity at that time. EMS was on site and able to immediately transfer the for further evaluation and treatment. With the initial diagnosis of tibiofemoral dislocation, time was of the essence to provide proper treatment to rule out and or treat a possible vascular injury. Upon review of radiographs, it was discovered that the athlete had a distal femur fracture involving the growth plate that was diagnosed as a Salter-Harris II fracture. The athlete was sedated and a closed reduction was performed. He was them placed into a splint. He underwent an open reduction with internal fixation of the right supracondylar distal femur the next day. One plate and eight screws

were used to reduce the fracture into the proper alignment. Post-operative treatment consisted of non-weight bearing in a long leg hinged brace. The athlete was to perform range of motion as tolerated. He was seen two weeks post-op by the PA. Rehabilitation consisted of wound check at ten days. Twelve days post op the athlete began passive range of motion. At his follow up with the PA his AROM was 0-80. He was told to continue rehabilitation and follow up in one month. At his two month follow up his motion had returned to normal limits. He was then allowed to begin partial weight bearing. As of this writing, the athlete was seen for his three month follow up by his surgeon. His fracture is radiographically united. His physis (distal femoral and proximal tibial) have fused bilaterally with no leg length discrepancy. He was cleared to begin strengthening as tolerated. He is full weight bearing at this time. He has no complaints at this time. Uniqueness: Distal femoral fractures only comprise 6% of all femur fractures. Of that 6% less than half (40%) occur in patients below the age of 40 (Link and Babst 2012). Salter-Harris II fractures are the most common fracture when dealing with distal femur fractures (Eid AM, Hafez MA 2002). Physeal closure is the most prevalent complication associated with surgical intervention of the Salter-Harris II. The small number of femur fractures also made this case unique. Conclusions: The injury allowed the medical staff make full use of its capabilities from on field management through to surgery and rehabilitation. The fact that this athlete was able to recover with minimal setbacks is a testament to the surgical skill of the surgeon as well as the athlete being complaint and working under the direction of his athletic training staff.

Free Communications, Rapid Fire Oral Presentations: Caring for the Baseball Athlete: Case Reports

Friday, June 29, 2018, 3:45PM-4:45PM, Room 220-222; Moderator: Rod Harter, PhD, ATC, FNATA

Neurological Deficits in the Upper Quarter Screening Reveals Papillary Thyroid Carcinoma in a Collegiate Baseball Player: A Case Report Gooding TM, Goodale AC, Charles-Liscombe RS: Mount St. Joseph University, Cincinnati, OH

Background: 21-year-old male NCAA Division III baseball pitcher reported to the athletic trainer complaining of insidious "burning pain" and soreness in left shoulder and flank. Initial examination revealed limited shoulder ROM, tenderness along left neck and shoulder, and altered C5-C8 myotomes and C5 dermatome. Patient received two days of treatments consisting of manual therapy and cryotherapy allowing brief alleviation of symptoms. Without significant improvement, he was referred to the team physician for evaluation. Differential Diagnosis: Cervical disc pathology, intervertebral stenosis, thoracic outlet syndrome, brachial plexus neuropathy, peripheral nerve injury, tumor. Treatment: The team physician's findings were consistent with the initial evaluation, with the addition of axillary nerve paresthesia. Upper extremity strength was normal; Spurling's and Empty Can special tests were positive. Two weeks after initial presentation, an MRI revealed a partially visible cervical mass (3.4x1.8cm) along the right (contralateral) side of the neck. The patient was referred to an otolaryngologist for subsequent evaluation and care. CT imaging revealed three masses along right aspect of neck (2.7x1.8cm, 3.8x1cm, and 2x2.1cm,) along with calcification of the right thyroid lobe. Fine needle aspiration (FNA) confirmed stage 3 metastatic papillary thyroid carcinoma (PTC). At seven weeks, a total thyroidectomy was performed removing a 5cm nodule, and a modified right radial neck dissection removed 53 suspicious lymph nodes, of which 20 were positive. Post operatively, patient began

taking calcium supplements (1000 mg daily) and Cytomel (25 mcg/d) returning to normal ADLs as permitted. At eight-weeks post surgery, an atypical lymph node (1.3 cm) in the left neck was identified. FNA again confirmed PTC. A second procedure of the left neck removed 29 (3 positive) lymph nodes, including one from the superior mediastinum. During the subsequent recovery period, the patient began experiencing a globus sensation in the larynx during moderate cardiovascular activity. The patient discontinued Cvtomel and underwent radioactive iodine therapy (RAI). Following RAI, patient began taking synthroid (200 mcg/d) and resumed normal conditioning and throwing, with restrictions on heavy lifting. Ten months post-surgery, the athlete continued experiencing the globus sensation during conditioning. The otolaryngologist ordered videostroboscopy and blood work to confirm suspected vocal chord dysfunction (VCD) and rule out Non-Hodgkin's Lymphoma. Training restrictions were altered to halt activity whenever the sensation occurred. Athlete is currently undergoing speech and breathing therapy for VCD and hopes to be cleared for the spring baseball season at his 12-month follow up. Uniqueness: Rarely seen in sports medicine, papillary thyroid cancer occurs three times as often in women than in men and is the most common (90%) of all thyroid malignancy occurring in 14 per 100,000 people in the United States. Common symptoms include masses or pain in the neck, vocal changes, and difficulty breathing and/or swallowing. There is significant risk of locoregional reoccurrence in patients ages 15 -35 years old, with reduced survival rate at 1 and 5 years for stage 3 and 4 tumors. The patient's neck girth inhibited detection of lateral neck masses and no prior symptoms were present. In this case, initial radiographic findings revealed masses on the contralateral side from symptoms reported in the left shoulder

and flank. Development of VCD and recurrent laryngeal nerve dysfunction are known complication following resection of these tumors. Conclusions: In overhead athletic populations, idiopathic complaints of pain and altered motor function in the upper quarter and cervical region that do not respond to treatment warrant increased suspicion for conditions such as cancer. Athletic trainers should be familiar with possible complications following radiation and lymphadenectomy as it influences patients' ability to engage in vigorous physical activity and return to sport. Athletic trainers should assist patients in monitoring for cancer recurrence.

Osteochondral Allograft Transplantation in a Professional Baseball Player: Surgical Treatment and Return to Play Outcomes

VanValkenburg C, DePhillipo NN, Martin BM, LaPrade RF: The Steadman Clinic, Vail, CO; The Steadman Philippon Research Institute, Vail, CO

Background: A 28-year-old professional baseball player presented with a chief complaint of anterior and medial knee pain and persistent effusions during activity. Conservative treatment including: rest, ice and NSAIDs provided no relief. The patient had a prior history of a chondral defect in his right knee and underwent two previous surgeries; first was a microfracture procedure and second was an autologous chondrocyte implantation. These procedures provided intermittent relief but ultimately failed to relieve the patient's symptoms. He also received two platelet-rich plasma and hyaluronic acid injections that did not alleviate his knee pain and reoccurring effusions. Differential Diagnosis: Clinically, cartilage defects in the knee present with vague symptoms of an unknown origin and persistent swelling which can mimic other common knee pathologies and make diagnosis difficult. Anterior knee pain and recurrent effusions can also be associated with patellar tendinopathy, patellofemoral pain syndrome, or pes anserine bursitis. In the youth population, these symptoms are typically associated with Osgood Schlatter's or Sinding Larsson Johannson disease. IT-band friction syndrome can also present with similar symptoms in the knee. Treatment: The patient presented to our office with the above mentioned complaints; after a benign knee examination, the treating surgeon performed a diagnostic knee arthroscopy to evaluate the cartilage defect and find the source of the patients continued knee swelling. A full-thickness chondral defect of the medial femoral condyle was identified and a planned procedure was performed two months later which consisted of a right knee fresh osteochondral allograft transplantation surgery (OATS) to address the full thickness cartilage defect with a concomitant proximal tibial osteotomy to address the patient's varus knee alignment. The patient's pain and swelling may have persisted following the two previous cartilage procedures due to the large size of his cartilage defect. At twelve months postoperatively, the patient was pain-free without any swelling; post-operative joint line measurements were 42.5 cm on the uninjured and 45 cm on the injured knee, and 12 months post-operatively measurements were 43 cm bilaterally. He reported a satisfaction of 10/10 and improvements in all subjective outcome scores including IKDC score from 63.2 to 87.3, Tegner 2 to 10, WOMAC pain 7 to 0, and Lysholm 51 to 100 from preoperative to postoperative, respectively. His strength was symmetric in knee extension, knee flexion, and hip abduction compared to his contralateral limb during hand-held dynamometer testing. Twelve months after the procedure he was cleared to return to sport (RTS) with no restrictions. Uniqueness: This case report describes a successful outcome and RTS following a combined OATS and proximal tibial osteotomy procedure in a professional baseball player who returned to the same level of competition prior to surgery. Allied health care professionals should be educated on the various surgical treatment options for chondral lesions due to the increase in injury incidence amongst recreational and competitive athletes. Chondral injuries remain a challenging injury to treat; despite long recovery periods, providers should consider OATS in athletes with large chondral defects that do not respond to conservative treatment as RTS in elite levels can be achieved postoperatively. Conclusions: ATCs should rule out chondral injury in competitive athletes who present with persistent anterior knee pain and swelling that does not respond to conservative treatment. If diagnosed quickly, ATCs can assist in improving patient-reported outcomes and RTS, as research has reported improved outcomes in patients with less than one year of pain.

Diabetic Shock in a Collegiate Baseball Player

Smith R, Combs J, Wallace JS: Youngstown State University, Youngstown, OH

Background: Diabetic Shock, or insulin reaction, is a consequence of too much insulin within the body system. Too much insulin results in hypoglycemia and can result in a life threatening medical emergency. Athletes with diabetes can experience complications and athletic trainers (AT) may have to respond to stressful situations should complications arise. Patient: A 19 year old male utility player for a Division I baseball program experienced a life threatening, diabetic shock emergency following a fall practice. The athlete was diagnosed with Type I Diabetes at age two and had been playing baseball with no previous complications. The AT was aware of this athlete's medical condition and actively monitored the athlete's activity level. The diabetic emergency that occurred was unexpected and in this instance, the athlete went into a seizure state and was briefly unable to breath. Fear and panic caused the athlete to hyperventilate and go into shock. The AT instructed the athlete to place his hands over his head and try to control his breathing. The AT tried to calm him down so he would be able to communicate what was wrong. The athlete complained of fatigue, weakness throughout his entire body, nausea, shakiness, dizziness and light-headedness. Due to the severity of the situation, the AT contacted local EMS and had him transported to the hospital. The initial diagnosis was hypoglycemia. Intervention or Treatment: The patient was monitored by physicians at the hospital over the next 3 days. Once released from the hospital, the athlete reported to the athletic training room daily over the next 9 months to monitor insulin and sugar levels. The athlete was set up with a proper meal plan that included daily food and liquids intake. Because the athlete had Type I Diabetes, he was already using an insulin pump.

The athlete and AT worked together to regularly check and adjust his blood sugar levels at practices and games. The athlete was required to check his blood sugar every 30 minutes leading up to game time and in between each full inning. The AT was prepared with snacks and liquids to help replenish the athlete if necessary. Outcomes or **Other Comparisons:** The patient was diagnosed with diabetic shock. Diabetic shock can be a life threatening emergency if not treated immediately. Diabetic shock has been known to lead to diabetic coma, brain damage, and even death. Annually, there are approximately 14 million medical emergencies reported to the hospital that lead to diabetic diagnoses. Of those 14 million, roughly 76,000 mortalities occur annually due to diabetic complications. Although the athlete had been diagnosed with Type I Diabetes during his childhood, he had never experienced a complication this serious before. Similarly, the AT had never worked with an athlete that had a severe diabetic complication. This event led the athlete and AT to refresh their diabetes knowledge and prepare for a future diabetic emergency. Conclusions: Diabetic shock is a rare occurrence in athletic populations. The athlete was able to recover from this life threatening situation and able to compete two weeks later. The physicians and AT were able to manage this athlete's diabetic emergency and reassure him that this type of situation could be prevented in the future. Clinical Bottom Line: Diabetes in athletes can be something that is often over looked by an AT. Also, the student-athlete lifestyle often leaves athletes pressed for time and makes it a challenge to eat and consume fluids on a regulated basis. ATs and sports medicine clinicians should always be prepared for a diabetic emergency and it is recommended that the AT and athlete work together to develop a plan.

UCL Tear in a Minor League Baseball Athlete

Morello AE, Felton SD, Craddock JC, Dietze C: Florida Gulf Coast University, Fort Myers, FL; Minnesota Twins, Fort Myers, FL

Background: This was a Level 3 case study focused on the diagnosis, treatment, and impending recovery of a baseball athlete with a UCL tear. UCL tears are common in professional and minor league baseball athletes. Evidence has indicated that the incidence of UCL tears varies depending strongly on biomechanics, however the incidence of radiocapitellar overload syndrome (RCOS) as a precursor to UCL tears is not well recorded. Research suggests that insufficient healing or laxity of UCL results in elbow instability, which increases valgus stress and compressive forces on the secondary stabilizer, radiocapitellar joint. Patient: Athlete was a 24 year-old (195.58 cm, 99.79 kg) male MiLB baseball pitcher. Athlete's previous history included right RCOS that occurred the year prior to UCL injury. Athlete reported to athletic trainer after workouts with a chief complaint of right medial elbow pain and explained symptoms began the Sunday prior from a single pitch that went unreported at TOI. While he played catch the same afternoon, the symptoms remained. No symptoms noted with non-baseball activities. Athlete was point tender over medial joint line, UCL and pronator teres. Both AROM and PROM were full with supination, pronation, elbow flexion, and extension when compared bilaterally. When strength was tested, there were no significant deficits noted in the affected arm, however symptoms increased with resisted wrist flexion and pronation. During special testing all tests on the left were negative, however on the right there was (-) Bounce test, (-) Tinnel sign, (+) Valgus, and (+) Milk test. There were no neurological or vascular symptoms noted. Differential diagnoses included right UCL injury and right flexor/pronator strain. Intervention or Treatment: Athlete received UCL reconstruction surgery the week following injury report. The left gracilis was the choice for tendon graft and he also received a bone marrow aspirate injection.

Procedure determined that UCL was open to valgus stress at 30 degrees and full extension. Phase I of rehabilitation, 0-3 weeks post-surgery, was geared towards protecting the area, decreasing pain, inflammation, and gradually regaining AROM with help from a brace. Phase II of rehabilitation, 3-8 weeks post-surgery, the athlete was on schedule to gradually increase ROM to regain full range of motion by approximately 4-6 weeks post-surgery. During Phase II the athlete also was taken through rehabilitation to promote healing and regain and improve muscular strength with therapeutic exercises. Phase III of the athlete's rehabilitation program, weeks 8-19 post-surgery, was aimed towards advanced strengthening. The goals were to increase strength and endurance of shoulder, scapula, and elbow. In Phase IV, 20-53 weeks post-surgery, return to play was initiated by the introduction of an interval throwing program. At about 6 month post-operation during Phase V, athlete will start the interval throwing program on the mound. At different points in this phase athlete will start throwing different styles of pitches depending on progression. **Outcomes or Other Comparisons:** Athlete is still rehabilitating his arm back to activity from UCL reconstruction. Conclusions: This was a Level 3 exploration case with concentration on the diagnosis, treatment, and forthcoming return of an athlete with a UCL tear preceded by RCOS. This case highlighted the approaching success of UCL reconstructive surgery. This case provides as an instance of the uncommon, poorly documented precursor to UCL injury, RCOS. This instance further illustrates the complexities of treatment of the upper extremity, particularly the elbow, in baseball athletes. After UCL reconstruction, the rehabilitation of the elbow remains the same as the typical presentation, however, it is important to monitor the radiocapitellar joint once the athlete starts their throwing program. Evidence supports that RCOS suggests UCL dysfunction. Clinical Bottom Line: Radiocapitellar overload syndrome may manifest as a precursor to UCL injury.

Acute Management of an Abductor Digiti Minimi Strain in a Collegiate Baseball Player: A Case Study

Rediger T, Warner BJ, Gallegos DM, Mesman DL, Cage SA: The University of Texas, Tyler, TX; Christus Trinity Mother Frances, Tyler, TX; Grand Canyon University, Phoenix, AZ; The University of North Carolina, Greensboro, NC; The University of Texas, San Antonio, TX

Background: A 22-year-old collegiate baseball shortstop reported to the athletic training staff complaining of sharp pain along the medial aspect of the hypothenar eminence of his right hand. Patient reported initial pain when he attempted to hit a pitch that was higher than he anticipated. Initial onset of pain was accompanied by a sensation of the surrounding musculature "tightening". The patient reported previous surgical excision of a fractured hook of the hamate in the same hand. Patient history also revealed a triangular fibrocartilage complex irritation earlier in the season. Upon initial examination, patient demonstrated full range of motion and strength with wrist function, and was treated with ice and sensory TENS for pain. Treatment plans included referral to the team physician if pain did not resolve. Differential Diagnosis: TFCC injury, Wrist Sprain, Wrist Strain, Subluxing Extensor Carpi Ulnaris. Treatment: Day 2, patient reported no decrease in pain and stated that he had difficulty sleeping due to the intensity of the pain. Fracture tests were negative, and secondary examination remained consistent with a soft tissue injury. Patient expressed concern about the ability to play in post season competition the following day. On Day 2, the team physician was consulted via phone call and the patient was removed from team activities and would be evaluated by the team physician prior to competition. Day 3, the team physician evaluated the patient. During evaluation, the patient presented with pain

during active ulnar deviation, and pain with weakness in fifth digit abduction. Patient was diagnosed with an abductor digiti minimi strain. Treatment options were discussed and the patient consented to a local injection of lidocaine and bupivacaine near the insertion of the abductor digiti minimi. Following injection, compression was applied utilizing kinesiology tape. Patient competed fully in the subsequent competition, reaching base on every at bat and recording all outs fielded at his position. Patient reported no pain during competition, and requested another local injection for the following competition. Day 4, patient was injected and taped again under the same parameters. Patient participated in competition without incident. The game was the final competition of the season. Potential exacerbating activities would be ceased for the near future. The patient was consulted on the necessity to rest his hand prior to gradual return to activities. Instructions were provided for follow up with the athletic training staff if symptoms did not begin to resolve over time. Patient has not reported any complications from symptoms. Uniqueness: A PubMed and Google Scholar search for "Abductor Digiti Minimi Strain" or "Abductor Digiti Minimi Injury" yielded no results. The patient's previous history of injury and initial evaluations confounded leading to a delay in final diagnosis. The patient's status at the end of intercollegiate eligibility and the completion of the season, led the sports medicine staff to elect the use of short-term treatment methods, allowing the patient to continue participation. Conclusions: Thorough evaluation and re-evaluation are important for appropriate management of musculoskeletal conditions. When prescribing a course of treatment for patients in a competitive setting, it is paramount that clinicians take into account patient centered values. If there is no risk of significant, long term injury clinicians should attempt to provide patients with the means to participate in activities if they should desire.

Venous Thoracic Outlet Syndrome With Paget-Schroetter's Syndrome in a Male Collegiate Baseball Player Jang J, Self C, Rosen AB: University of Nebraska Omaha, Omaha, NE; Creighton University, Omaha, NE

Background: A NCAA Division I baseball middle infielder (20-year old male, height = 182.1 cm, mass = 83.5kg) complained of discomfort in his right upper extremity on January 13, 2017. He reported no specific mechanism of injury. He had a history of right elbow fracture at age 8 with joint displacement. However, no other previous injury to his upper extremity was reported or documented. He did not feel any pain or abnormal sensations while exercising, but noted some discomfort in the right arm, shoulder and pectoral muscles afterward. In the athletic training clinic he presented with sudden swelling, a reddish-purple discoloration, and cold sensations from his right hand up to the right shoulder. The evaluating athletic trainer also noted obvious swelling of the right arm, decreased radial pulse, and positive Roo's and Adson's Tests. He was referred to an emergency department where a radiograph, and right upper extremity venous duplex scan were conducted. The venous duplex scan showed superficial thrombophlebitis in the basilic vein and superficial vein thrombosis. He was then started on aspirin (81 mg per day) and instructed to discontinue weightlifting. On January 18, a venogram revealed a thrombosis of the right axillary and subclavian vein with multiple collateral vessels. He was started on Plavix (75 mg a day), Xifaxan (550 mg three times daily) and told to return slowly to activity. As he was increasing his activity levels, he noticed an area of erythema in the medial aspect of the arm, accompanied by recurrence of the edema, and pain. On January 24, he was reevaluated as having a superficial vein thrombosis. On February 14, he visited specialized vascular surgeons

for a second opinion and after arterial physiologic studies he was diagnosed with venous thoracic outlet syndrome with Paget-Schroetter's syndrome. Differential Diagnosis: Neurogenic or arterial thoracic outlet syndrome, lymphatic obstruction, intramuscular hemorrhage. Treatment: He was prescribed Xarelto (15 mg a day) for three months to promote recanalization of his right subclavian vein. An arm sleeve with a gauntlet for 15-20 mmHg compression was prescribed for symptom relief and was sent for physical therapy. He visited a physical therapist once a week for six weeks and completed internal and external passive range of motion and stretching activities with the arm below 90°. Pulsed non-thermal ultrasound was used on the pectoralis minor and scalene prior to deep tissue mobilization and stretching. After three months of taking anticoagulants and rehabilitation, a CT venogram demonstrated that his right subclavian vein was not recanalized, but numerous new collaterals to compensate for the blocked subclavian vein had developed. He returned to normal practice after 4 months from the initial diagnosis. He continues to wear compressive sleeves on his arm for symptomatic relief during exercise and sporting activities. Uniqueness: Venous thoracic outlet syndrome is an uncommon condition in baseball players, with arterial and neurogenic being more prevalent comparatively. In addition, Paget-Schroetter's syndrome accounts for only 1-2% of reported venous thrombosis. Conclusions: Clinically, venous thoracic syndrome is difficult to evaluate and diagnose and is especially complex in cases of Paget-Schroetter's syndrome due to its' idiopathic nature. Despite its rarity, sports medicine professionals should be suspicious of these conditions and conduct a thorough initial evaluation in baseball athletes with exercise-induced swelling, discoloration, and bilateral temperature differences.

Free Communications, Poster Presentations: Ankle Taping for Chronic Ankle Instability

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer

Review Authors - Last Names N through Z: 11:15AM-12:00PM

Examining the Positional Fault of the Fibula Using Diagnostic Ultrasonography After Fibular Reposition Taping in Individuals With Chronic Ankle Instability Fitch CA, Donovan LT, Armstrong CW, Ingersoll CD, Glaviano NR: University of Toledo, Toledo, OH; Texas Health Ben Hogan Sports Medicine, Arlington, TX; University of North Carolina at Charlotte, Charlotte, NC

Context: Individuals with chronic ankle instability (CAI) often present with both mechanical and functional insufficiencies that manifest as numerous clinical characteristics, such as reductions in dorsiflexion, strength, and postural control. Potential positional fault of the distal fibula, characterized by the fibular malleolus being anteriorly positioned relative to the talus, is one possible insufficiency that contributes to characteristics associated with CAI. Fibular reposition taping (FRT) is a suggested intervention to correct this malalignment. FRT has been found to improve postural control, muscle activity, and landing mechanics. However, there is limited evidence if it truly corrects the anterior position of the fibula. Additionally, it is unknown if diagnostic ultrasound is a reliable method to measure fibular position following FRT. Objective: Examine if the position of the fibula changes after application of the FRT technique, and to assess the intrarater reliability of utilizing diagnostic ultrasound to measure fibular position. Design: Crossover. Setting: Laboratory. Patients or Other Participants: Twenty individuals with CAI (Age: 21.5 ± 4.1 years, Mass: 81.8 ± 22 kg, Height: 170 ± 7.5 cm, IdFAI: 22.0 \pm 5.5, FAAM-Sport: 63.9 \pm 17.6) with no history of lower extremity surgery, ankle fracture, ankle injury in the past 6 weeks, or any vestibular

or balance disorders. Interventions: Participants completed three taping conditions: FRT, sham tape, and no tape (control). Taping order was randomized. Main Outcome Measures: Diagnostic ultrasound measurements were taken for each taping condition by an investigator blinded to tape condition, and the distance between the talus and fibula was measured. An ANOVA, with Tukey post hoc testing, was used to compare differences in the fibular to talus distance between taping conditions. Alpha was set at p < .05. Intraclass correlation coefficient (ICC₃₁) and associated standard error of measure (SEM) was calculated to determine intrarater reliability. Results: There was no statistically significant difference between the three taping conditions (control: 3.16 ± 0.25 cm, sham: 3.18 ± 0.32 cm, and FRT: 3.17 ± 0.27 cm, p = 0.960). Intrarater reliability was deemed to be excellent $(ICC_{31} = 0.98)$, and the associated SEM (0.015 cm) was applied to the difference between the FRT and sham conditions for each subject. Out of the 20 subjects, 8 were identified to have changes in fibular position outside the SEM after the FRT technique. Conclusions: No significant differences were found between any of the conditions, indicating that the FRT technique did not alter the position of the fibula. Since previous studies found significant improvements in postural control, muscle activation, and ankle kinematics during a landing task after application of FRT, it is possible that changes are occurring through other mechanisms of the tape. Findings of the present study suggest diagnostic ultrasound is a reliable tool for assessing position of the fibula. Further research should be conducted to determine if there are certain characteristics that determine if an individual is more likely to respond to the FRT technique.

Dynamic Balance and Functional Performance is Not Improved With Extended Kinesio Tape Use in Those With Chronic Ankle Instability

Kim H, Takahashi KZ, Grindstaff TL, Rosen AB: Marquette University, Milwaukee, WI; University of Nebraska at Omaha, Omaha, NE; Creighton University, Omaha, NE

Context: Individuals with chronic ankle instability (CAI) often have deficits in dynamic balance and functional performance. Although healthcare professionals frequently utilize Kinesio Tape (KT) to improve these deficits, only anecdotal evidence supports efficacy in those with CAI, especially for prolonged periods. **Objective:** To assess the prolonged use of KT versus a sham, non-elastic tape (ST) on dynamic balance and functional performance in individuals with CAI. Design: Randomized controlled trial. Setting: University research laboratory Patients or Other Participants: Twenty individuals with CAI (Age: 23.4 ± 3.1 years; height: 169.3 ± 8.3 cm; mass: 71.7 ± 12 kg, Cumberland Ankle Instability Tool: 19.3 ± 3.5) were randomly assigned to a KT (n = 10) or ST (n = 10) group. **Interventions:** KT was applied on the tibialis anterior with 20% elasticity, fibularis longus with 20% elasticity, and from the medial malleolus, across the plantar surface of the foot, to the lateral malleolus with 50% elasticity. ST was applied in a similar manner but utilized a non-elastic tape. The tape was worn without removal for 3 days. Participants performed three trials of a double-limb jump to single-limb landing and balanced for 3 seconds on a force plate, three directions of Star Excursion Balance Test (SEBT), and a single limb Figure-of-8 hop test (FHT). They were tested at three-time points before taping (T1), immediately after taping (T2), and 3

days after taping (T3). Main Outcome Measures: Dynamic postural stability-indices in the mediolateral (MLSI), anteroposterior (APSI), vertical (VSI), and a composite of the three directions (DPSI) during the single-limb landing were calculated from force plate data. Additionally, SEBT reach distance for anterior (AL), posteromedial (PML), and posterolateral (PLL) directions were calculated as well as a composite score (CS). Finally, total time (s) to perform FHT was also assessed. Separate two-way repeated measure multivariate analyses of variance (MANOVA) was used to determine differences between groups ($p \le 0.05$) for DPSI, SEBT and FHT dependent variables. Results: There were no significant multivariate interaction effects between time and treatment groups (DPSI p = 0.07, SEBT p = 0.82, FHT p = 0.36). There were also no significant multivariate main effects across groups (DPSI p = 0.14, SEBT p = 0.62, FHT p = 0.40). There was a significant improvement in FHT across the three-time points regardless of group (T1:12.7 \pm 2.2 sec, $T2:12.3 \pm 2.3 \text{ sec}, T3:11.9 \pm 1.9 \text{ sec}, p$ = 0.001). However, there was no multivariate main effect for DPSI (p = 0.07) or SEBT (p = 0.13) variables over time. Conclusions: Prolonged use of KT on the ankle joint is not effective to improve dynamic balance or functional performance compared to ST in people with CAI. Further studies should be done to assess differences in application methods such as different elasticity, taping areas, or application periods.

Effects of External Ankle Taping on Lower Extremity Kinetics and Kinematics in Young Adult Males Moore CD, Donovan LT, Murray AM, Armstrong CW, Glaviano NR: University of Toledo, Toledo, OH; Harvard University, Cambridge, MA; University of North Carolina at Charlotte, Charlotte, NC

Context: Lateral ankle sprains (LAS) are one of the most common musculoskeletal injuries. As a response, clinicians often use external ankle taping prophylactically to reduce LAS by providing additional static stability to the joint. Although external ankle taping techniques have been shown to reduce passive ankle frontal and sagittal motion, one common criticism is whether reducing ankle motion via external tape increases injury risk to proximal joints by changing motion and moments of these joints. Currently, there is limited research on the effects of external ankle taping during sport specific tasks on lower extremity biomechanics. **Objective:** To compare the effects of external ankle taping on ankle, knee and hip kinematics and kinetics compared to no taping during a straight sprint task and an anticipated sidestep cutting task. Design: Crossover. Setting: Laboratory. Patients or Other Participants: Sixteen healthy males (age: 23.1 ± 2.6 years, mass: 81.4 ± 11.4 kg, height: 181.7 ± 7.3 cm) with no history of lower extremity surgery, lower extremity injury in the past six months or any vestibular or balance disorders. Interventions: Participants completed both an external taping technique and a no taping condition (Control). Order of intervention was counterbalanced. Main Outcome Measures: Three-dimensional kinematics and kinetics were collected with a 12-camera motion capture system and in-ground force plate. Each participants completed 5 trials of a sprint and anticipated side-step cut with or without external ankle taping. The sprinting trials required participants to maintain a speed of 3.5-5.0m/s. For the sidestep cutting

trials, participants approached the force plate at the same pre-determined speed and cut at 45 degrees. Frontal, sagittal, and transverse kinematic group means and associated 90% confidence intervals were plotted across 100 data points across each task. Internal joint moments normalized to body mass and height were also plotted with group means and 90% confidence intervals. Significance was identified when the confidence intervals did not overlap for three consecutive data points. Paired t-tests were conducted to compare differences in running speed between trials, significance set at p < .05. **Results:** No significant differences in speed for the straight sprint (Control: 4.31 ± 0.42 m/s; Tape: 4.29 ± 0.42 m/s, p = 0.45) and sidestep cutting task (Control: 4.17 \pm 0.35 m/s; Tape: 4.11 \pm 0.30 m/s, p = 0.70). No significant differences in ankle, knee, or hip kinematics or kinetics were found during both the sprinting and sidestep cutting tasks between taping conditions. Conclusions: External ankle tape did not have a significant effect on kinetics or kinematics in healthy adult males during a sprinting or anticipated side-step cutting task. It appears external ankle taping does not influence lower extremity biomechanics during a sprinting or a controlled cutting task in a laboratory setting. To closer replicate current clinical applications of external ankle taping, future research should evaluate its effectiveness on individuals following LAS or with chronic ankle instability.

The Impacts of Three Different Ankle Tapings on Lower Extremity Kinematics and Muscle Activation in Those With and Without Chronic Ankle Instability During Single-Leg Balance

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Context: Impaired ligaments and decreased proprioception associated with chronic ankle instability (CAI) following repeated ankle sprains have been found to result in postural control deficits. Clinicians often use various taping strategies to protect the at-risk ankle and research supports the use of ankle taping strategies during in dynamic functional tasks. However, the effects of different ankle taping applications on biomechanics and muscle activations during static balance are unclear. **Objective:** To examine the immediate effects of three different ankle taping techniques on muscle activation and lower extremity joint angles during single-leg stance in those with and without CAI. Design: Triple-blind randomized crossover. Setting: University laboratory. Patients or Other Participants: A total of 28 subjects [14 healthy (age: 27.57 ± 3.23 years; height: 169.61 ± 8.33 cm; weight: 76.98 ± 17.95 kg), 14 CAI (age: 24.07 ± 4.46 years; height: 175.06 \pm 5.09 cm; weight: 82.24 \pm 10.38 kg) participated. Individuals with CAI were evaluated using International Ankle Consortium guidelines on the Foot and Ankle Ability Measure (FAAM) and Cumberland Ankle Instability Tool (CAIT). Interventions: Four different taping conditions [no tape (NT), traditional ankle taping (TT), kinesiology taping (KT), and fibular repositioning tape (FRT)] were randomly assigned to each participant. Main Outcome Measures: A 3D motion analysis system was utilized to capture hip, knee, and ankle angles in all planes during 10 a second single leg stance. Mean values of each joint angle of the involved leg during the 10 second trial were calculated. The muscle activation of tibialis anterior (TA), soleus (SOL), peroneal longus (PL), rectus femoris (RF), gluteal medius (GMed), and biceps femoris (BF) were collected using a wireless electromyography (EMG) system. The collected EMG data were normalized by peak root mean squared value of maximum vertical jump (% RVC). Trials were completed with eves opened and closed eyes for 10 seconds before and after each tape application. A 2 (group) X 4 (condition) mixed repeated ANOVA was used to examine taping effects on kinematics and EMG during single-leg balance. Results: A significant interaction between group and taping condition was found in SOL ($F_{378} =$ 2.971, P < .05, $\eta_n^2 = .103$) with opened eyes. In pairwise comparison analysis, greater SOL (Healthy = $12.89 \pm 8.24\%$ RVC, CAI = $7.88 \pm 3.11\%$ RVC) was observed with opened eyes after FRT application. Other significant differences were not found. Conclusions: FRT application significantly reduced soleus muscle activation level in CAI participants, but the result may not meaningful enough to warrant one tape application over another for altering muscle activation patterns and improving joint stability post-taping in CAI patients. Given that CAI is associated with reduced proprioception, further study is needed to understand how different taping strategies may mitigate this impairment and be utilized to reduce risk of further injury.

A Comparison of Tapings Immediate Impacts on Muscle Activation Levels Between Healthy and Chronic Ankle Instability During Dynamic Postural Control

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Context: Chronic ankle instability (CAI) has been associated with a reduction in proprioception which often results in postural control deficits. Clinicians regularly utilize ankle taping strategies to address ankle instability. Though many different ankle taping applications are employed, the effect of these on muscle activation in dynamic balance is unclear. **Objective:** To compare the immediate effects of prophylactic tapings on muscle activation of lower extremity during dynamic postural control. Design: Triple-blind randomized crossover. Design: Tripleblind randomized crossover. Setting: University laboratory. Patients or Other Participants: A total of 28 subjects [14 healthy (age: 27.57 \pm 3.23 years; height: 169.61 ± 8.33 cm; weight: 76.98 ± 17.95 kg), 14 CAI (age: 24.07 ± 4.46 years; height: 175.06 \pm 5.09 cm; weight: 82.24 \pm 10.38 kg) participated in this study. CAI participants were recruited per International Ankle Consortium guidelines using the Foot and Ankle Ability Measure and Cumberland Ankle Instability Tool. Interventions: Participants were randomly assigned to the following taping techniques on separate days: traditional ankle taping (TT), kinesiology taping (KT), or fibular repositioning taping (FRT). Main Outcome Measures: Muscle activation was assessed during a modified Y-Balance test in the anterior direction. Electromyography

(EMG) of tibialis anterior (TibA), soleus (SOL), peroneal longus (PeL), rectus femoris (RecF), gluteal medius (GluM), and biceps femoris (BicF) were collected using a wireless EMG system. Root mean squared (RMS) EMG was then calculated and normalized using maximal voluntary isometric contractions (nRMS EMG). All measurements were conducted before tape application and 60 minutes following application of each taping condition. 4 (Intervention) X 2 (Group) repeated ANOVAs were used to assess differences in baseline and post-taping mean of nRMS EMG on the stance leg during anterior-reach phases. Results: All nRMS EMG values during anterior-reach phase were significantly decreased regardless of taping technique compared to the pre-taping condition (P < .001). TibA ($F_{3,78} = 9.48$, P < .001, η_p^2 = .267), PeL ($F_{3,78}$ = 12.56, P < .001, η_p^2 = .326), SOL ($F_{3,78}$ = 6.88, P < .001, η_p^2 = .209), RecF ($F_{3,78} = 8.99$, P < .001, η_p^2 = .257), BicF ($F_{3,78} = 10.41$, P < .001, η_p^2 = .286), GluM ($F_{3,78} = 10.83$, P < .001, $\eta_n^2 = .294$). Also, values of mean±standard deviation are reported in Table1. Conclusions: A reduction in all muscle activation levels were reported during anterior-reach phase across all taping conditions. Clinicians should be aware prophylactic ankle taping techniques can reduce muscle activation during functional performance, which may impair athletic performance and increase risk of injury. Therefore, rehabilitation programs that improve muscle activation may be valuable for athletes who receive ankle taping intervention prior to athletic performance. Further study is needed to determine the effect this decreased muscle activation has on functional and athletic performance.

No Immediate Impacts of Three Ankle Taping Techniques on Pre Muscle Activation in a Single-Leg Drop in Individuals With Chronic Ankle Instability

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Context: In sports medicine, ankle taping is often times used as a prophylactic measure. Although ankle taping is frequently prescribed, the effects of tape on pre-muscle activation is not well understood. **Objective:** To investigate the effects of prophylactic taping on pre-muscle activation 200ms before initial contact of single-leg drop landing. Design: Tripleblind Randomized Crossover Setting: University Laboratory. Patients or Other Participants: A total of 28 subjects [14 healthy (age: 24.07 ± 4.46 yrs; height: 175.06 ± 5.09 cm; weight: 82.24 ± 10.38 kg) 14 CAI (age: 27.57 ± 3.22 vrs; height: 169.61 ± 8.32 cm; weight: 76.65 ± 18.14 kg] participated. The presence of CAI was determined based on the International Ankle Consortium guideline using the Foot and Ankle Ability Measure (FAAM) for activities of daily living and sport, as well as the Cumberland Ankle Instability Tool (CAIT). Interventions: Participants were randomly assigned to one of four conditions on separate testing days: no tape (Baseline), traditional taping (TT), fibular repositioning taping (FRT), or kinesiology taping (KT). Main Outcome Measures: Wireless electromyography (EMG) was used to assess muscle activation of the tibialis anterior (TibA), soleus (SOL), peroneal longus (PeL), rectus femoris (RecF), gluteal medius (GluM), and biceps femoris (BicF). The EMG signal was calculated to integrated EMG (iEMG) and linear envelope. The iEMG value during

200ms were normalized by peak value of linear envelope (%ms). A 2 (group) X 4 (condition) mixed repeated ANOVA was conducted to examine the effects of each ankle taping technique. Results: Muscle activation differences were not found between groups (Healthy vs CAI) and conditions (Baseline, TT, FRT, KT) across any of the tested muscles. TibA (Condition: $F_{2.05.53.29} = 1.30$, p > .05, $\eta_p^2 =$.047; Condition by Group: $F_{2.05,53,29} = .12$, p > .05, $\eta_p^2 = .005$). SOL (Condition: $F_{2.29, 59.50} = .54, p > .05, \eta_p^2 = .020;$ Condition by Group: $F_{2.29,59.50} = .17$, p > .05, $\eta_n^2 = .007$). PeL (Condition: $F_{2,24,58,42}$ = 1.44, p > .05, η_p^2 = .053);Condition by Group: $F_{2,24,58,42} = .86$, p > .05, $\eta_p^2 = .032$). ReF (Condition: $F_{2,90,54,30} = 1.73$, p > .05, $\eta_p^2 = .063$; Condition by Group: $F_{2.90,54.30} = .11, p > .05, \eta_p^2 = .004$). GluM (Condition: $F_{2.23,59.90} = 1.35, p > .05, \eta_p^2 = .05$.049; Condition by Group: $F_{2.30,59.90} = .15$, p > .05, $\eta_p^2 = .006$). BicF (Condition: $F_{1.97,51,15} = 1.42, p > .05, \eta_n^2 = .052);$ Condition by Group: $F_{1.97,51.15} = .15$, p > .05, $\eta_{p}^{2} = .006$). <u>Conclusions:</u> As significant differences were not observed between group or condition, the practicing clinician can utilize these taping techniques without impairing muscle pre-activation. However, the use of the tapes also does not appear to improve muscle pre-activation. Thus, the use these techniques does not appear to provide prophylactic support through preparing a person for sports activity through enhanced muscle pre-activation of the lower extremity.

Do Prophylactic Ankle Tapings Influence Time to Boundary of Individuals With Chronic Ankle Instability?

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Context: Individuals with chronic ankle instability (CAI) may present with static postural control deficits which may lead to further injury. Clinically, various prophylactic ankle tapings have been commonly used to prevent injury. However, there is a paucity of evidence on the effect of ankle taping on static postural control. **Objective:** To investigate how different ankle taping techniques influence static postural control in individuals with and without CAI. Design: Triple-blinded randomized crossover. Setting: Laboratory. Patients or Other Participants: A total of 28 subjects (14 healthy: height = $169.61 \pm$ 8.33 cm, weight = 76.98 ± 17.95 kg, age = 27.57 ± 3.23 years, FAAM-ADL = 99.32 \pm 1.30, FAAM-SS = 99.11 \pm 1.46, CAIT $= 29.93 \pm 0.27$; 14 CAI: height $= 175.06 \pm$ 5.10 cm, weight = $82.24 \pm 10.38 \text{ kg}$, age = 24.07 ± 4.46 years, FAAM-ADL = 86.69 \pm 6.71, FAAM-SS = 75.45 \pm 6.70, CAIT = 17.64 ± 4.14) participated in the study. Interventions: Baseline (BL), traditional tape (TT), fibular repositioning tape (FRT), and kinesiology tape (KT) were randomly applied to each participants' ankle on different days by a single clinician. Main Outcome Measures: The time to boundary (TTB) in mediolateral (ML) and anteroposterior (AP) direction was measured during a 10-second single-leg standing task with eyes open (EO) and eyes closed (EC) : absolute minimum of TTB (TTB_{ML}, TTB_{AP}), mean of minima of TTB (MeanTTB_{ML}, MeanTTB_{AP}), and</sub> standard deviation of TTB (SDTTB_{MI}, $SDTTB_{AP}$). A 2 (group) X 4 (condition) mixed ANOVA was performed to examine the effect of each taping method on

the single-leg balance. Results: No significant interaction was found between group and condition. Significant main effects for tape techniques were indicated in MeanTTB_{ML} ($F_{2.43,63.20} = 3.04$, p < .05, $\eta_p^2 = .11$) and MeanTTB_{AP} (F_{2.05,53,34} = 3.62, p < .05, η_p^2 = .12) with EO, and TTB_{ML} (F_{3.78} = 3.10, p < .05, $\eta_p^2 = .11$), $TTB_{AP}^{(1)}(F_{2.26.58.82}^{(1)} = 5.30, p < .05, \eta_p^{(2)} = .17),$ $\begin{array}{l} MeanTTB_{ML} (F_{2.16,56,18} = 5.21, p < .05, \eta_p^2 = \\ .17), MeanTTB_{AP} (F_{2.17,56,46} = 8.73, p < .05, \end{array}$ $\eta_p^2 = .25$), and SDTTB_{AP} (F_{2.45,63,66} = 4.21, p < .05, $\eta_{\rm p}^2 = .14$) with EC. In post hoc analysis, greater MeanTTB_{ML} (BL: Healthy = 1.26 ± 0.34 s, CAI = 1.56 ± 0.20 s; FRT: Healthy = 1.40 ± 0.52 s, CAI = $1.78 \pm$ 0.37s) and MeanTTB_{AP} (BL: Healthy = 4.27 ± 1.05 s, CAI = 4.91 ± 0.60 s; FRT: Healthy = 4.46 ± 1.24 s, CAI = $5.38 \pm$ 0.89s) were observed after application of FRT in EO. In EC, increased TTB_M (BL: Healthy = $0.20 \pm 0.02s$, CAI = $0.22 \pm$ 0.04s; FRT: Healthy = $0.21 \pm 0.04s$, CAI $= 0.24 \pm 0.05$ s) and TTB_{AP} (BL: Healthy $= 0.60 \pm 0.15$ s, CAI $= 0.63 \pm 0.16$ s; FRT: Healthy = 0.65 ± 0.18 s, CAI = $0.82 \pm$ 0.27s) were also observed after applying FRT. Significantly increased MeanTTB_M was indicated after application of all tape techniques (BL: Healthy = 0.67 ± 0.16 s, $CAI = 0.77 \pm 0.16s$; TT: Healthy = 0.78 ± 0.21s, CAI = 0.87 ± 0.24 s; FRT: Healthy $= 0.78 \pm 0.22$ s, CAI $= 0.94 \pm 0.20$ s; KT: Healthy = 0.69 ± 0.16 s, CAI = $0.91 \pm$ 0.18s). After employing FRT and KT, significantly increased MeanTTB_{AP} (BL: Healthy = 1.95 ± 0.40 s, CAI = $2.29 \pm$ 0.51s; FRT: Healthy = 2.16 ± 0.49 s, CAI $= 2.69 \pm 0.73$ s; KT: Healthy $= 2.18 \pm$ 0.32s, CAI = 2.48 ± 0.37 s) and SDTTB_{AB} (BL: Healthy = 1.18 ± 0.27 s, CAI = $1.44 \pm$ 0.41s; FRT: Healthy = 1.40 ± 0.43 s CAI = 1.70 ± 0.71 s; KT: Healthy = 1.37 ± 0.25 s, $CAI = 1.62 \pm 0.40s$) were displayed. Conclusions: The results suggest that FRT is more effective for enhancing static postural control than TT or KT. Interestingly, FRT displayed remarkable effects on static postural control compared to KT which has been theoretically known to have proprioceptive benefits through stimulating cutaneous sensory. Therefore, the results provide scientific evidence to support clinical application of FRT for improving static postural control.

Free Communications, Poster Presentations: Athletic Training Practice, Education, & Administration

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Medical Claims at NCAA Institutions: The Athletic Trainer's Role

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Context: National Collegiate Athletic Association (NCAA) institutions are required to certify insurance coverage of medical expenses for athletic related injuries sustained while partaking in an NCAA event. Institutions assign this role to a variety of employees, including athletic trainers (ATs), athletic administrators, business managers, secretaries, or other institution employees. In 1994 Street, Yates, Lavery, and Lavery observed that ATs were responsible for administering medical insurance/claim payments at 68.1% of the institutions studied. Anecdotally, ATs do not always feel well suited to perform these tasks. **Objective:** Investigate the ways that athletic associations/departments coordinate athletic medical claims and the role the AT holds in the administration of this task. Design: Cross-sectional study. Setting: Online web-based survey. Patients or Other Participants: Responses from 184 (38%) head ATs employed in collegiate settings were analyzed. Interventions: None. Main **Outcome Measures:** Demographics. Results: In 62% of institutions observed an AT was responsible for processing athletic medical claims. The mean hours spent was 6.17 and 10.32 hours per week by head ATs and assistant ATs respectively. Most respondents (65.6%) reported no formal training in athletic medical insurance claims. When asked when/how is it most appropriate to learn these concepts, respondents reported: within an accredited AT program curriculum (36%), on the job training (34%), or continuing education event (30%). Conclusions: It is clear that ATs at NCAA institutions are responsible for the administration of athletic medical claims and that most have no formal training. An AT may not be the most ideal individual to handle these athletic medical claims; however, even if ATs do not maintain sole responsibility for this task they will remain involved as the coordinator of care. Therefore, AT programs and professional organizations who offer continuing education should consider increasing emphasis of this content.

Longitudinal Biometric Changes in Athletic Training Students Hawkins JR, Heumann KJ, Reeder M: Colorado Mesa University, Grand Junction, CO

Context: Matriculating in an athletic training program requires significant time and effort from athletic training students, sometimes at the expense of their health and fitness. Objective: To assess biometric measures of health in athletic training students during matriculation in an undergraduate athletic training program. Design: Observational. Setting: Laboratory. Patients or Other Participants: Nine athletic training students (1 male: height = 185.4 cm, weight = 68.1 kg, age = 20years; 8 females: height = 164.6 ± 5.8 cm, weight = 70.9 ± 8.3 kg, age = $21.9 \pm$ 1.9 years) volunteered for participation at the beginning of their junior year. Interventions: At the beginning of the first semester of their junior year (F1), the end of the first semester of their junior year (F2), the end of the second semester of their junior year (S1), and the beginning of the first semester of their senior year (F3), participants reported to a human performance lab for the following measurements: F1 weight, blood pressure, BIA, fasting blood glucose, BodPod, and step test; F2 – weight, and blood pressure, BIA; S1 - weight, blood pressure, BIA, fasting blood glucose, BodPod, and step test; F3 - weight, blood pressure, and BIA. Main Outcome Measures: The dependent variables were weight, systolic blood pressure, diastolic blood pressure, percent body fat as measured by BIA and BodPod, fasting blood glucose, and predicted VO, max. A repeated measures ANOVA, followed by pairwise comparisons, was run to determine changes over the 4 time points measured. Alpha set a priori at P =.05. Results: The male participant was

excluded from analysis so as to have a homogenous data set. Statistical significance was observed in weight (F_{1.76.12.35} = 8.64, P = 0.005; F1 = 70.9 ± 8.3 kg, $F2 = 70.7 \pm 7.6 \text{ kg}$, $S1 = 74.3 \pm 8.0 \text{ kg}$, $F3 = 74.9 \pm 8.7$ kg), with F1 differing from S1 (P = .006) and F3 (P = .016) and F2 differing from S1 (P = .005) and F3 (P = .025). No other variables were significantly different (systolic blood pressure: $F1 = 110.0 \pm 8.7$, F2 = 120.25 \pm 7.4, S1 = 116.88 \pm 9.1, F3 = 119.25 \pm 11.2; diastolic blood pressure: F1 = 67.5 \pm 7.8, F2 = 75.3 \pm 6.6, S1 = 69.25 \pm 7.8, $F3 = 71.1 \pm 9.4$; percent body fat via BIA: $F1 = 33.8 \pm 5.8$, $F2 = 34.5 \pm 3.6$, $S1 = 36.0 \pm 5.5$, $F3 = 35.8 \pm 4.9$; percent body fat via BodPod: $F1 = 31.7 \pm 7.5$, $S1 = 33.2 \pm 6.2$; fasting blood glucose: $F1 = 91.4 \pm 15.2$, $S1 = 84.9 \pm 8.1$; predicted VO₂ max: $F1 = 41.4 \pm 6.4$, S1 = 42.5 ± 10.2), although some of the numbers warrant concern for student health. Conclusions: During the year of participating in this study, the participants gained weight on average and blood pressure and percent body fat trended in a negative direction. This cohort will be followed through graduation and a second cohort has begun. Increased efforts may be needed to more appropriately help athletic training students meet the demands of their professional preparation while maintaining their health.

Health Care as a Team Sport? Studying Athletics Through a World Cafe' to Improve Interprofessional Collaboration Breitbach AP, Reeves S, Fletcher S: Athletic Training Program, Saint Louis University, St. Louis, MO; Centre for Health and Social Care Research, Faculty of Health, Social Care and Education, Kingston University and St. Georges, University of London, UK

Context: Organizations value teamwork and collaboration as they strive to build culture and attain their goals and objectives. Sports provide a useful and easily accessible means to study teamwork. Interprofessional collaborative practice (IPCP) has been identified as a means to improve patient and population health outcomes. Principles of teamwork in sports can inform health professionals and organizations regarding possible improvement strategies and barriers in the optimization of IPCP. **Objective:** This research project investigated how teamwork principles from sport could be applied to healthcare and sports medicine. Design: This study involved the organization of a consensus event using a World Café technique with stakeholders (e.g. practitioners, educators, researchers) from interprofessional healthcare fields. This methodology draws on seven integrated design principles and applies action research with a participatory approach. Setting: This study took place at the "All Together Better Health VIII" (ATBH VIII) - an international conference, which was held at Oxford, United Kingdom in September 2016. It presented an opportunity to engage with clinicians, researchers and educators from many different health professions from many different countries. Patients or Other Participants: 28 participants were recruited voluntarily from the delegates at the ATBH VIII Conference who, by their participation in the conference, demonstrated a strong interest in interprofessional health care. As an international, interprofessional conference it provided

an excellent opportunity to engage a variety of health professions from diverse international contexts. Data Collection and Analysis: These discussions were captured electronically, transcribed and coded by the primary investigator electronically through Dedoose. This coding was then reviewed by the co-investigators. Coding was based in the domains developed by the Interprofessional Education Collaborative (IPEC) along with extrapersonal or interpersonal loci. Results: Extrapersonal factors regarding structure of leadership, roles and organizational commitment can be positive factors to promote teamwork. However, interpersonal factors affecting communication, values and lack of commitment to collaboration can serve as barriers. Conclusions: Principles of teamwork in sports can inform health professionals and organizations regarding possible improvement strategies and barriers in the optimization of IPCP. Extrapersonal factors regarding structure of leadership and roles, along with organizational commitment can be positive factors to promote teamwork. However, interpersonal factors affecting communication, values and commitment to collaboration can serve as barriers. Athletic trainers and other sports medicine professionals can serve as valuable members of interprofessional teams and teamwork is essential in the field of sports medicine.

Desired Hiring Characteristics for Occupational Health Athletic Training Employers

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Context: Athletic trainers (ATs) reduce employee days away from work by >25%, ultimately reducing the financial burden on the employer through decreased costs from workers' compensation claims, hiring replacements, and loss of productivity. **Objective:** To identify employers' desired hiring criteria for athletic trainers in the occupational health setting. Design: Consensual qualitative research. Setting: Individual telephone interviews. Patients or Other Participants: Ten athletic training employers in the occupational health setting (4 men, 6 women; age = 32.5 ± 5.2 y, experience = 2.5 ± 2.3 y) who were part of the hiring process in their company in the last 6 months completed the interviews. Data saturation guided the number of participants. Data Collection and Analysis: Interviews were recorded and transcribed verbatim using an external transcriptionist. Transcriptions were checked for accuracy by the primary investigator. We used a 3-person consensus team to identify codes and themes. Data were coded independently and then discussed to formulate a consensus codebook. We utilized multiple researchers, an external auditor, and member checks to establish credibility of the process. Results: Three themes emerged that described the desired hiring characteristics of AT employers in the occupational health setting: unique characteristics of the role, qualifications, and personal characteristics of an ideal employee. ATs in the occupational health setting must follow specific guidelines. They should be prepared to focus within the prevention domain of clinical practice, operating under regulations mandated by the Occupational Safety and Health Administration (OSHA). Employers found ATs who previously possessed additional credentials were particularly successful in fulfilling their roles. Due to the uniqueness of the setting, employers spend a substantial amount of time training new employees so they understand their specific expectations. Employers have a dedicated focus to training, concentrating substantial resources to train new employees. When seeking new ATs, qualifications for which employers are looking are previous experience in the occupational health setting, experience in business practices, an ability to work autonomously, and certificates of added qualifications are highly sought after. However, the most important aspect employers discussed was their specific desire for employees' personal characteristics. ATs who are outgoing, effective communicators, willing to take initiative, and able to adapt to different situations are typically selected due to the uniqueness of the setting, where instead of patients coming to the athletic training facility, the AT is responsible for being present within the workplace facility to identify injuries before they happen. Employers stated explicitly that they avoid hiring introverts for similar reasons. Conclusions: The occupational health setting is unique in that it requires an AT to focus their work on injury prevention. Similar to previous research in other settings, employers value personal characteristics and setting-specific previous experience in which ATs understand role requirements and have already been socialized to meet the demands of the job.

The Impact of Athletic Trainers in a Clinic Setting Kirsch DK, David SL, German NA,

Reed BD: North Dakota State University, Fargo, ND; Sanford Health, Fargo, ND

Context: Athletic Trainers (ATs) in the clinic setting is a newer employment opportunity and has shown to have a positive impact on the clinic and physicians. However, little is known about how this change impacts the patients. **Objective:** To determine if patients understand the abilities and skill sets of ATs while in the clinic and to examine the influence of ATs employed in an orthopedic sports medicine clinic setting on patient satisfaction. Design: Non-experimental survey. Setting: Orthopedic sports medicine clinic in the upper Midwest. Patients or Other Participants: A total of 126 participants, 68 male and 58 female (85 participants were between 13 and 29 years old) patients seen at the clinic voluntarily participated in the study. Inclusion criteria included participants between the age of 13 and 70, fluent in reading and writing in English and were seen by an athletic trainer prior to the physician. Interventions: A survey to determine patient satisfaction, perception and knowledge of ATs was adapted by combining portions of three previously validated surveys. In order to validate the adapted survey, a pilot study was completed that included think-alouds and three content experts. The validated survey was distributed to participants using an iPad with a link to the Qualtrics online system. Main Outcome Measures: Descriptive information was analyzed including means, standard deviations, and frequencies (percentages). **Results:** Responses revealed that 62.7% of participants were able to correctly identify the AT and 77.8% of participants agreed that an AT had "a lot" or "a great deal" of knowledge in the field of orthopedics. Additionally, at least 47.5% of participants were either "very familiar" or "extremely familiar" in the skills and abilities of an AT. Lastly, 93% of

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participants rated their satisfaction during their experience with an AT an eight or higher out of ten. Conclusions: Overall, a majority of participants had an understanding of the skills and abilities of an AT and were able to correctly identify the various roles of an AT. Findings from this study indicate that patients seen in an orthopedic sports medicine clinic are satisfied with his or her experience with an AT. Athletic trainers employed in an orthopedic sports medicine clinic appear to have a positive impact on patient's satisfaction. Therefore, ATs should continue to be considered when staffing an orthopedic sports medicine clinic.

Retained Knowledge and Confidence of Evidence-Based Practice Concepts Among Athletic Trainers Manspeaker SA, Hankemeier DA: Duquesne University, Pittsburgh, PA; Ball State University, Muncie, IN

Context: Athletic trainers (ATs) are required to obtain continuing education units in the area of evidence-based practice (EBP) in order to maintain good standing with the Board of Certification (BOC). Analysis of outcomes following attendance to a BOCapproved Foundations of EBP course is lacking. **Objective:** To evaluate ATs' retained knowledge and confidence in EBP concepts 12-months following a Foundations of EBP course. A secondary aim was to determine ATs perceptions regarding barriers to, use of, and resources for EBP. Design: Repeated within-subjects measures, survey. Setting: Continuing professional education workshop hosted at two Division I universities. Patients or Other Participants: 27 respondents (15 males, 12 females) from a convenience sample of 123 ATs (22% response rate) participated in the 12-month follow-up. Participants averaged 35.22 ± 10.24 y/o and 10.65 ± 8.21 years of clinical practice. Interventions: Participants voluntarily enrolled in a 5-hour BOCapproved Foundations of EBP workshop which, was developed by three EBP content experts. The survey instrument, Evidence-Based Concepts: Knowledge, Attitudes, and Use (EBCKAU) was administered online via Survey Monkey to ascertain ATs' perceived EBP knowledge over a 12-month period. This instrument has a Kuder-Richardson (K20) value of 0.435 and Cronbach $\alpha = 0.70$. Data were collected at three time points: prior to, within 48 hours following the workshop, and 12 months post-workshop. Main Outcome Measures: Descriptive statistics and correlations were calculated. Knowledge (11-multiple choice questions) and confidence (11 corresponding Likert scale ratings

from 1-4, not at all confident to extremely confident) scores were summated. Repeated measures ANOVA with Bonferroni correction and Wilcoxon signed ranks determined differences between knowledge and confidence scores, respectively. Open-ended responses were catalogued according to themes and coded. Results: Perceived knowledge increased significantly [F (2.0, 52.0) = 18.91, P < .001 from pre (6.40 ± 1.77) to immediately post-workshop $(8.15 \pm 1.51, P < .001)$ and pre to 12-months post-workshop (7.30 ± 1.64) , P < .002). Medians for confidence in knowledge were statistically significant over time with an immediate increase from pre-workshop (median = 28) to post-workshop (median = 37; z = -4.55, P < .001); followed by a decrease in confidence from immediately to 12 months post-workshop (median = 29; z = -4.39, P < .001). Both prior to and since the workshop, ATs reported low levels of incorporating patient reported outcome measures (PROM) and were equally likely to use compilation research in clinical practice. Barriers to use of EBP were identified as time and available resources. Improving patient care was reported as the primary area of envisioned future EBP use. Conclusions: ATs improved their perceived and retained knowledge in EBP concepts over time; however, confidence in knowledge decreased over the same time frame. Lack of implementation may have contributed to the decrease in confidence; EBP concepts should be integrated into clinical practice in order to see behavior change and potential patient outcome improvement.

Examining Stakeholder Perceptions of Programmatic Design of the Post-Professional Clinical Doctoral Degree in Athletic Training

Potteiger K, Baker RT, Huxel Bliven KC, Pitney WA: Northern Illinois University, DeKalb, IL; University of Idaho, Moscow, ID; A.T. Still University, Mesa, AZ

Context: The proliferation of clinical doctoral degree programs in athletic training (DAT) is outpacing the profession's ability to provide guidance on the direction of post-professional education. **Objective:** To explore stakeholder perceptions regarding programmatic design elements of the DAT. Design: A cross-sectional survey of 4 stakeholder groups. Setting: Online survey. Patients or Other Participants: 911 respondents (faculty = 261, 19.7% response rate; clinicians = 369, 7.4% response rate; employers = 136, 6.6% response rate; academic administrators (AA) = 145, 13.0% response rate) out of 9,481 total invitations were considered complete and used for analysis. Interventions: Surveys were developed for each group and validated (face and content) using the content validity index score (all items \geq 0.78). Survey items in four categories were used for this study, including: demographics, characteristics of the graduate, program design, and influence on patient care. Main Outcome Measures: Respondents recorded their perceptions using a 7-point Likert scale (1 = strongly disagree, 4 = neutral, 7= strongly agree). Responses to items were examined with exploratory factor and internal consistency analyses to determine underlying constructs. Group differences on identified constructs were assessed with separate ANOVAs. Scores were reported as a group mean \pm standard deviation. Alpha was set at p ≤ 0.05 . **Results:** The analysis revealed four constructs among the stakeholder groups: (1) "Practice-Focused Student Outcomes (PFSO)," (2) "Program Design Requirements (PDR)," (3) "Clinically-Focused Program Goals (CFPG)" and (4) "Additional Administrative Coursework (AAC)" (Table 1). All stakeholder groups reported general agreement with desired student outcomes aimed to improve clinical practice (PFSO). Faculty (6.15 \pm 0.91) and clinicians (6.13 \pm 0.91) reported significantly ($p \le .038$) higher scores than employers (5.87 ± 1.19) or AA (5.75 ± 1.10) on this construct. Faculty (5.54 ± 0.97) , clinician $(5.94 \pm$ 0.95), and AA (5.58 ± 1.29) stakeholders also reported agreement with the PDR construct for mentoring students, but clinicians reported significantly ($p \le$.001) higher agreement than faculty and AA. All of stakeholder groups reported general agreement for CFPG within the program design. Faculty (6.44 ± 0.76) and clinicians (6.30 ± 0.85) reported significantly ($p \le .001$) higher scores than AA (5.94 \pm 1.03), and faculty also reported significantly ($p \le .002$) higher scores than employers (6.10 ± 0.91) on this construct. Faculty (5.01 ± 1.20) , clinicians (5.80 ± 1.13) , and employers (5.19 ± 1.63) agreed on the potential for AAC within a program, but clinicians reported significantly ($p \le .001$) higher scores than those two stakeholder groups. Conclusions: All stakeholders agree that DAT student and program outcomes should be clinically focused. Additionally, stakeholders generally agree the DAT programs should include a mentoring component and additional administrative coursework. More research is needed to determine if these constructs are actually included in current DAT programs.

Examining Stakeholder Attitudes of Professional Enhancement Related to the Post-Professional Clinical Doctoral Degree in Athletic Training Baker RT, Potteiger K, Huxel Bliven

KC, Pitney WA: University of Idaho, Moscow, ID; Northern Illinois University, DeKalb, IL; A.T. Still University, Mesa, AZ

Context: Athletic training is experiencing a proliferation of post-professional clinical doctoral degree (DAT) programs. Currently, stakeholder perceptions of its impact on clinical practice and the profession are unknown; therefore, the ability to provide guidance on the DAT is challenging. **Objective:** To explore stakeholder perceptions of the influence of the DAT on the athletic training profession. Design: Cross-sectional survey of 4 stakeholder groups. Setting: Online survey. Patients or Other Participants: Stakeholders included faculty (primary position in NATA membership), academic administrators (AA; chair, dean, provost, president in CAATE directory), clinicians (primary position in NATA membership), and employer (individuals advertising positions in NATA career center). A total of 911 responses (faculty = 261, 19.7% response rate; clinicians = 369, 7.4% response rate; employers = 136, 6.6% response rate; AA = 145, 13.0% response rate) out of 9,481 invitations were considered complete and used for analysis. Interventions: Surveys were developed and validated (face and content) using the content validity index score (all items ≥ 0.78). Survey items in five categories were used for this study, including: demographics, characteristics of the graduate, influence on patient care, employment opportunities, and benefits to the profession. Main Outcome Measures: Respondent perceptions were answered using a 7-point Likert scale (1 = strongly disagree, 4 = neutral, 7 = strongly agree). Exploratory factor and internal consistency analyses were conducted to determine underlying constructs. ANOVAs were utilized to determine group differences. Scores are reported as group mean \pm standard deviation. Alpha was set at $p \le 0.05$. **Results:** Four constructs were identified: (1) "Enhancement of the Profession (EoP)," (2) "Enhanced Patient Care (EPC)," (3) "Enhanced Educator Value (EEV)" and (4) "Enhanced Practice Opportunities (EPO)." Clinician perceptions (4.93 \pm 1.34) were significantly ($p \le .001$) higher regarding the benefit for EoP than faculty (4.32 ± 1.34) , employers (4.37) \pm 1.37), or AA (4.29 \pm 1.57), but the groups were neutral regarding the perceived professional benefit. The stakeholder groups agreed DAT graduates would be effective in EPC, with faculty (5.60 \pm 1.16) and clinicians (5.63 \pm 1.01) reporting significantly ($p \le .007$) higher scores than AA (5.20 ± 1.43) , but not employers $(5.32 \pm 1.26, p \ge .062)$. Clinicians (5.72 ± 1.194) and employers (5.22 ± 1.22) agreed DAT degrees would provide EEV to graduates, which were significantly $(p \le .001)$ higher than faculty (4.64 \pm 1.49) and AA (4.80 \pm 1.40). Clinicians (5.11 ± 1.33) , faculty (4.94 ± 1.38) , and AA (5.06 ± 1.38) agreed a DAT could result in EPO, but significant (p = .018) differences in scores were only found between clinicians and employers (4.70 ± 1.52) ; employers were more neutral regarding a potential benefit. Conclusions: Perceived benefits by stakeholders differ within the constructs, but stakeholders generally agree DAT graduates have potential to provide enhanced patient care, educational value, practice opportunities. Group differences may be due to a lack of understanding regarding the DAT. More research is needed to determine if these benefits are realized.

Candidate and Institutional Predictors of Performance on the Board of Certification Examination

Parham CS, Caswell SV, Caswell AM: George Mason University, Manassas, VA

Context: Research examining national examination data in health professions indicates that individual candidate and higher education institution (HEI) characteristics are significant predictors of performance.1 Athletic training (AT) research has a need to examine how demographic factors relate to student success. To date, no studies have investigated relationships between the Board of Certification examination (BOC) performance and candidate or institutional characteristics. **Objective:** To investigate if candidate and institutional factors predict BOC performance. Design: Retrospective analysis of BOC data from February 2012 to June 2016. Setting: N/A Patients or Other Participants: The dataset included 18,127 first-time candidates, mean age 22.9 ± 2.4 years. Candidates self-reported race and sex on the examination application and were coded as White (n = 12,730) or people of color (POC) (n = 2,926) and female (n = 10,371)or male (n = 7,016). Candidates represented 346 HEI, which were public (n = 190) or private (n = 156) and classified as predominantly White (PWIs) (n = 320), Hispanic-serving institutions (HSIs) (n = 24), or historically Black colleges and universities (HBCUs) (n = 2). All National Athletic Trainers' Association districts were represented. Interventions: Race, age, and sex were level 1 independent variables (IV). Funding type, institution type, and geographic location were level 2 IVs. Main Outcome Measures: The dependent variable was BOC performance. Performance was dichotomously coded as pass or fail. Using multilevel logistic modeling, the dataset was analyzed to determine if the IVs predicted performance. Results: The intraclass correlation for the full model was .2. Race (P

< .001) and sex (P < .001) were statistically significant predictors of performance at level 1. The odds ratio (OR) for POC was .4. POC candidates were less likely to pass than the reference, White candidates. The OR for male was 1.2. Males were slightly more likely to pass than the reference, females. At level 2, attending a private institution (P <.001), HBCU (P < .001), or institution in Districts 5 (P < .05), 8 (P < .05), or 10 (P < .05) predicted performance. The ORs were .6 for private institutions, .1 for HBCUs, .6 for District 5, 2.5 for District 8, and 1.9 for District 10. Private institution, HBCU, and District 5 candidates were less likely to pass than candidates in their reference categories. Districts 8 and 10 candidates were more likely to pass than reference candidates in District 4. Conclusions: The AT profession's racial composition should reflect the populations we serve.² The lower likelihood of POC to pass the BOC examination is concerning. BOC examination failure among POC may propagate AT homogeneity and suppress efforts to confront racial health care disparities. Additional research is necessary to investigate how the combination of demographic and academic variables influence BOC performance.

Elevating Undergraduate to Graduate Education Through the Substantive Change Process: A Report From the Athletic Training Clinical Education Network

Henning JM, Brown S, Taylor L, Anderson BE, Walker SE, Eberman L: Athletic Training Clinical Education Network, Boston, MA; High Point University, High Point, NC; Boston University, Boston, MA; Texas Tech University, Health Sciences Center, Lubbock, TX; A.T. Still University, Mesa, AZ; Ball State University, Muncie, IN; Indiana State University, Terre Haute, IN

Context: Programs have begun transitioning their baccalaureate (BS) programs to master's (MS) programs but it is unknown how the curriculums are changing as the degree level is being elevated. **Objective:** To identify curricular features that differed between BS and MS programs. Design: Cross-sectional. Setting: Online survey (Qualtrics®, Provo, UT). Patients or Other Participants: 381 programs received an email to participate; 119 program directors responded (31.2% response rate) and 17 (14.2%) were eligible for the study through submission of the CAATE Substantive Change indicating they had transitioned or were in the process of transitioning from the BS to the MS. Participants were employed at both public (n = 7, 41.2%) and private (n =10, 58.8%) institutions, predominantly offering a 2-year post-baccalaureate degree (n = 9, 52.9%). Interventions: A 45-item survey; 11 participant and institution/program demographic questions, 3 program planning processes questions, 20 academic alignment and admission criteria differences between the BS and MS degrees questions, 11 curricular feature differences between the BS and MS degree questions. Four educational research experts reviewed the survey to determine face and content validity. Main Outcome Measures: Descriptive statistics and

frequency counts were used to describe data for academic alignment with health professions programs, opportunities for interprofessional experiences, clinical immersion experiences, perception of increased rigor, and use of specific educational strategies. **Results:** Four (24%) programs changed academic units to align with other health professions programs. Planned interprofessional education and practice occurred 2 to 3 times more frequently in MS programs as compared to BS programs. Fifteen (88.2%) MS programs offered clinical immersion compared to 3 (17.6%) BS programs. The majority of programs reported they increased the level of rigor "a lot" or "a great deal" in the current educational competency domains of evidence-based practice (n = 15, 88.2%), clinical examination/diagnosis (n = 12, 70.6%), therapeutic interventions (n =12, 70.5%), psychological strategies/referral (n = 10, 58.8%), and prevention/ health promotion (n = 9, 52.9%). MS programs incorporated capstone experiences (n = 16, 94.1%), high fidelity simulators (n = 11, 64.7%), standardized patients (n = 13, 76.5%), objective structured clinical exams (OSCE) (n = 7, 41.4%), and end-of-program summative assessment exams (n = 13, 76.5%)more frequently than BS programs [capstone experiences (n = 7, 41.2%), high fidelity simulators (n = 6, 35.3%), standardized patients (n = 7, 41.2%), OSCE (n = 3, 17.6%), and end-of-program summative assessment exams (n = 9, 52.9%)]. Conclusions: Our findings indicate that degree elevation has resulted in the use of more high-impact healthcare education practices, including aligning with other healthcare professions, interprofessional education and practice opportunities, clinical immersion, and competency based evaluation tools. As more programs transition to the MS degree, research should continue to understand how programs are elevating the rigor of the curriculum and factors that affect their decision making.

Arizona Athletic Trainers' Awareness and Knowledge of the Executive Summary Consensus Recommendations on the Appropriate Care of Spine Injured Athletes Root HJ, Snyder Valier AR, Kucera KL, Welch Bacon CE, Williams RM: A.T. Still University, Mesa, AZ; University of North Carolina, Chapel Hill, NC

Context: In 2015, the NATA released an Executive Summary on Appropriate Care of Spine Injured Athletes (ES-Spine) through website posting and national and district presentations. Understanding state-specific needs to enhance athletic trainers' (ATs) knowledge of acute spine care best practices and awareness of recommendations is necessary to craft tailored implementation strategies for clinicians. **Objective:** To determine Arizona ATs' knowledge regarding the ES-Spine and determine if and how ATs learned about the ES-Spine. Design: Cross-sectional. Setting: Self-reported online survey. Patients or Other Participants: Of the 506 ATs contacted, 62 (28 males, 34 females; age = 33 ± 10 years) completed the survey (completion rate = 12.4%). Most participants practiced in secondary schools (n = 25/62, 40.3%) and colleges/universities (n = 21/62,33.9%). Interventions: Participants were solicited via email to complete the Athletic Trainers' Beliefs, Attitudes, and Implementation Strategies on Appropriate Care of Spine Injured Athletes (BAISAC-Spine) survey. The BAISAC-Spine consisted of several multipart questions to assess ATs' knowledge, comfort, ease, success, influential factors and barriers related to implementation of the appropriate care of spine injured athletes based on the ES-Spine. The BAISAC-Spine knowledge section included 11 questions specific to the ES-Spine recommendations. Main Outcome Measures: The outcomes of interest were AT knowledge and awareness of the ES-Spine recommendations. Knowledge composite

scores were calculated for each participant by awarding 1 point for correct responses and 0 points for incorrect responses on each of the 11 questions, with scores ranging from 0 (all incorrect) to 11 (all correct). Higher composite knowledge scores indicated greater knowledge of the ES-Spine recommendations. Means, standard deviations, frequencies and percentages were reported. Results: The average composite knowledge score for participants was $(\text{mean} \pm \text{SD}: 6.71 \pm 1.90 \text{ [range: 2.0-})$ 11.0]). Questions most frequently answered correctly related to availability of athletic training services at all sporting events (n = 47/62, 75.8%) and sports medicine team familiarity with protective equipment and removal techniques (n = 46/62, 74.2%). Questions most frequently answered incorrectly related to the 3-person technique for football helmet removal (n = 9/62, 14.5%) and the 8-person lift technique to maintain cervical neutrality during spine boarding (n = 14/62, 22.6%). Only 59.7% (n = 14/62, 22.6%)37/48) of ATs reported they were aware of the ES-Spine. Of those who reported awareness, the most frequently endorsed methods for learning about the recommendations included: the NATA website (n = 17/37, 45.9%), E-blast from professional association (n = 9/37, 24.3%), and course in school or from professor (n = 6/37, 16.2%). The least frequently endorsed method was social media (n = 1/37, 2.7). <u>Conclusions:</u> A gap exists between Arizona ATs' knowledge and the ES-Spine recommendations, and overall levels of awareness are low. These findings highlight a need to increase state specific dissemination efforts through other avenues, like social media, to expand reach and improve knowledge and awareness of appropriate care of spine injured athletes so that best practice guidelines can be implemented.

Experiences of Athletic Trainers Who Have Worked With Athletes With a Physical Disability in School-Based Sports MacDonald RL, Fay D, Snyder Valier AR: A.T. Still University, Mesa, AZ

Context: The United States Department of Education suggests that school-based sports programs provide students with disabilities equal participation opportunities. Athletic trainers (ATs) are central to student athlete safety and health, and their experiences with athletes with disabilities may provide insight into promoting inclusion. **Objective:** To describe the experiences of ATs who have worked with athletes with a physical disability in school-based sports. Design: Cross-sectional. Setting: Online Survey. Patients or Other Participants: 6,417 secondary school ATs were invited through email to complete the survey. 894 ATs accessed the survey and 598 completed the entire survey (completion rate = 66.9%). Most respondents were 21-40 years old (69.9%, n = 432) and female (59.5%, n = 365), with over 3 years experience (85.8%, n = 532). 81.7% (n = 495) of respondents worked in public schools. Interventions: A 45-question survey was created to gather insight into AT's' experiences with providing athletic training services to athletes with physical disabilities in school-based sports. Questions related to exposure to types of physical disabilities, challenges and modifications to care, as well as familiarity, confidence, and comfort with managing care of athletes with physical disabilities. A 3-stage survey validation process consisting of expert panel reviews of content, length, format, and readability was used to create the survey. Email invitations were sent in Fall 2016, with reminders at 2 and 5 weeks post-initial invite. Main Outcome Measures: Responses to survey questions are reported as frequencies and percentages. **<u>Results</u>**: Of respondents, 54.0% (n = 416/771) indicated experience providing athletic training services to athletes

with physical disabilities and 46.0% (n = 355/771) indicated they had not. Most ATs (61.3%, n = 211) reported working with 1-3 athletes with a physical disability. The most frequent physical disabilities experienced were hearing impairments (23.5%, n = 169/719), traumatic brain injuries (13.6%, n = 98/719) and visual impairments (13.2%, n=95/719). Football (18.7%, n = 167/892), trackand-field (12.7%, n = 113/892), ambulatory basketball (10.8%, n = 96/892), and soccer (10.3%, n = 92/892) most frequently had team members with physical disabilities. Most ATs (81.3%, n = 274/337) reported not needing to make changes to athletic training related processes or spaces to support inclusion of athletes with a physical disability, but of those who did (18.7%, n = 63)the most frequent adjustments were to emergency action plans (29.1%, n = 32)and standing orders (22.7%, n = 25). About half of ATs reported they were somewhat or very familiar with safety considerations (51.8%, n = 284/548)and injury prevention strategies (50.4%, n = 276/547) related to care of athletes with physical disabilities, and were confident (49.0%, n = 270/551) and comfortable (52.4%, n = 288/550) with providing care. Conclusions: While a large percentage of athletic trainers reported exposure to and familiarity with care of athletes with physical disabilities in school-based sports, many did not. These data provide baseline information related to experiences with student-athletes with disabilities and may initiate conversations related to the role ATs could play in inclusion efforts.

Preceptors' Frequency and Supervision of Athletic Training Students' Medical Documentation During Clinical Education Neil ER, Welch Bacon CE, Nottingham SL, Kasamatsu TM, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN; A.T. Still University, Mesa, AZ; Chapman University, Orange, CA: California State University, Fullerton, CA

Context: Athletic trainers (ATs) who serve as preceptors for athletic training students (ATS) must model, facilitate, and guide professional skills and behaviors, including medical documentation. Documentation has been reported as an area of weakness in clinical practice, and preceptors have the unique ability to combine skill practice with real-time patient encounters for ATSs. **Objective:** To describe the frequency of preceptors who allow ATSs to complete medical documentation, and investigate the rationale for and supervision of their decisions. Design: Crosssectional survey, with qualitative analysis. Setting: Web-based survey (Qualtrics®) with open-ended responses. Patients or Other Participants: 1,216 of 9,578 ATs responded to the survey sent via email (access rate 12.7%) and among the 959 individuals who completed the survey, only 382 participants indicated they were a preceptor for a professional athletic training program. Participants (age = 34 \pm 11 y, clinical practice experience = 11 \pm 10 y) were predominantly female (n = 207, 54.8%) and held a masters degree (n = 259, 62.4%). Interventions: The survey was developed (Cronbach's α = 0.887) from previous qualitative inquiry, and content validity was established by expert group analysis. Open-ended responses were separated from the remaining data for this analysis. Main Outcome Measures: A 3-member data analysis team coded the information following the consensual qualitative research approach. Each member checked the first 50 responses and created a consensus codebook. The remainder of the coding was completed by the primary investigator and confirmed by the data analysis team. Data were categorized based on the emergent themes, and responses were categorized as more than one code when appropriate. Frequency counts were calculated for each of the categories. Results: 82.5% of participants (n = 315) allowed their ATSs to complete medical documentation. Five themes emerged regarding the rationale to allow/not allow ATSs to complete medical documentation. 337 total participants noted that logistics of documentation (n = 177, 52.5%) including the specifics of how medical documentation occurs, providing opportunities for practice and experience (n =167,49.6%), and facilitating learning and developing/demonstrating competence (n = 159, 47.2%) were among the more common reasons to allow ATSs to document patient encounters. However, participants noted the degree of oversight to the ATS (n = 110, 32.6%) and deterrents to documentation $(n = 63, \dots, m)$ 18.7%) also influenced their decision. When a preceptor allowed an ATS to complete medical documentation, supervision of ATS was influenced by the logistics (n = 233, 74.0%) and deterrents of documentation (n = 15, 4.8%) along with the degree of oversight (n = 189,60.0%) required. Conclusions: While a large majority of preceptors stated they allowed ATSs to complete medical documentation in clinical education, the reasons to allow them varied and implied additional work and oversight by the AT. Most preceptors provide direct supervision or have experienced logistical issues with ATSs completing medical documentation. Preceptors would benefit from formal and informal training that facilitates their allowance of students to complete quality medical documentation.

Athletics Health Care Administrator: Selection, Implementation, and Perceived Impact on NCAA Division I Athletics Degerstrom SD, Neil ER, Laursen RM, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN; Boston University, Boston, MA

Context: In 2016, National Collegiate Athletics Association (NCAA) Division I institutions opted into legislation to provide an athletics health administrator (AHCA) that create and enforce an administrative structure of independent medical care. **Objective:** To describe AHCA selection, the position implementation, and perceived impact of independent medical care. Design: Crosssectional, qualitative survey. Setting: Web-based survey (Qualtrics[®], Provo, UT). Patients or Other Participants: 338 Division I Head Athletic Trainers (AT)/Directors of Sports Medicine (supervising ATs); 162 individuals (47.9% response rate); male (n = 117, 72.2%); 8 ± 5 staff ATs; traditional model of athletic healthcare delivery (n = 139, 85.8%). Interventions: We developed a survey that focused on descriptive characteristics of the institution and athletic training unit. Five open-ended items were included. A key variable of interest was what healthcare model used at the institution: athletics model, academic model, medical model internal to the institution, and medical model that external to the institution. We evaluated the instrument using an expert panel to establish content validity. Main Outcome Measures: The main outcome measures included the process for selecting the AHCA, perceptions of how the AHCA position will ensure independent medical care, how the AHCA position has been provided support for its role in medical oversight, and the decision making and reporting structure at the institution. We calculated descriptive statistics to describe the

institution and athletic training services unit. We used a qualitative inductive approach to identify themes and supporting categories. Trustworthiness was established using cross analysis and external review. Results: AHCA selection occurred by appointment, through collaboration among stakeholders, or through consensus (internal to the institution, through a member organization, or athletic conference). Most frequently, the position was filled by the supervising AT (n = 92, 56.8%) by appointment (n = 120, 74.1%); however, participants indicated a lack of consultation with higher administration, a lack of selection criteria, and little consideration of the additional administrative load assigned to the AT when selecting the AHCA. Supervising ATs perceived that there would be little impact of the AHCA on healthcare delivery; this was expressed both by participants describing a strong culture of independence and those that described not having a strong culture of independent medical care. Supervising ATs described a healthcare model that was predominantly supervised under athletics, but that the team physician heavily influenced patient care decisions. They also described an environment where ATs, physicians, and coaches were part of reporting and decision-making, yet they rarely indicated that patients played an influential role in their own care. Conclusions: Supervising ATs were predominantly selected as the AHCA at their respective institutions and they are confident they are providing patient care that is independent of external influence, with or without an AHCA. Yet, they describe decision-making processes that are clinician-centered and often do not include patient input.

Free Communications, Poster Presentations: Balance Outcomes

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present lune 24: Deer Paview Authors - Lest Nernes A through Mi 10:20AM 11:15 + Mi Paer

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Balance Outcomes With Different Modes of Augmented Feedbacks Using the Modified Star Excursion Balance Test

Davis B, Saville S, Kaptaine Z, Pritchard K, Pye M: Shenandoah University, Winchester, VA

Context: Augmented feedback is any external source that provides some type of information that can facilitate learning. Various modes of feedbacks can be implemented in rehabilitation in to improve neuromuscular control performance such as, visual, auditory, and tactile. Although research has shown that visual feedback is beneficial for multijoint movements, we were interested in determining the most auspicious timing for providing feedback: concurrent or delayed. Concurrent feedback allows an individual to focus on a visual cue during performance. Whereas delayed feedback allows an individual to view their performance afterwards to look for any changes that may be needed to aid in the activity. **Objective:** To determine if visual augmented feedback (concurrent or delayed) will improve balance outcomes in healthy individuals compared to no feedback. Design: Randomized Control Trial. Setting: Shenandoah Athletic Training Room, University of Richmond Athletic Training Room. Patients or Other Participants: 47 recreationally active healthy individuals $(22 \pm 2.4 \text{ years}; 172.3 \pm 10.4 \text{ cm}; 74.7$ \pm 14.4 kg) participated in this study. Participants had no lower extremity injury or concussion within the past 6 months, not pregnant, and not diagnosed with a vestibular or neurological disorder. Interventions: Modified Star Excursion balance test with a mirror for concurrent feedback, an iPad using the HUDL app for delayed feedback, and a control with no feedback. Main Outcome Measures: Normalized composite reach distance on the Modified Star Excursion Balance Test were calculated ((anterior + posterior medial + posterior lateral)/3 * 100%) were calculated for each intervention group (no feedback, concurrent feedback, and delayed feedback). A two-way repeated measures ANOVA with Bonferroni post hoc tests was used to assess differences in normalized composite reach distance between groups. Results: Concurrent feedback (88.8 \pm 0.09 cm; p = .001) and delayed feedback (89.7 \pm 0.08cm; p = .001) both showed statistical significance for improving balance outcomes compared to the control group (86.5 \pm 0.1 cm). We observed a main effect for group (F(1,7) = 17.645, p < 0.001); however, there was no statistical difference between concurrent feedback and the delayed feedback group (p = 0.188). Conclusions: The clinical implication to this study is that it may be beneficial to integrate feedback during balance training. Whether that be concurrent feedback using a mirror, or delayed feedback using the HUDL app. Visual feedback was proven with statistical significance to increase reach distance compared to no feedback. Future research will need to examine the retention of balance improvements from each feedback group, as well as seeing if the dynamic balance improvements would transfer to other functional tasks commonly performed by athletes.

Reactive Balance Following Acute Lateral Ankle Sprain

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Context: It is well documented that acute lateral ankle sprain (ALAS) impairs postural control. However, the impairment was commonly found in a steady-state balance condition where patients were asked to maintain upright posture. Reactive balance, characterized by recovery of balance when it is perturbed, is more important in an injurious situation, but it is unknown that the reactive balance is altered in patients with ALAS. **Objective:** To examine effects of ALAS on reactive balance. Design: Casecontrol. Setting: Laboratory. Patients or **Other Participants:** Nineteen patients with ALAS that had occurred within 72 hours (9 men, age = 21 ± 2.7 yrs, height = 173.2 ± 9.2 cm, mass = $71.7 \pm$ 11.7 kg) and 19 healthy matched controls (CON) without any history of ankle sprain (9 men, age = 22 ± 2.2 yrs, height = 170.8 ± 9.2 cm, mass = 68.9± 14.2 kg) participated. Interventions: Motor Control Tests (MCT) was used to assess reactive balance. During MCT, each subject was asked to bilaterally stand, and quickly recover following either forward or backward perturbation of support surface with 3 different strengths: small, medium, and large. Three trials of 6 tasks on MCT were performed in the order of small, medium, and large perturbations in the backward direction, and followed by the forward. Main Outcome Measures: Reactive balance was quantified by reaction time in millisecond between the onset of support surface perturbation and subject's reactive responses in both legs: the shorter reactive time indicates

better reactive balance. Averages of 3 trials in each perturbation condition were used for statistical analysis. Separate 2 (group) by 2 (limb) repeated ANOVAs were conducted with an alpha level set at .05. Results: There were no significant interactions for any of perturbations: small backward $(F_{(1,17)} =$.303, P = .59), medium backward ($F_{(1,18)}$ = 2.520, P = .13), large backward ($F_{(117)}$ = .066, P = .80), small forward $(F_{(1,15)} =$.001, P = .98), medium forward ($F_{(1,16)}$ = .999, P = .33), large forward $(F_{(1,15)} =$.932, P = .35). Similarly, there were no significant main effects for group and limb (P > .05). For display of descriptive data, ALAS and healthy matched control's means and standard deviations are presented: small backward (ALAS: 141.99 ± 12.50 , CON: 137.54 ± 19.35 ms), medium backward (ALAS: 135.59 \pm 13.52, CON: 129.82 \pm 8.44ms), large backward (ALAS: 128.07 ± 12.16 , CON: 125.34 ± 7.10 ms), small forward (ALAS: 149.08 ± 17.51, CON: 134.63 \pm 17.43 ms), medium forward (ALAS: 135.65 ± 13.75 , CON: 137.39 ± 24.90 ms), large forward (ALAS: 128.47 \pm 11.08, CON: 120.94 \pm 10.05 ms). **Conclusions:** Reactive balance during recovery of upright posture following support surface perturbation was not significantly delayed following ALAS. This may be due to the reflexive control of muscle spindles in ankle muscles that were not affected by ALAS.

Prediction of Balance Deficits From Patient-Reported Outcome Measures in Older Adults Richason MD, Docherty CL, Simon JE: Ohio University, Athens, OH; Indiana University, Bloomington, IN

Context: It has been shown that fall risk increases as an individual's age increases. Due to the increase in number of falls, falls have become the most prevalent accident and injury in individuals who are older aged. This can lead to consequences relating to time, money, and injuries to the individuals affected. **Objective:** Evaluate the predictive ability of patient-reported outcomes on a clinical balance measure. Design: Cross-sectional. Setting: Research laboratory. Patients or Other Participants: Two-hundred individuals $(52.13 \pm 7.37 \text{ years}, 83.22 \pm 18.33)$ kg, 175.97 ± 14.76 cm) volunteered to participate in this study. The participants were between the ages of 40 and 65 years old, answered "no" to all questions on the Physical Activity Readiness Questionnaire (PAR-Q), and were cleared by a physician to participate in physical activity. Interventions: The participants were asked to complete two patient-reported outcome scales (American Academy of Orthopaedic Surgeons (AAOS) Foot and Ankle Questionnaire and the Knee Injury and Osteoarthritis Outcome Score (KOOS)). Additionally, participants were asked to complete the Balance Error Score System (BESS) test. Each participant completed two practice trials of the full BESS test before the recorded BESS test to account for the learning effect associated with the BESS. The BESS was performed in a combination of three postural positions (single leg stance, double leg stance, tandem stance) and two standing surfaces (firm and foam). Each BESS condition was 20 seconds with the participant's eyes closed and their hands on their hips. For each error in the participant's postural stability (i.e., moving the hands off of the iliac crests) one point was given with a maximum error score being 10 per position.

Main Outcome Measures: The outcome variable was the total BESS score with the predictor variables, score on the AAOS foot and ankle questionnaire, KOOS-pain, KOOS-symptom, KOOS-ADL, KOOS-Sport, and KOOS-OOL scales. A multiple forward stepwise regression was run to predict BESS total score from the scores on the AAOS foot and ankle questionnaire, KOOS-pain, KOOS-symptom, KOOS-ADL, KOOS-Sports, and KOOS-QOL. Results: The assumptions of linearity, independence of errors, homoscedasticity, unusual points and normality of residuals were met. The model retained two predictors KOOS-Sport and KOOS-OOL. All other predictors did not contribute more than 2.0% to Adj R² and were not retained in the model. KOOS-Sport and KOOS-QOL statistically significantly predicted balance, $F_{(1, 198)} = 279.356$, p < .001, adj. $R^2 = 0.586$. Specifically, for every decrease of one point on the KOOS-Sport or KOOS-QOL, there was an increase in total BESS score by 1 error. Conclusions: The findings concluded that patient reported outcome scales, such as the KOOS, could be effective tools in identifying individuals with possible balance deficits. Specifically, it was found that the KOOS sport/recreation and QOL scales were significant.

Single-Leg Hop for Distance Limb Symmetry and Performance Following a Lower Extremity Injury

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Context: The use of the contralateral limb to determine return to play readiness after injury is a common clinical practice. However, the dependence on limb symmetry performance between the injured and uninjured limbs for return to play decision making is likely flawed as the uninjured limb has up to a 15 times greater risk of injury relative to those who have no injury history. **Objective:** To determine limb symmetry and performance on the single-leg hop for distance (SLHOP) pre lower extremity injury and at return to play. Design: Cross-sectional. Setting: High school gymnasium. Patients or Other Participants: Two-hundred thirty-six adolescent athletes $(15.69 \pm 1.36 \text{ years})$ 171.12 ± 7.57 cm, 70.34 ± 15.31 kg) completed the SLHOP before the beginning of the season (pre-injury). Thirty-four adolescent athletes sustained a lower extremity injury (22 ankle and 12 knee) and missed at least three days of sports participation $(15.05 \pm 1.02 \text{ years}, 168.57 \text{ })$ ± 5.12 cm, 69.31 ± 12.42 kg). All participants were members of their respective high school's football, girls' volleyball, or boys' or girls' basketball (14 football, 7 volleyball, 6 girls' basketball, and 7 boys' basketball). Interventions: All individuals had completed the SLHOP before the beginning of the season (pre-injury) and at discharge (post-injury). Each participant performed three trials of the SLHOP per leg during each testing session (alternating legs). To be counted as a successful trial the participant had to maintain postural stability for two seconds after the landing and the contralateral leg was not allowed to touch the ground. The maximum distance across trials was used for all analyses. Main Outcome Measures: The independent variable was time (pre-injury and post-injury). The dependent variables were injured and un-injured leg SLHOP distance (centimeters), and SLHOP symmetry (% = maximum distance of injured)limb/maximum distance of uninjured limb*100). Three dependent t-tests were conducted for each dependent variable. Alpha level with a Bonferroni correction to account for multiple t-tests was set at 0.017. Results: A degradation of 30% (mean difference: $30.23 \pm$ 8.53 cm, p < 0.001) in SLHOP distance was seen pre-injury to return to play on the injured side but also on the uninjured side 22% (mean difference: 22.36 \pm 7.62 cm, p < 0.001). Limb symmetry was not significantly different pre-injury to return to play (93.1% vs 94.6%, p = 0.18). <u>Conclusions:</u> Following a lower extremity SLHOP performance degrades not only for the injured limb but also the uninjured limb. However, limb symmetry did not change following a lower extremity injury. Limb indices may overestimate function after injury while performance deficits still exist. These data support the need for baseline testing instead of depending on the uninjured limb to determine return to play decision making.

A 4-Week Supplemental Plyometrics or Balance Training Program Does Not Change Lower Body Power, Balance, and Reaction Time in Collegiate Basketball Athletes: A Randomized Control Trial

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Context: The high-intensity nature of playing sports like basketball requires athletes to repeatedly perform quick movements with sudden directional changes as players react to stimuli. Accordingly, high ankle and lower body injuries rates exist in basketball. Practitioners often integrate plyometric training programs that include quick explosive motions into training programs to improve performance and reduce injury risk. Improved balance is also associated with decreased injury risk. However, whether these training programs improve jump, sprint, and agility in athletes remains unclear. **Objective:** Examine the effects of a 4-week supplemental plyometric training or balance training program on lower body power, balance, and reaction time in collegiate basketball athletes. Design: Randomized-Controlled-Trial Setting: University Patients or Other Participants: Twenty-Six National Collegiate Athletic Association Division III men's and women's basketball players, $(14 \text{ women}, 10 \text{ men}; 18 \pm 2.2 \text{ years}, 172.5)$ \pm 9.4 cm, 71.9 \pm 8.9 kg) **Interventions:** Participants were randomly assigned to 3 different training groups: (1) Plyometric (n = 8), (2) Balance (n = 9), (3) Control (n = 7). Participants' in the plyometric and balance training groups performed supplemental plyometric and balance training 2 times per week for 4 weeks in the pre-season with the control

group not performing any added training outside of regular practice. Main Outcome Measures: Separate 2 (time: pre, post-within) x3 (group: plyometric, balance, control-between) repeated-measures ANOVAs with adjusted-Bonferroni pairwise-comparisons examined participants' Single leg triple hop (SLTH,m), Balance Error Scoring System (BESS, error score) scores, and Reactive Agility (RA,s) scores before and after training. P < .05 **Results:** Overall, no interactions existed across all analyses. Participants' scores remained similar before and after training (SLTH: $F_{2.21} = 2.1$, p = 0.15; BESS: $F_{2,21} = .52$, p = 0.6; RA: $F_{2,21} =$ 2.2, p = .13). Overall the groups had similar SLTH($F_{2,2} = 0.07$, p = 0.80) and BESS scores ($F_{2,2} = 3.8$, p = 0.06). Although the groups had different RA scores ($F_{2,2} = 22.2, p < .001$), Bonferroni pairwise-comparisons did not reveal pairwise group differences between scores. Conclusions: A 4-week supplemental plyometric training and balance training programs did not change lower body power, balance, and reactive agility time in collegiate basketball athletes. Possible reasons for these findings may include the short time and frequency of the training programs, and the fact that the collegiate athletes were already performing at a higher level of physical performance. The intensity of the programs may also not have been demanding for collegiate athletes. The optimal dosage and intensity of training programs that can effectively alter functional outcomes in collegiate athletes needs further study, so that athletic trainers can implement these programs to improve performance and possibly decrease injury risk in basketball and other athletes.

Predictors of Center of Pressure Velocity in Healthy High School Athletes

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Context: Center of pressure excursion velocity (V-COP) is a commonly used balance measure. Faster V-COP in single limb stance has been linked to increased risk of lower extremity injury. Understanding other relevant COP factors that influence V-COP may assist in the interpretation of injury risk assessment and intervention using instrumented technology. **Objective:** To quantify the influence of complex COP measures that take into account excursions and the size of the base of support on V-COP for medial-lateral (ML) and anterior-posterior (AP) directions. Design: Cross-sectional study. Setting: Nine local high school gymnasia. Patients or Other Participants: 182 interscholastic basketball athletes (n males = 73, n females = 109; age = 15.7 ± 1.4 yrs; height = 153.3 ± 30.5 cm; mass = 68.5± 4.2 kg). Interventions: Participants performed 3 trials of 10s single-limb stance on a force plate with eyes-closed on each leg. COP data were extracted and averaged across trials. Independent variables (predictors) for both directions of COP excursions included 1) the COP standard deviation (SD-COPML, SD-COPAP), 2) the mean of time-toboundary minima (TTBML, TTBAP), and 3) the standard deviation of TTB minima (SD-TTBML, SD-TTBAP). Main Outcome Measures: Dependent variables included V-COP in both directions (V-COPML, V-COPAP). Separate stepwise linear regression models determined the best predictors of V-COPML and V-COPAP. All 6 predictors were entered into each model regardless of direction. Alpha level was $p \le 0.05$ to enter the model. For predictor variables that met statistical significance and were included in the model, an additional threshold of 5% adjusted R² change was applied for predictors to remain included. Results: No substantial side differences were identified, therefore limb data were pooled. For V-COPML (m: 5.1 ± 1.2 cm/s), substantial predictors were TTBML (m: 0.8 ± 0.3 s; r:-0.79; adjusted R^2 : 62.0%; p < .001) and SD-COPML (m: 1.0 ± 0.2 cm; r: 0.73, adjusted R²: 80.2%; p < 0.001). The SD-TTBML and SD-TTBAP were statistically significant, however did not reach the 5% adjusted R² threshold. TTBAP and SD-COPAP were not statistically significant. For the V-COPAP (m: 5.0 \pm 1.5 cm/s), substantial predictors were TTBAP (m: 2.2 ± 0.7 s; r: -0.86; adjusted R²: 74.6%; p < .001) and SD-COPAP (m: 1.4 ± 0.4 cm; r: 0.75; adjusted R²: 83.5%; p < 0.001). For the AP direction, SD-COPML and SD-TTBAP were statistically significant, however did not reach the 5% threshold. TTBML and SD-TTBML were not statistically significant. Conclusions: V-COP is a result of both displacement (cm) and time (s). Accordingly, the strongest predictor of V-COP was TTB, which captured the critical points of balance. Lower TTB indicated the participant was approaching the boundaries of the foot faster, and had less time to make corrections. Concurrently, larger SD-COP indicated larger variation in COP excursion. This prediction model explained approximately 80% of the V-COP variance. Individuals who demonstrate faster V-COP have less time to make corrections, with more variable excursions when corrections do occur. The use of V-COP as a balance variable can be more meaningfully interpreted as its use in instrumented technology for risk assessment is expanding.

Effect of Kinesiology Tape to the Gluteus Medius on Lower Extremity Balance

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Context: Kinesiology tape is often used in an attempt to correct balance related issues caused by weakness or decreased proprioceptive sense in the gluteus medius muscle. At this time, little evidence is available to support the use of kinesiology tape of the gluteus medius to improve balance. **Objective:** The purpose of this study was to examine if the application of kinesiology tape to the gluteus medium muscle of the hip region improves balance measures of the lower extremity in a population of healthy physically active participants. Design: Repeated measures design. Setting: Laboratory setting. Patients or Other Participants: Eighteen (18) physically active female participants (20.33 + 1.19 yrs. old, 175.26 + 7.29 cm, 59.03 + 10.87 kg). Interventions: Kinesiology tape for the gluteus medius muscle was applied in a Y fashion starting at the lateral surface of the greater trochanter with no tension. The anterior tail of the tape pulled toward the anterior inferior iliac spine and the posterior tail of the tape was pulled toward the posterior inferior iliac spine. Kinesiology tape was applied in two conditions, 50% tension of the tape and 100% tension on the tape. Main Outcome Measures: The NeuroCom Balance Manager VSR Sport (Natus Medical Inc., Seattle, WA) was used to measure sway velocity (°/s) with the participant barefoot under three conditions (no tape, tape with 50% tension, and tape with 100% tension). Balance of the non-dominant leg was assessed in a single leg stance during a 20-second trial on a stable and unstable surface using an Airex foam pad. Assignment of the independent variables was counter-balanced to minimize the effects of learning and fatigue associated with the testing procedures. Separate univariate repeated measures analysis of variance was used to

analyze the difference in sway velocity between the no tape, tape with 50% tension, and tape with 100% tension during stable and unstable balance assessment. All tests of significance were carried out at an alpha level = 0.05. Results: Significant differences for stable stance between condition (barefoot = $1.91^{\circ}/s$ \pm 0.63, 50% tape tension = 1.64°/s \pm 0.51, and 100% tape tension = $1.79^{\circ}/s$ \pm 0.58) was not found (F_{2.34} = 1.99, p = 0.15). Significant differences for unstable stance between condition (barefoot $= 3.36^{\circ}/s \pm 1.07$, 50% tape tension = $3.53^{\circ}/s \pm 1.01$, and 100% tape tension = $3.54^{\circ}/\text{s} \pm 1.11$) was also not found (F_{2.34} = 0.26, p = 0.77). <u>Conclusions</u>: Results from this study indicate that kinesiology tape of the gluteus medius did not affect balance in healthy physically active participants. Future research should focus on testing an athletic and/or physically active population with a history of hip or pelvis musculoskeletal pathology to determine if kinesiology tape effects balance in individuals with potential musculoskeletal deficits

The Inter-Rater and Intra-Rater Reliability of the Star Excursion Balance Test and Y-Balance Test: Systematic Review

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Context: Dynamic balance is essential for sport and activities of daily life. As such, it has been used as a predictor of lower extremity injury and as a returnto-play criteria following injury. Due to dynamic balance's role in clinical decision making, it is imperative to ensure current quantification methods are reliable. **Objective:** To conduct a systematic review to synthesize the evidence describing the inter-rater and intra-rater reliability of the Star Excursion Balance Test (SEBT) and Y-Balance Test (YBT). Data Sources: Electronic databases (PubMed, MEDLINE, and SportDiscus) were searched from inception through March 2017. Search was completed using a combination of key words related to the SEBT, YBT, and reliability. A hand search of references was also completed. Search limits were full text publications written in English. Study Selection: Inclusion criteria required that studies evaluated the inter-rater and or intra-rater reliability of the SEBT/YBT, were peer reviewed, and included human participants free of lower extremity injury. Articles were excluded if they did not evaluate reliability using intraclass correlation coefficients (ICC) or failed to provide the data needed to calculate this statistic and if the primary patient population were under 18 years of age. Data Extraction: The Quality Appraisal of Diagnostic Reliability (QAREL) was used to determine the quality of included studies. The level of evidenced was assessed using the Strength of Recommendation Taxonomy. ICCs, standard error measurement (SEM), and minimal detectable change (MDC) were extracted or calculated from the included studies for the anterior, posteromedial, and posterolateral reach directions of the SEBT/YBT. Data Synthesis: Nine studied met the inclusion criteria and

were included. Eight studies examined the inter-rater reliability of the SEBT/ YBT (QAREL Median = 59%, Range = 33-77%). Five studies examined the intra-rater reliability of the SEBT/YBT (OAREL Median = 62%, Range = 33-77%). Anterior reach inter-rater reliability had a median ICC of 0.92 (Range = 0.83-1.00) and a median normalized MDC of 4.95% (Range = 4.40-10.20%) and non-normalized 2.23cm (Range = 1.91-9.42 cm). Anterior reach intra-rater reliability had a median ICC of 0.89 (range = 0.84-0.94) and a median MDC of 5.79% (Range = 1.80-8.99%) and non-normalized 5.74cm (Range = 5.57-6.93 cm). Posteromedial reach inter-rater reliability had a median ICC of 0.91 (range = 0.84-1.00) and a median MDC of 8.90% (Range = 6.90-10.41%) and non-normalized 3.27cm (Range = 1.88-8.87 cm). Posteromedial reach intra-rater reliability had a median ICC of 0.885 (range = 0.82-0.94) and a median MDC of 8.28% (Range = 6.68-10.7%) and non-normalized 7.44cm (Range = 6.10-11.06 cm). Posterolateral reach inter-rater reliability had a median ICC of 0.88 (range = 0.73-1.00) and a median MDC of 10.76% (Range = 9.00-12.30%) and non-normalized 2.35cm (Range = 2.02-12.20 cm). Posterolateral reach intra-rater reliability had a median ICC of 0.92 (range = 0.86-0.94) and an median MDC of 9.98% (Range = 7.11-12.70%) and non-normalized 7.62cm (Range = 6.40-8.62 cm). Conclusions: There is Grade B evidence that the SEBT/YBT has good intra-rater and inter-rater reliability in all three reach directions. This indicates that the SEBT/ YBT is a consistent measure of dynamic balance between raters and over time. Furthermore, this review provides summary values of responsiveness.

Sex Differences in Loading Characteristics During a Single-Leg Jump Landing Task

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Context: Females exhibit larger jump landing vertical ground reaction forces(vGRF) as compared to males following ACLR, which has been significantly correlated with greater knee abduction loading. However, it is unclear if there are sex differences in loading characteristics present among healthy males and females or if this difference is a consequence of knee joint injury. Sex differences in loading characteristics during a challenging lower extremity task, such as a single leg landing, may contribute to increased risk of knee injury in females. **Objective:** To compare sex differences in normalized vGRF and linear loading rate(LLR) during a single-leg jump landing task among healthy male and female participants. Design: Descriptive Study Setting: University Laboratory. Patients or Other Participants: Twenty-five healthy, recreationally active, males (age = 24.0 ± 4.1 years, height = 180.0 ± 7.3 cm, weight = 81.9 ± 9.6 kg) and twenty-one females $(age = 22.3 \pm 3.0, height = 168.9 \pm 9.3)$ cm, weight = 65.9 ± 11.9 kg) volunteered for this study. Interventions: None. Main Outcome Measures: Participants performed five single-leg landings from a 30 cm box onto a target that was centered on a force plate. VGRF was sampled at 1,200 Hz and filtered through a 4th order Butterworth filter with a cutoff of 100Hz prior to analysis. Average peak vGRF (N) was calculated across 5 single-leg landing trials for each limb and was then normalized to body weight (xBW). Linear loading rate (BW/s) was defined as the slope of the vGRF data from initial contact (vGRF > 10 N) to peak vGRF. Percent asymmetry was calculated for mean vGRF and LLR by calculating the absolute difference between observed limb symmetry(LS_{observed}

= (right limb/left limb)*100) and optimal limb symmetry (LS_{optimal} = 100%). Separate between sex comparisons of right limb and left limb normalized vGRF and LLR were made using independent samples t-tests. Between limb percent asymmetry for each outcome measure was also compared using separate independent samples t-tests. The magnitude of sex differences were estimated using Cohen's d effect sizes and 95% confidence intervals. Results: Males exhibited a significantly greater normalized vGRF in the right limb $(male = 4.30 \pm 0.62 \text{ x BW}, female =$ $3.83 \pm 0.67 \text{ x BW}, P = 0.02, d = -0.73,$ UB = 0.13, LB = -1.33) but not left limb $(male = 4.11 \pm 0.58 \text{ x BW}, female = 3.8)$ \pm 0.51 x BW, P = 0.06, d = -0.58, UB = 0.01, LB = -1.17) or between limb asymmetry (male = 7.02 ± 5.14 , female $= 7.17 \pm 0.56$, P = 0.92, d = 0.03, UB = 0.61, LB = -0.55) compared to females. There were no significant sex differences for LLR in the left limb (male = 79.80 ± 18.55 BW/s, female = $75.70 \pm$ 24.55 BW/s, P = 0.62, d = -0.19, UB = 0.56, LB = -0.94), right limb (male $= 74.35 \pm 21.72$ BW/s, female = 82.36 \pm 16.74 BW/s, P = 0.28, d = -0.42, UB = 1.16, LB = -0.32), or percent asymmetry (male = $10.84 \pm 10.44\%$, female $= 10.59 \pm 11.53\%$, P = 0.95, d = -0.02, UB = 0.76, LB = -0.72). Conclusions: Limb differences were present between sexes; however no symmetry-based differences were found for normalized vGRF or LLR. Sex differences in lower extremity loading may be present in healthy and physically active populations which may have implication for knee injury risk.

Does Verbal Encouragement Change Reach Distances? The Effect of Verbal Encouragement on Star Excursion Balance Test Performance

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Context: Quantification of postural control is among the most important measures for assessing patients' injury status and function for devising an appropriate plan of care. It is of great interest for clinicians to formulate objective methods for assessing postural control that are easy to administer. Star Excursion Balance Test (SEBT) is one of the most commonly used functional balance assessment tools in sports medicine with maximum reach distances taken as the measure of postural control. However, the effect of verbal encouragement on the ability to perform maximum reaches has not been investigated. **Objective:** To investigate the effects of verbal encouragement on maximum reach distance performance in healthy college age subjects. Design: Repeated-Measure design. Setting: Laboratory. Patients or Other Participants: 14 Healthy subjects (6 men, 8 women; age = 19.07 ± 0.73 years; height = 171 ± 9.88 cm; mass = $67.06 \pm$ 12.58 kg) participated. Interventions: Participants performed the SEBT with standard instructions followed by another performance in a similar manner but with verbal encouragement. Main **Outcome Measures:** Anterior (ANT), Posteromedial (PM) and Posterolateral (PL) reach distances (cm) were measured in SEBT trials conducted and composite score (cm) was also calculated. Adequate practice trials were performed before the measurements were taken to control for learning effects. The average of the three maximum reach distance measures were taken in each direction for both conditions. All the reach distances were normalized to the leg length of the participants. Mean and SD were calculated for all the individual and composite reach scores for each limb. Paired t-tests were utilized to make the comparisons between the two conditions with 95 % confidence intervals. Results: Statistically significant differences (p < 0.05) were found between the two conditions for all the normalized individual and composite reach distance scores when verbal encouragement was used. The reach distance scores with verbal encouragement for the right limb ANT (73.50 ± 4.46) , PM (86.29 \pm 8.52), PL (78.51 \pm 10.68), composite (79.43 ± 7.49) were found to be significantly higher than ANT (70.06 ± 4.55), PM (79.97 ± 9.54), PL (74.34 ± 10.75) and composite (74.79) \pm 7.47) reach scores without verbal encouragement. Similarly, the reach distance scores with verbal encouragement for left limb ANT (73.99 \pm 3.96), PM (87.87 ± 8.92) , PL (78.70 ± 9.39) , composite (80.19 ± 6.30) were significantly greater than ANT (68.57 \pm 4.45), PM (82.18 ± 10.52) , PL (74.37 ± 10.06) and composite (75.04 ± 7.54) reach distance scores without verbal encouragement. **Conclusions:** Significant improvement was seen in the SEBT performance with verbal encouragement. Motivation of participants can play an integral role in driving effort to aim for maximum reach distances while performing the SEBT. Motivational status of the participant should be taken into consideration in addition to the balancing ability and strength measures while interpreting the maximum reach distances.

The Immediate Effects of a Visual-Motor Targeted Neuromuscular Intervention Hosier KD, Simon JE, Starkey C, Grooms DR: Ohio University, Athens, OH

Context: Vision training can enhance skills like reaction time, anticipatory timing, and memory. The recent advent of stroboscopic glasses allow visual feedback to be altered during neuromuscular training to potentially improve visual-motor function. Objective: Determine if a stroboscopic visual feedback disruption addition to standard injury prevention training could improve lower extremity visual motor performance. Design: Randomized cohort. Setting: University gymnasium. Patients or Other Participants: Twenty-two physically active (Tegner >7) participants were recruited. Eleven individuals were randomly selected for the control group (4 Male, 7 Female, 20.18 ± 2.60 years, $173.86 \pm$ 13.21 cm, 72.37 ± 12.59 kg) and 11 for the stroboscopic training group (5 Male, 6 Female, 21.55 ± 2.29 years, $168.33 \pm$ 10.03 cm, 68.16 ± 9.22 kg). Individuals were excluded if they had a history of a lower extremity injury in the past six months, history of seizures, migraines, sensitivity to light, color blindness, and concussion in the past three months. Interventions: Anticipatory timing and short-term visual memory during landing and cutting tasks were assessed with Fitlights (Fitlight Sports Corp., Aurora, Ontario), a sensor that measures time to contact and can display various color lights as go signals. Anticipatory timing was conducted by having the participants drop from a 31 cm box and anticipate when the Fitlight would cycle to the target location and sprint to that location upon landing. Short-term visual memory had each Fitlight flash a different color for a half second and then the participant would drop from the box and run to the Fitlight that illuminated green. After baseline testing, participants were randomized into a strobe (glasses with strobe effect) or control group (glasses with no strobe effect) while completing neuromuscular training (single-leg

balance for 30 seconds while catching a tennis ball, single-leg jump with 180° turn while jumping to a target for 30 seconds, and single-leg jump 90° for distance for 30 seconds). The post-test lower extremity anticipatory timing and shortterm memory tests were then repeated. Main Outcome Measures: The independent variables were group (control and stroboscopic) and time (pre and post intervention). The dependent variables were short-term memory (seconds) and anticipatory timing (seconds). A multivariate repeated measures ANOVA was conducted for the combined dependent variables. If the overall multivariate repeated measures ANOVA was significant follow up repeated measures ANOVAs were conducted for each dependent variable. Alpha level was set at p<0.05 for all analyses. Results: The multivariate repeated measures ANOVA was not significant for time, group, or time*group (p > 0.05). The pre and post-test performance for anticipation was moderately correlated (r = 0.504, p = 0.017) and highly correlated for memory (r = 0.858, p =0.001). Conclusions: The immediate effects of a stroboscopic visual-motor targeted neuromuscular intervention may not be beneficial on lower extremity visual-motor ability. More research on the efficacy of visual-motor targeted neuromuscular training is needed to determine clinical utility.
Free Communications, Poster Presentations: College Football Case Studies

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Displaced Fracture of Distal Phalanx With Flexor Tendon Rupture

Romero J, Wujciak D, Matuseski N: Kean University, Union, NJ

Background: Finger injuries are prevalent in athletics because of the lack of protection and mobility that they have. Assessments of hand injuries are difficult because of the vast amount of small structures. Normally, avulsion fractures of the distal phalanx are graded as type 1, 2, or 3. However, in a study done on injuries of this pathology, a type 4 was designated to describe an injury of this nature because of its rarity. Patient: A 25-year-old male Division 3 football player was referred for the repair of a displaced fracture of the right fourth digit. The athlete stated that when making a tackle, his finger got caught in another player's equipment. At the time of injury he felt a sharp pain, but then felt paresthesia immediately afterwards. The athletic trainer's initial assessment was a flexor tendon tear due to his inability to flex his finger. X-rays were administered two days post injury where a displaced fracture of the base of the distal phalanx was found. Intervention or Treatment: Surgery was scheduled to repair his fracture. During surgery, a flexor tendon rupture was discovered after the surgeon stabilized the fracture and still did not have DIP flexion. Three separate incisions were made to find the tendon which had slipped into his palm. It was repaired using the button pullout technique. The athlete was immobilized for three weeks post operatively. The physician then deemed that the athlete could to return to play wearing a club cast to reduce the risk of reinjury. Prescribed tendon gliding exercises focusing on different hand positions and blocking exercises were incorporated into the rehab by the athletic trainer. **Outcomes or Other Comparisons:** Normally, a mechanism that would result in these two injuries would result

in an avulsion fracture or flexor tendon rupture, not both. Surgery is necessary in the case of flexor tendon ruptures because of the lack of connectivity of the tendon. With this being a designated type 4 avulsion fracture of the distal phalanx, the diagnosis through only x-rays made it difficult to correctly diagnose the injury. As opposed to most post-operative patients, he fully returned to play before his rehabilitation was finished. Conclusions: Finger injuries are common in collegiate athletes who play contact sports that involve grabbing or tackling. This injury resulted from a combination of blunt force and improper technique. Tendons rely heavily on gliding over surrounding structures to function properly, so surgery will almost always decrease mobility because of scar tissue. Clinical Bottom Line: While finger injuries are not emergent in athletics, if not treated properly, they can cause lifelong debilitating effects. The athlete needed surgery but could return to play within three weeks of his surgery while adhering to his physicians' and athletic trainers' guidelines.

Isolated First Rib Fracture in a Collegiate Football Player Sweeney J, Haggard C, Guy J, Clair D: University of South Carolina, Columbia, SC; Palmetto Health - USC Orthopedics, Columbia, SC; Palmetto Health - USC Vascular Surgery, Columbia, SC

Background: A 20 year-old football player reported to the athletic training room the day after a game complaining of upper back and shoulder pain stating, "I think I broke my rib." The athlete reported he sustained an injury during a punt return in which the opposing player hit directly on top of his shoulder, close to his neck. He reported getting a massage by the massage therapist complaining of a knot in his trap during half time but did not report his symptoms to an athletic trainer. He was able to finish the game but stated his pain continued to get worse throughout the night. Initial evaluation revealed tenderness over the rhomboids and upper trapezius with no ecchymosis or edema. All cervical and shoulder range of motion was within normal limits and strength was rated a 5/5. Dermatomes and myotomes were also found to be normal but the athlete had a mildly positive O'Brien's test for pain; all other special tests were normal. X-rays were ordered for the shoulder and ribs, and revealed a possible displaced first rib. Therefore, a CT scan was ordered, confirming an oblique fracture of the first rib with displacement. He was then referred to a specialist for further evaluation and treatment. Differential Diagnosis: Rib fracture, displaced rib, contusion, muscle strain, neurovascular injury, clavicle fracture, sternoclavicular sprain, or acromioclavicular sprain. Treatment: Surgery was performed to remove the right first rib. An axillary approached was used to avoid disturbing the complex neurovascular structures in the neck and shoulder. During surgical exploration the first

rib was more displaced than originally thought, therefore was removed in two separate halves. Following surgery, the athlete was placed in a shoulder immobilizer for 3 weeks. After an initial follow-up the athlete was cleared for range of motion and light strengthening exercises. After a second follow-up appointment, he was cleared for full return to play progression and has since regained full range of motion and strength, and is participating in non-contact drills during practice. Uniqueness: Isolated first rib fractures are incredibly rare with few reports found in the literature. Among the few reports found in the literature it was found they are caused from major blunt trauma and are usually treated with rest and mild analgesics.1 Additionally, it is unusual the athlete had no point tenderness directly over the first rib but rather had referred pain in the upper trapezius and rhomboids. Conclusions: Since there are so few cases to occur it is important for athletic trainers to report these injuries along with their treatments of first ribs fractures so it can be better understood what is the best practice in treating this injury.

Level 4 Clinical CASE Study: Superior, Anterior Labral Tear With Hill-Sachs Lesion, Spinoglenoid Notch Cyst, and Glenoid Bone Loss After Recurring Shoulder Dislocations Piche L, Beard MQ: Capital University, Columbus, OH

Background: A 19-year-old wide receiver on a division III collegiate football team sustained an injury to his right shoulder during practice. The athlete went down on the field and when approached by the team's athletic trainer reported his arm being forced into hyperextension while blocking a defender. The athlete reported that he had dislocated this shoulder twice before. The athlete's shoulder was reduced on the field by the certified athletic trainer; vitals were checked pre and post-reduction. When the athlete was examined by the team athletic trainer, the athlete had pain in both the anterior and posterior shoulder capsule. The athlete was removed from activity and monitored until he was seen by the team physician. When the team physician examined the athlete a few days later, the athlete had decreased shoulder range of motion and strength secondary to pain. Further examination revealed a positive anterior apprehension test and a positive O'Brien's test. Neer's impingement and Hawkins-Kennedy tests were negative. Based on the findings of the examination, the physician ordered an x-ray, MRI and CT-Scan. The diagnosis after imaging was an anterior labral tear, Hill-Sachs lesion, 15% glenoid bone loss, and a spinoglenoid notch cyst (SGNC). SGNCs are located in the spinoglenoid notch. The athlete had an arthroscopic labral repair after his second dislocation. Differential Diagnosis: Anterior shoulder instability. Treatment: The extent of glenoid bone loss and type of repair indicated an open shoulder surgery was the superior option compared to arthroscopy and conservative rehabilitation. The athlete began shoulder strengthening exercises and used the GameReady machine prior to surgery. The athlete underwent an open Latarjet procedure to restore the glenoid bone and improve anterior shoulder stability. The athlete also had the SGNC removed. Following the surgery, the athlete was placed in a sling for six weeks, and began the return to play protocol. Uniqueness: The glenohumeral joint allows for the greatest range of motion in the human body, and is the most commonly dislocated joint with an incidence rate of 1.1 per 1000 every year. The reoccurrence rate for anterior shoulder dislocations is up to 90% in young males. Approximately 90% of individuals with recurrent instability experience glenoid bone loss. After a Latarjet repair the rate of reoccurrence of an anterior dislocation is less than 5%, however the rate of arthritic change after six years is about 40% of patients. Spinoglenoid notch cysts (SGNCs), or ganglion cysts that are named for their location in the spinoglenoid notch, are found in approximately 2% of patients after a shoulder dislocation. Most importantly, ganglion cysts are a strong indicator of capsule and labral degeneration when located in the posterior and superior shoulder region, such as the spinoglenoid notch. History of joint injury alone is established as a key risk factor for joint degeneration. An SGNC combined with glenoid bone loss could be additional indicators of long term consequences such as joint degeneration. Conclusions: A traditional role of athletic trainers is the primary prevention and treatment of our athletes. However, athletic trainers and the sports medicine team need to be aware of the long-term health-related impairments after a joint injury. Reoccurring dislocations repeatedly traumatize the shoulder joint frequently resulting in glenoid bone loss and less commonly an SGNC. Athletic trainers need to be cognizant of these signs which indicate a risk for joint degeneration. After a shoulder dislocation, and more important when these signs are found, the primary goal is to educate athletes and families on the long term health consequences as well as the appropriate management strategies to preserve shoulder joint health and overall well-being.

Fracture of Radial Head With Ulna Dislocation

Schappacher S, Felton SD, Craddock JC, Desmarteau TJ: Florida Gulf Coast University, Fort Myers, FL; Webber International University, Babson Park, FL

Background: Athlete is a 20-year-old male, 190.5 cm and weighing 108.86 kg, NAIA football athlete. Athlete's prior medical history included scar tissue removal in the right elbow, right ACL surgery, and flexor tendon repair in the right hand. Athlete was participating in competition when he fell on an out stretched arm, athlete remained on the ground holding his right elbow. After being removed from the field the athlete was further evaluated by the team doctor. Palpation revealed he radial head seriously displaced. Relocation attempts with the Team Physician of the elbow were unsuccessful, causing extreme pain. The athlete was unable to perform forearm supination as well as pronation. Very limited elbow extension or flexion was performed. At the hospital, an x-ray and CT scan were both performed. This report is a Level 4: Rare Case Study Topic Differential Diagnosis: Radial head fracture, lateral epicondyle fracture, annular ligament tear, elbow dislocation. Treatment: X-ray revealed that the radial head was fractured as well as displaced, athlete also dislocated the ulna. Athlete was given morphine in the hospital. Athlete was later splinted and released from the hospital Athlete was scheduled for surgery right away, a procedure that lasted four hours. Conservative rehabilitation began a few days following. Light active ROM focusing on extension and supination. We will continue to work and stretch the elbow joint. The athlete will focus on stretching muscles that attach at the elbow such as the biceps, triceps, flexor muscles, and extensor muscles. Athlete is currently wearing a splint at night to work on stretching the elbow back in to full extension. Uniqueness: Radial head fractures can be quite common when falling on an outstretched hand. About 20% of FOOSH (falling on an outstretched hand) injuries result in a fracture of the radial head, but more commonly in ages 30-40 years old. This athlete did in fact fall on an outstretched hand and completely shattered his radial head. Not only did the athlete fracture his radial head, he also dislocated his ulna. Immense forces are required to cause such an injury, as the elbow is a stronger and more stable joint. There are numerous surgeries to fix a radial head fracture, depending on the severity and displacement of the bone. This study aims to focus on those varies forms of surgery. Conclusions: This case highlighted the unique surgical procedures and recovery from such an injury, a specialized operation that required eight screws and two plates. This study elaborates on the popular mechanism of FOOSH injuries and the many injuries that can result with it. This case highlighted the rehabilitation and recovery process from an elbow dislocation and radial head fracture, the complexities of treating athletes with related injuries.

Free Communications, Poster Presentations: Diagnostic Imaging

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer

Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Rate of Atrophy and Hypertrophy of the Quadriceps and Hamstring Muscles After the ACL Reconstruction Surgery and During Rehabilitation: Preliminary Study

Study K, Akehi K, Noeldner F, Ryan W, Bice M, Unruh S: University of Nebraska, Kearney, NE

Context: Anterior cruciate ligament (ACL) reconstruction surgery and its rehabilitation are one of most common procedures that athletic trainers and other health care providers perform in sports medicine. However, there is limited research to examine how quadriceps and hamstring muscles atrophy and/or hypertrophy after the surgery and rehabilitation. **Objective:** The purpose of the study was to determine how the ACL reconstruction surgery and rehabilitation induce muscle atrophy and/ or hypertrophy on the quadriceps and hamstring muscles in female competitive college athletes. Design: A repeated measure study. Setting: Research laboratory. Patients or Other Participants: Six competitive college female athletes $(age = 20.83 \pm 0.90 \text{ yrs}, height = 165.95)$ \pm 3.79 cm, body mass = 49.17 \pm 22.27 kg) who experienced a non-contact Grade 3 ACL sprain during their athletic events between 2015 and 2018 academic year voluntarily participated the study. The ACL reconstruction surgery and rehabilitation for all participants were conducted by the same surgeon using the same hamstring graft technique and physical therapist using the standardized rehabilitation protocol. Interventions: Participants reported to the lab before the ACL reconstruction surgery and every 4 weeks during its rehabilitation to determine their thigh muscle morphological characteristics using a tape measure and diagnostic ultrasound unit. Main Outcome Measures: Thigh circumference (cm), subcutaneous tissue thickness (ST; cm), muscle thickness (MT; cm), and echo intensity (EI; a.u.) of the rectus femoris (RF), vastus intermedius (VI), vastus lateralis (VL), vastus medialis (VM), vastus medialis oblique (VMO), and biceps femoris (BF) muscles on both legs were measured. International Knee Documentation Committee (IKDC) scores were also collected. Results: We observed the significant atrophy on all quadriceps and hamstring MT immediately after the ACL reconstruction surgery up to about 46% and decreased EI up to about 59% comparing to the pre-surgery measures, respectively (Tukey-Kramer, P < 0.01). MT_{RF} increased up to about 15% immediately after the initial stage of the rehabilitation compared to the 1^{st} post-op measures (P < 0.05). Thigh circumference measures were not a sensitive method for detecting thigh and hamstring atrophy and hypertrophy (Tukey-Kramer, P > 0.05). IKDC scores and MT or EI of each thigh muscle were not strongly associated (P >0.05). Conclusions: Muscle atrophy is a common occurrence after the surgery. Minimizing muscle atrophy after surgery positively influence rehabilitation progression. However, hypertrophy of VI, VL, and BF did not occur until the participants started closed-kinetic chain exercises. These results provided the rate of hypertrophy depended upon the stage of ACL reconstruction rehabilitation. It was unique to find that the EI of each muscle changed along with MT changes. Any post-surgical rehabilitation absence due to the knee pain or swelling would also limit the muscle hypertrophy and potentially delay the rehabilitation process and time for return-to-play.

Using MRI to Quantify Rotation of the Talus Among Individuals With and Without History of Lateral Ankle Sprain

Gribble PA, Kosik KB, Johnson NF: University of Kentucky, Lexington, KY

Context: Documented cases of post-traumatic osteoarthritis among young-adult patients with previous lateral ankle sprains (LAS) are on the rise. Excessive anterior linear displacement of the talus has been described in this population. Limited research has suggested excessive rotation of the talus may also be present, subjecting the ankle to abnormal loading patterns and increased shear forces. **Objective:** Compare transverse-plane rotation of the talus in the ankle mortise using MRI analysis in persons with and without a history of LAS. Design: Case-control. Setting: Research laboratory. Patients or Other Participants: Twenty-seven volunteers with (n = 17;age: 44.13 ± 15.82 yrs; height: $168.38 \pm$ 11.89 cm; mass: 78.15 ± 15.56 kg) and without (n = 10; age: 33.80 ± 16.80 yrs; height: 168.15 ± 10.70 cm; mass: 65.98 \pm 16.23 kg) self-reported history of previous LAS. Interventions: Participants reported to the research laboratory for MRI scans. The ankle with previous history was scanned in the LAS group, while a randomly selected ankle was scanned for the Control group. Main **Outcome Measures:** Participants were positioned in the scanner using a custom orthotic and straps to secure the ankle in approximately 90 degrees. Imaging of the ankle was conducted with a 3Tesla MRI scanner using a 4-channel large flex coil and a 3D FLASH sequence with a 500 Hz spin lock power. On a coronal view of the joint, a line was drawn over the anteriorlateral border of the tibia, and another that passed over the anterior portions of the medial and lateral facets of the talar dome. The intersecting lines produced an angle representing rotation of the talus.

An angle >90 degrees represented an internally rotated talus, while an angle <90 degrees represented an externally rotated talus. Prior to the group analysis, two investigators established excellent interrater (ICC₂₂: 0.95-0.99) and intrarater (ICC₂₁: 0.99) reliability of the technique using five randomly-selected participants. Analysis of all participants proceeded with confidence, and independent t-tests and Cohen's d effect sizes were used to compare the LAS and Control groups. Statistical significance was set at p < 0.05. **<u>Results</u>**: The LAS group presented with an externally rotated talus ($86.38 \pm 6.09^\circ$), which was significantly different than the Control group's talar position $(91.32 \pm 5.81^{\circ})$ (p = 0.049). This was supported by a large effect size (d = 0.82). <u>Conclusions:</u> The LAS group had a more externally rotated talus within the ankle mortise, suggesting they had a more prominently positioned anteriormedial surface of the talus, which could increase exposure to joint loading forces. This helps substantiate the reported pattern of cartilage degeneration over this portion of the talus in persons with LAS history. Continued work is needed to improve the understanding of the structural instabilities and aberrant patterns experienced in the ankle joint that contribute to ankle joint health degeneration among those with a history of LAS.

Radiographic Evidence of Fibular Position: A Reliability Study

Locke C, Wellin B, Stacer J, Kingma JJ, Docherty CL: Indiana University, Bloomington, IN; Southern Indiana Radiological Associates, Bloomington, IN

Context: Lower limb alignment, and specifically fibular position, has been an area of investigation when evaluating the presence of chronic ankle instability, as well as other lower limb pathologies. This study was designed to create a proper protocol for addressing trunk and lower limb alignment, as well as positioning of the foot and ankle during standard radiography imaging to determine fibular position. **Objective:** To determine the reliability of radiographic imaging for examining the position of the fibula. Design: Repeated Measures Design Setting: Research laboratory Patients or Other Participants: 35 physically active participants from Indiana University were recruited for this study. All participants were between the ages of 18 and 23 years. Twenty-four participants were female and 11were male. Inclusion criteria included that participant being physically active which was defined as at least 30 minutes of activity three times per week. Exclusion criteria included a history of injury of fracture that required surgical intervention, pregnancy, cancer and medications that could be affected by radiography. Interventions: Participants took part in two days of testing. On each day of testing, the participants were placed in a modified night splint to keep the ankle in neutral. The participants were positioned using a padded wooden brace at a 90-degree angle to assure a neutral and consistent positioning of the pelvis. Once positioned, a lateral radiograph was taken. The images were saved and sent to a licensed radiologist for analysis. The radiologist used the computer software (Agfa DICOM viewer) to determine fibular position. Fibular position was determined by measuring the distance between the most anterior portion of the tibia to the most anterior portion of the fibula in millimeters. An Interclass Correlation Coefficient $(ICC_{(2,1)})$, standard error of measurement, minimal detectable change and Hedge's effect size were calculated. Main Outcome Measures: Fibular position (mm) Results: Fibular position for day 1 and day 2 were $15.57 \pm$ 3.68 mm and $15.20 \pm 4.23 \text{ mm}$ respectively. Interpretation of the results revealed an ICC₍₂₁₎ = 0.77 for day-day reliability. Further interpretation of the data illustrated a Standard Error of Measurement of 1.78 mm, a Hedge's effect size of 0.09, and a Minimal Detectable Change of 4.92 mm. Conclusions: Our study determined a reliable protocol for identifying distal fibular position using standard radiography. Interestingly, while the reliability was good, the minimal detectable change was larger than expected and should be used during the clinical application of this technique.

Ultrasound Imaging Reveals Gluteal Muscle Changes During Gait in Healthy Individuals With Medial Knee Displacement

DeJong A, Mangum LC, Resch JE, Saliba S: University of Virginia, Charlottesville, VA

Context: Medial knee displacement (MKD) during a single leg squat is a common risk factor for lower extremity injury, and has previously been related to altered gluteal muscle activity. Ultrasound imaging (USI) is a reliable means to explore mechanical muscle activity in a variety of positions and tasks, and overcomes issues such as cross-talk and electromechanical delay as seen with electromyography. Currently, very little is known regarding USI of the gluteal muscles during gait in a MKD population. This exploratory study may provide valuable insight into dynamic muscle activity over the course of a daily task. Objective: To determine differences in gluteal muscle activity using USI during walking gait in individuals with and without MKD. Design: Descriptive laboratory study. Setting: Laboratory. Patients or Other Participants: Twenty-eight healthy subjects enrolled in this study. Fourteen individuals exhibited MKD unilaterally during a single leg squat (4 males, 10 females, 19.36 ± 1.51 years, ht: $69.73 \pm$ 7.50 cm, mass: 62.01 ± 10.57 kg), and fourteen individuals served as matched non-MKD participants (4 males, 10 females, 20.29 ± 1.73 years, ht: 167.24 \pm 9.07 cm, mass: 67.53 \pm 16.03 kg). Interventions: Bilateral B-mode USI of the left and right gluteus maximus (Gmax) and medius (Gmed) muscles were obtained during quiet stance, heel strike, and over a 10-second clip during a 1.1 m/s treadmill walking pace. Main Outcome Measures: Muscle thickness measures were normalized to quiet stance to vield activity ratios (AR) and %muscle thickness change from quiet stance to heel strike. Differences between groups were assessed using Cohen's d effect sizes with 95% confidence intervals (CI). For each 10% of the gait cycle, ARs with 90% CI were used to compare the magnitude of thickness changes between groups and between limbs over the entire gait cycle. A subsample of 10 subjects were randomly selected and images were measured to determine intertester

reliability. Results: USI revealed decreased Gmax and Gmed %change at heel strike (Gmax %change = -8.76% \pm 4.26, p = 0.002; Gmed %change = $-9.57\% \pm 7.15$, p < 0.001) for the MKD limb compared to matched non-MKD participants. The MKD limb compared to the contralateral limb exhibited a decreased Gmed AR at 30% of gait (MKD $= 0.89 \pm 0.06$; non-MKD $= 1.01 \pm$ 0.05). No other outcome measures were statistically significant between groups. Intertester reliability was excellent for Gmax (ICC = 0.98 ± 0.01) and Gmed $(ICC = 0.99 \pm 0.01)$ measurements, each p < 0.001. Conclusions: USI highlighted decreased gluteal muscle activity in MKD limbs during gait compared to those with healthy movement patterns. Significant alterations were seen at heel strike and midstance for MKD individuals, which are critical timepoints when load transfer between limbs occurs during gait. These results suggest a link between hip muscle activity and faulty lower extremity movement patterns. Additionally, intertester reliability was excellent, supporting the clinical utility of this technology when examining the gluteal muscles.

Figure 1. Cohen's *d* effect sizes for the MKD limb compared to the Non-MKD matched limb for quiet stance and average heel strike measures.



Gmax AR, gluteus maximus activity ratios from quiet stance to heel strike; Gmed AR, gluteus medius activity ratios from quiet stance to heel strike; Gmax %change, gluteus maximus percent change from quiet stance to heel strike; Gmed %change, gluteus medius percent change from quiet stance to heel strike. Gmed AR and Gmax AR were significantly lesser in MKD limbs compared to healthy matched counterparts.

Relationship of Ulnar Collateral Ligament Characteristics Using Ultrasound Imaging and Demographic Information in Collegiate Baseball Players Hernden K, Mangum LC, Higgins M, Saliba S: University of Virginia, Charlottesville, VA

Context: The elbow ulnar collateral ligament (UCL) is one of the most commonly injured structures in collegiate baseball players and is the top reason for baseball players missing greater than 10 days of sport participation. Ultrasound imaging (USI) provides non-invasive visualization of musculoskeletal structures and is reliable in imaging the UCL. It is unknown whether the UCL thickness or length is related to player age, position, or number of years playing. Understanding possible relationships between the ligament and player demographics may help identify potential risk factors. **Objective:** To determine the relationship between player demographics and UCL features (thickness and length) in collegiate baseball players. Descriptive laboratory study. Setting: Laboratory. Patients or Other Participants: 16 Division-I collegiate men's baseball players from 2 schools volunteered (Age: 20.2 ± 1.4 years; Height: 184.6 ± 4.9 cm; Mass: 86.8 ± 7.6 kg). One participant had a history of UCL reconstruction on his throwing elbow and was excluded from analysis. Interventions: The UCL was assessed in 3 wrist positions by USI and then measured bilaterally using two different measurement techniques. Main Outcome Measures: UCL thickness and length (mm) was assessed using USI in 3 different forearm and wrist positions: neutral (NFP), forearm flexed (FFP), and curveball (CFP), and compared bilaterally. The Nazarian method of thickness measurement was also used in NFP images. The relationships between these UCL characteristics in each limb and the players' position, age, and the number of years playing baseball were compared. Means and standard deviations of each UCL characteristic and demographic variables were calculated. Pearson's r correlation coefficients were generated for relationships between all variables assessed. Results: Measurements in the throwing arm of the UCL in the NFP were: thickness $(1.45 \pm 0.31 \text{ mm})$, length $(25.11 \pm 2.30 \text{ mm})$, and Nazarian thickness (6.15 \pm 0.60 mm). A significant negative correlation (r = -0.63, p = .01) was found between non-throwing arm UCL thickness and age. A significant negative correlation was also found between throwing arm UCL thickness and players' mass (r = -0.66, p = .01) and height (r = -0.60, p = .02). There was a significant difference between pitchers and all other position players in years playing baseball year-round (10.14 vs. 6.25 years, p = .05) and UCL thickness (Nazarian method: 6.60 ± 0.4 mm vs. 5.75 ± 0.4 mm, p < .001). Conclusions: Baseball player demographics such as age, height, mass, and competitive baseball experience are related to UCL characteristics. Pitchers were also found to have competed in year-round baseball for a longer period leading up to collegiate participation than other position players, which may be related to increased incidence of UCL injury in pitchers well-documented in sports medicine literature. It is not known whether changes in the UCL are a result of throwing, however, USI can be assessed quickly and non-invasively to assess changes over time, thus leading to a better understanding of injury and protective factors for this vulnerable anatomical structure.

	Neutral r p-value				Forearm Flexion				Curveball r p-value			
	Thickness		Length		Thickness		Length		Thickness		Length	
	Т	NT	Т	NT	Т	NT	Т	NT	Т	NT	т	NT
Age (years)	-0.21 0.46	-0.63 0.01*	-0.04 0.89	-0.32 0.25	0.15 0.59	-0.49 0.07	-0.11 0.70	-0.15 0.60	-0.44 0.10	-0.47 0.08	-0.25 0.37	-0.18 0.53
Height (cm)	-0.19 0.50	0.03 0.91	0.08 0.78	0.44 0.11	-0.60 0.02*	-0.04 0.90	0.28 0.31	0.18 0.51	-0.08 0.78	-0.07 0.82	0.11 0.70	0.39 0.15
Mass (kg)	-0.33 0.23	-0.17 0.56	0.13 0.64	0.44 0.10	-0.66 0.01*	-0.30 0.28	0.36 0.19	0.26 0.34	-0.19 0.50	-0.36 0.18	0.09 0.75	0.40 0.15

Table 1. Pearson's *r* correlation values and corresponding *p*-values for participant demographics and UCL thickness and length values. Thickness and length values for the throwing and non-throwing arms of all participants in the NFP, FFP, and CFP were used. T, Throwing arm. NT, Non-throwing arm.

Ultrasound Assessment of Transverse Abdominis Function in Various Positions in Individuals With Patellofemoral Pain Following Impairment-Based Rehabilitation Mangum LC, Marshall AN,

Glaviano NR, Saliba S: University of Virginia, Charlottesville, VA

Context: Patellofemoral pain (PFP) is a common knee condition among active individuals. Rehabilitation programs for PFP often target hip and knee muscle dysfunction, although recent studies have also started to explore the incorporation of core-focused exercises to target the lumbopelvic-hip complex. However, the role of core musculature and how to target dysfunction in this pathology is not well understood. Ultrasound imaging provides a visual representation of muscle activity of the transverse abdominis (TrA), which plays a key role within the core and can be assessed in different positions and functional tasks. Objective: To examine the effects of a 4-week impairment-based rehabilitation program including a core-focused component on TrA muscle activity in various positions (tabletop, bipedal stance, unipedal stance, single leg squat) before and after rehabilitation. Design: Prospective cohort study. Setting: Laboratory. Patients or Other Participants: 19 PFP patients $(23.7 \pm 4.8 \text{ yrs}, 69.6 \pm 15.1 \text{ kg}, 168.7 \pm 6.8 \text{ s})$ cm, 14 F, 5 M) volunteered to participate in this study. Interventions: Ultrasound images of TrA thickness were collected pre-and-post rehabilitation on tabletop, bipedial stance, unipedal stance, and at peak knee flexion during a single leg squat. Rehabilitation included abdominal draw-in maneuver (ADIM) training in addition to impairment-based exercise to address hip and knee neuromuscular dysfunction and weakness. Main Outcome Measures: Three images were captured, muscle thickness was measured, and then averaged to generate activation ratios for each condition. Traditional activation ratios (muscle thickness during an ADIM over a rested thickness) were calculated in tabletop and bipedal stance. TrA thickness during unipedal stance and the single leg squat was normalized to quiet bipedal standing thickness to form the functional activation ratio. Activation ratios above 1.0 indicate a greater thickness during contraction or the functional movement as compared to a rested measure. Activation ratio means and standard

deviation (mean±SD) were calculated for each pre-and-post condition. Paired t-tests were used to determine differences following impairment-based rehabilitation. Results: For the bipedal stance (pre: 1.54 ± 0.37 ; post: 1.39 ± 0.33), individuals with PFP significantly decreased their TrA activation ratio following rehabilitation (mean diff: 0.15 ± 0.29 , p = .04). There were no significant differences in the other positions: tabletop (pre: 1.53 \pm 0.35; post: 1.54 \pm 0.29), unipedal stance (pre: 1.06 ± 0.11 ; post: $1.03 \pm$ 0.13), and at peak knee flexion during a single leg squat (pre: 1.26 ± 0.29 ; post: 1.18 ± 0.19) (all p > .05). Conclusions: Individuals with PFP decreased TrA activation during a bipedal stance following impairment-based rehabilitation. Bipedal stance activation was based on an ADIM and this decreased activation may be linked to a more efficient utilization of other muscles besides the TrA in a standing, loaded position. Individuals with PFP may also utilize more of a core strategy in functional tasks, such as unipedal stance and single leg squat, due to weakness and dysfunction at the hip and knee.





Ultrasonography of Gluteal and Fibularis Muscles During Tabletop and Band Walking Exercise in Individuals With History of Lateral Ankle Sprain Koldenhoven RM, Fraser JJ, Saliba S, Hertel J: University of Virginia, Charlottesville, VA

Context: Individuals with history of lateral ankle sprains (LAS) demonstrate alterations in ankle and hip muscle function. Muscle activation has traditionally been studied using electromyography, however, ultrasound imaging (USI) offers insight to the mechanical aspect of muscle activity through thickness or cross-sectional area (CSA) changes. USI has not been extensively used to identify differences in muscle activity in individuals with history of LAS. **Objective:** To compare gluteus maximus (GMax), gluteus medius (GMed), and fibularis group (longus & brevis) muscle activation during tabletop and band walking exercises across 4 groups: healthy (no history of LAS), ankle sprain coper, subacute LAS, and chronic ankle instability (CAI). Design: Cross-sectional. Setting: Laboratory. Patients or Other Participants: Sixtynine individuals (16 healthy, 17 coper, 17 subacute LAS, 19 CAI) participated and were classified into groups based on the health status of their ankle (# LAS: healthy = 0 ± 0 , coper = 1.1 ± 0.3 , subacute LAS = 2.9 ± 2.4 , CAI = 5.3 \pm 5.9; FAAM Sport: healthy = 100.0 \pm 0.0, coper = 99.3 \pm 2.0, subacute LAS = 46.7 ± 26.9 , CAI = 69.4 ± 16.0 ; IdFAI: healthy = 0.6 ± 1.0 , coper = 6.9 \pm 2.4, subacute LAS = 3.9 \pm 5.3, CAI = 23.7 ± 3.6 ; Months since last LAS: healthy = 0 ± 0 , coper = 59.3 \pm 39.4, subacute LAS = 0.9 ± 0.6 , CAI = 19.6 ± 13.9). Interventions: USI measures of fibularis CSA were collected for ankle eversion (contracted and resisted positions). Gluteal muscle thicknesses were collected for side-lying abduction (contracted and resisted positions) and during lateral band walking (lower leg and forefoot band placement). Main **Outcome Measures:** Tabletop exercise

measures were normalized to a rested measure and band walking positions were normalized to quiet standing to indicate the percent change of muscle activation. Separate 4x2 RM-ANOVAs for each muscle were calculated and Fisher's LSD was used for post hoc analyses. Results: All groups increased 3.2-4.1% in fibularis group activation from contracted to resisted position. Only the subacute LAS and CAI groups increased in GMax thickness during side-lying abduction (6.4% and 7.2% respectively). A significant position*group interaction was identified for the GMed (p = 0.007) in side-lying. All groups increased in GMed activity (5.3-11.8%) from contracted to resisted except CAI (-0.4%). In the resisted position, the CAI group's GMed activity was 6.3-8.5% lower than all other groups. In band walking, healthy and subacute LAS groups increased in GMax activity (4.8% and 8.1% respectively) and all groups increased in GMed activity (3.0-5.8%) from the lower leg to forefoot position. Although not significant, copers had highest amount of GMed activity during band walking activities (copers = 23-26%, healthy = 17-23%, LAS = 11-15%, CAI = 15-19%). No significant between group differences were found for the side-lying positions or band walking activities. Conclusions: All groups increased in fibularis activity when task difficulty increased and no differences existed between the groups. In a side-lying position, individuals with CAI may rely more on GMax activity than GMed during abduction. Copers exhibited the highest GMed activation during band walking exercises which suggests that targeting gluteal activity in individuals with history of LAS may be warranted.

Free Communications, Poster Presentations: Energy Needs and Disordered Eating

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Examination of Energy Needs in Adult Recreational Athletes

Moore EM, Torres-McGehee TM, Emerson DE, Pritchett K, Vandever L: University of South Carolina, Columbia, SC; University of Kansas, Lawrence, KS; Central Washington University, Ellensburg, WA

Context: Recreational athletes are an understudied population for energy availability (EA) with or without eating disorder (ED) risk. This may be due to lack of knowledge of proper nutritional practices, underestimating the demands of exercise or due to potential negative pathogenic behaviors. With increase pressures to combat obesity, adult recreational athletes may be at an increased risk for compromised energy needs and ED behaviors. **Objective:** To investigate the prevalence of low energy availability (LEA) with or without ED risks behaviors in adult recreational athletes. Design: A volunteer, cross-sectional cohort study. Setting: Large Southeastern public university and surrounding area. Setting: Large Southeastern public university and surrounding area. Patients or Other Participants: Twenty-four recreational athletes (males: n = 9 age: 24.1 ± 1.6 yrs, height: 178.1 + 5.9 cm, weight: 80.7 + 11.2 kg, body fat: 11.7 + 2.4% and females: n = 15, age: 25.6 ± 8.1 yrs, height: 165.9 + 7.1 cm, weight: 65.9+ 10.3 kg, body fat: 25.2 + 6.5%) participated in a 7-consecutive day data collection. Interventions: Energy intake (EI) and exercise energy expenditure (EEE) are the independent variables. Basic Demographic Survey, Eating Disorder Inventory-3 (EDI-3) and Symptom Checklist (r = 0.98), anthropometric measurements (Resting Metabolic Rate [RMR], height, weight and body fat percentage [r = 0.957 - 0.987]) and self-reported 7-consecutive day Food and Exercise Logs were completed. Main Outcome Measures: Low EA with or without ED risks are the dependent variables. Both dietary logs and activity logs were assessed using an online data entry, ESHA FoodProdigy system to calculate EI and EEE. The Ainsworth and Heyward equations calculated EEE from self-reported activity logs, defined as EEE= duration (minutes) x ((METs x 3.5 x weight (kg))/200). Energy availability (EA) was calculated using 'EA = (EI-EEE)/FFM' with at risk category of LEA defined as <30 kcal-1kg-1FFM, for all recreational athletes regardless of gender. Participants who scored a "Typical" or "Elevated Clinical" were assessed for increased ED risk. Results: Overall, recreational athletes presented as high-risk for LEA with 78% of males (n = 7) and 80% of females (n = 12)presenting with LEA over the 7 days (p = 0.02). Pathogenic behaviors revealed 54.2% (males: n = 4, females: n = 9) of the participants reported using dieting to control weight, while 16.7% (males: n = 1; females: n = 3) reported more than 75% of their exercise was aimed at controlling weight. Significant differences were revealed between genders and RMR (males: 1757.8 + 327.9 kcals; females: 1401.3 + 324.4 kcals; p = 0.02) and EI (males: 2312.9 + 700.6 kcals; females: 1632.5 + 526.67 kcals; p = 0.02). No significant differences were found regards to EEE (males: 687.8 + 183.9 kcals; females: 531.1 + 275.8 kcals; p = 0.95) and EA (males: 23.1 + 10.9kcal-1 kg-1FFM; females: 22.8 + 13.3 kcal⁻¹ kg⁻¹FFM; p = 0.15). Conclusions: Adult recreational athletes have an increased risk of LEA with ED risks. Future research should increase medical coverage for this population and examine educational interventions targeting proper nutrition and ED therapies.

Prevalence of Low Self-Esteem, Body Image Dissatisfaction and Weight Pressures Among Collegiate Female Athletes Weber SR, Jamerson S, Torres-McGehee TM, Monsma E, McCall M: University of South Carolina, Columbia, SC

Context: Previous studies have examined clinically diagnosable mental health disorders in athletes, but very few have examined the prevalence of signs and symptoms of sub-clinical mental health conditions (i.e., low self-esteem [LSE], body image dissatisfaction [BID], and weight pressures [WP]). Understanding these subclinical mental health conditions may aide in preventing mental health disorders. Objective: Examine the prevalence of LSE, BID and WP in sport among female collegiate athletes. A secondary purpose will examine differences in LSE, BID, and WP in sport among lean sports versus non-lean sports. Design: Crosssectional study. Setting: Collegiate institutions (NCAA, NAIA, and NCCAA). Patients or Other Participants: Female athletes (n = 689; age: 19.6 ± 1.3 years, height: 168.5 ± 10.1 cm, weight: $64.9 \pm$ 10.6 kg) from different sports (e.g., basketball, softball, track, volleyball, etc.) participated in the study. Distribution of sport type was lean sports (n = 442) and non-lean sports (n = 247). Interventions: Independent variable are sport type (lean vs. non-lean). Participants completed an online survey. Main Outcome Measures: Low self-esteem was measured using Rosenberg's Self-Esteem Scale, BID was measured by perceived body image (PBI) and desired (DBI) in clothing (daily clothing [DC] vs. competitive uniform [CU]) and PBI and DBI by meta- perceptions (Peers [P], Parents [PA], coaches [CO]) using a BI silhouette Likert scale, and WP was examined by the Weight Pressures in Sport-Female (WPS-F). Cross tabulations and chi square analyses examined the relationship and distribution of LSE

and WP risk and sport type. Repeated measures ANOVA examined differences in BID between sport type, clothing type, and meta-perceptions. Results: LSE risk was 3.4% with no significant differences between lean and non-lean sports. Weight pressures within sport comprised 4.4% of the total sample of female athletes; however, within the different subscales, percentages were higher for concerning self-consciousness from WP (11.0%) and concerning the importance of weight and appearance to sport (17.7%). There was also a weak, negative correlation between self-esteem and weight pressures in sport (p < .001, r = -0.294). Repeated measures ANOVA indicated perceptions in clothing type by sport group interaction ($F_{1.46.88} = 22.10$, P < .001, n² = .032). Body image results revealed athletes desired to be smaller than their current perceived BMI in both daily clothing and uniforms (PBI = 3.6 ± 0.97 vs. DBI = 2.0 ± 0.84 and PBI = 3.6 ± 1.0 vs. DBI = 3.0 ± 0.73), with no differences between lean and non-lean sport groups. Repeated measures ANOVA also indicated perceptions by meta-perceptions by sport group interaction ($F_{1,42.37} = 19.87$, P < .001, n² = .028). Athletes reported parents perceived them smaller than their current perceived image (PBI = 3.4 ± 1.0 vs. DBI = $2.3 \pm$ 0.91), whereas coaches wanted them to be larger (PBI = 2.7 ± 1.3 vs. DBI= $3.1 \pm$ 0.8). Conclusions: Although, LSE and WP were low in female athletes, BI dissatisfaction was more prevalent in both lean and non-lean sports. Healthcare professionals working with athletes need to be cognizant of these subclinical mental health concerns so they do not turn into more serious mental health disorders.

Prevalence of Eating Disorder and Body Image Dissatisfaction Risks in Male Collegiate Athletes Smith AB, Torres-McGehee TM, Garcia AJ, Monsma E, McCall M: University of South Carolina, Columbia, SC

Context: Male athletes make up a larger portion of the NCAA athletic population and may be exposed to the same eating disorder (ED) and body image (BI) risk factors as females. Discrepancy between perceived BI (PBI) and desired BI (DBI) has been associated with a variety of maladaptive thoughts and behaviors, but little is known about clothing type and BI meta' perceptions from others (e.g., perception of what others perceive about that athlete's body). Objective: To estimate the prevalence of ED risk and BI dissatisfaction by clothing type (daily clothing-DC, competitive uniform-CU) and by meta- perceptions (peers-P, parents-PA, coaches-CO). Design: Crosssectional study. Setting: National Collegiate Athletic Association (NCAA) Division I, II, and III and National Association of Intercollegiate Athletics (NAIA) institutions. Patients or Other Participants: Male collegiate athletes (n = 415) participated in the study (male: n = 415; age: 19.5 ± 1.4 years, height: 183.7 ± 7.2 cm, weight: 81.4 ± 10.0 kg). Interventions: Independent variables were sport, ethnicity and academic status. Main Outcome Measures: Participants self-reported height, weight, and desired weight. Participants also completed the Eating Attitudes Test (EAT-26) and BI dissatisfaction was measured via PBI and DBI in clothing (daily clothing [DC] vs. competitive uniform [CU]) and PBI and DBI by meta- perceptions (P, PA, CO) using body image silhouette Likert scale. Results: Male ED risk was estimated at 17.3% (n = 72), with 15.9% (n = 66) at risk for pathogenic behaviors (e.g., binge eating, vomiting to control weight, use of laxatives, diet pills or diuretics to control weight, etc.), and 2.9% (n = 12) at risk for just ED attitudes. A 2 (clothing: DC, CU) x 2 (perception: PBI, DBI) repeated measures ANOVA indicated a main effect (F, $_{391} = 8789.6, p \le .001, \eta^2 = .957$) with an interaction of perceptions and clothing type ($F_{1,391} = 4.832$, p = .029, $\eta^2 = .012$) as well as an interaction by perceptions $F_{1,390} = 25.285, p \le .001, \eta^2 = .061$). A 3 (meta-perceptions: P, PA, CO) x 2 (perception: PBI, DBI) repeated measures ANOVA indicated a main effect ($F_{1,390} =$ 9140.2, $p \le .001$, $\eta^2 = .959$) with an interaction with perception ($F_{1,390} = 25.285$, $p \le .001, \eta^2 = .061$). <u>Conclusions:</u> Male, collegiate athletes are at moderate risk for developing eating disorders with the highest risk of engaging in pathogenic behaviors. Regardless of clothing type, male athletes desired to be larger than perceived size; and across the board, male they believed their friends, parents, and coaches would also like for them to be a larger size. Coaches had the greatest influence with body size being the largest size, however parents had the largest discrepancy between DBI and PBI. Our findings, warranting further examination of correlates of maladaptive thoughts and behaviors.

Free Communications, Poster Presentations: Factors Affecting Concussion Management

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Effects of Cryotherapy on Cortical Hemodynamics and Cognitive Performance in Healthy Participants

Lempke LB, Fraser JJ, Erdman N, Barone NA, Saliba SA, Resch JE: University of Virginia, Charlottesville, VA

Context: Superficial cranial cryotherapy is purported to alter cerebral perfusion and oxygen saturation, and has been suggested as a potential treatment for concussion. Currently, limited evidence exists supporting the effects of cryotherapy on altering cortical hemodynamics. **Objective:** To determine the effects of superficial cranial cryotherapy on cortical hemodynamics and neurocognitive function in healthy young adults. Design: Parallel, single-blinded randomized control trial. Setting: Laboratory. Patients or Other Participants: Thirty-four healthy adults (aged 21.3 ± 1.6 years; height 173.8 ± 10.6 cm; mass 73.3 ± 12.5 kg). Interventions: Participants were randomized a priori to either cryotherapy (CryoHelmetTM) or a no-treatment control intervention. Near-Infrared Spectroscopy (NIRS; Artinis PortaLite) was used to assess functional cortical hemodynamic changes over the left prefrontal cortex. Participants were seated in a quiet room and asked to sit for a five-minute period of cognitive rest required for equipment calibration and baseline assessment. Participants completed a pre-intervention Stroop Task test (CNS Vital Signs) followed by a second five-minute rest period. Either a 20-minute cryotherapy treatment or control treatment where participants were asked to sit quietly for 20 minutes was administered Both groups then completed a post-intervention Stroop Task test and a final five-minute period of cognitive rest. Hemodynamic measures were continuously monitored throughout the timeline. Main Outcome Measures:

A two-way repeated measures analysis of variance (2x5 ANOVA) was used to assess hemodynamic response (oxygenated hemoglobin [HbO], deoxygenated hemoglobin [HbR]), by Stroop Task neurocognitive variables Reaction Time, Simple Reaction Time, Complex Reaction Time Correct, Stroop Reaction Time Correct, and Stroop Commission Error pre- and post- Stroop Task testing, during intervention, and pre- and post-intervention. Results: There were no significant differences observed between group demographics (p > 0.05). No significant interaction effect existed for HbO (F_(4,128) = .39, p = .81, η^2_p = .01) or HbR (F_(4,128) = .85, p = .50, η^2_p = .03) at each time point. The main effect of time approached significance for HbR increasing throughout the study $(F_{(4\,128)} =$ 2.12, p = .08, η_{p}^{2} = .06). The cryotherapy group committed significantly fewer Stroop Commission Errors following the intervention compared to controls $(0.7 \pm 0.26 \text{ Vs. } 1.2 \pm 0.23, \text{ p} = .05, \eta^2$ = .12). Conclusions: Superficial cranial cryotherapy did not significantly influence cortical hemodynamic responses or cognitive performance in a healthy sample. Significantly fewer errors in the intervention group were committed but were likely due to increased arousal resulting from the cryotherapy. Although SCE was statistically different, the clinical meaning of a 0.5 error difference may have limited clinical meaning. Further research is needed to examine the full effects of cryotherapy on cortical hemodynamics in a concussed population.

Does Test Order Affect Vestibular/Ocular Motor Screening Scores in High School Athletes?

D'Amico NR, Elbin RJ, Schatz P, Kontos AP: University of Arkansas, Fayetteville, AR; Saint Joseph's University, Philadelphia, PA; University of Pittsburgh Medical Center, Pittsburgh, PA

Context: The Vestibular/Ocular Motor Screening (VOMS) tool is a brief assessment of vestibular/oculomotor impairments and symptoms following sport-related concussion (SRC) that comprises four oculomotor components (smooth pursuits [SP], horizontal and vertical saccades [SAC], and near-point convergence distance [NPC]) followed by three vestibular components (horizontal and vertical vestibular ocular reflex [VOR], visual motion sensitivity [VMS]). The administration of these components is fixed, and therefore, may be influenced by testing order effects. **Objective:** To compare VOMS component scores between the fixed/standardized testing order and a randomized testing order in a sample of non-concussed high school athletes. Design: Prospective cohort. Setting: A Midwest community, multi-site sample of high school athletes. Patients or Other Participants: Fifty high school athletes (24 M/26 F, M age = 15.64 ± 1.12 years) were administered the VOMS in a randomized testing order (RNDM) and were matched to 50 high school athletes (24 M/26 F, M age = $15.64 \pm$ 1.12 years) that completed the VOMS in the fixed/standardized testing order (STD). Groups were similar in age (p = 1.00), sex (p = 1.00), SRC history (p= .66), PCSS total symptoms (p = .36), and self-reported diagnosis of learning disorder (p = .16) and ADHD (p = .65). Interventions: All athletes completed the VOMS individually in a quiet testing room and a computerized neurocognitive assessment in a quiet group setting that included a demographics and symptom section by a trained researcher. Athletes in the RNDM group completed the VOMS components in a randomized testing order as determined by a random number generator. Athletes in the STD group completed the VOMS components in the standardized testing order: SP, horizontal SAC, vertical SAC, NPC, horizontal VOR, vertical VOR, and VMS. Main Outcome Measures: The VOMS component scores were the main outcome measure. Tests for assessing normality indicated a non-parametric sample due to a high rate of VOMS component scores of zero. Therefore, between-group differences were assessed using Mann-Whitney U tests with statistical significance set at p < .05. **Results:** The groups were similar on VOMS Pretest symptoms (p = .54). There were also no group differences for testing order on symptom provocation following the SP (p = .36), horizontal SAC (p= .40), vertical SAC (p = .14), NPC (p= .37), horizontal VOR (p = .23), vertical VOR (p = .37), and VMS (p = .28) components; as well as NPC distance (p = .16). Conclusions: Testing order does not affect VOMS component scores at baseline in non-concussed high school athletes. The VOMS components can be administered at baseline using the fixed/standardized testing order per the instructions. Moving forward, researchers should replicate the current research in athletes following SRC.

Level of Agreement Between Human-Rated and Computerized Balance Error Scoring System Scores

Malvasi SR, Hoch MC, Cameron KL, Svoboda SJ, Houston MN: Keller Army Hospital, West Point, NY; University of Kentucky, Lexington, KY

Context: Clinicians have used the Balance Error Scoring System (BESS) for the past two decades to quantify postural control for concussion and lower extremity injury management. However, the reliability of the human-rated BESS has varied which has prompted the development of computerized BESS tests to automate scoring and minimize subjectivity. However, the agreement between human-rated and computerized BESS scoring is unknown. **Objective:** To determine the level of agreement between human-rated and computerized BESS scores. Design: Cross-sectional. Setting: United States Service Academy. Patients or Other Participants: Thirtyfive participants (21 males, 14 females; 19.40 ± 1.38 y, 68.66 ± 4.59 in, 166.97 \pm 31.63 lbs) with no history of concussion or lower extremity injuries within three months were recruited from a US service academy. Interventions: Participants completed all BESS stances (double-limb (DL), single-limb (SL), tandem (TAN)) on two surfaces (firm, foam). The participants were asked to close their eyes and maintain each stance without error for 20 seconds. The Tekscan MobileMat[™] (Tekscan, South Boston, MA) was used to quantify BESS errors while a human-rater simultaneously scored the BESS live. The human-rater was a certified athletic trainer with two years of experience scoring the BESS in a research setting. During testing, the human-rater was blind to the MobileMat[™] scores. Main Outcome Measures: BESS errors were tallied for each stance with scores ranging from 0 to 10, for a Total-BESS score out of 60. Bland-Altman level of agreement analyses evaluated the agreement between scoring methods (MobileMat[™]-Human) for each BESS stance and surface condition. For each analysis, the mean bias between scores with a 95% confidence interval (95% CI) was calculated. A mean bias >0 indicated the MobileMatTM recorded more errors than the live rater. A mean bias <0 indicated the rater recorded more errors than the MobileMat[™]. The width of the 95% CI was also examined to determine the precision of the mean bias estimates. Results: Agreement between the live rater and MobileMatTM was poor based on mean bias estimates >1 and/or wide 95% CI for Firm-SL (0.00; 95 % CI: -5.82, 5.82), Firm-Tan (2.06; 95%CI: -1.40,5.52), Foam-DL (1.43; 95%CI: -1.98, 4.83), Foam-SL (-1.71; 95% CI: -5.47, 2.05), Foam-Tan (0.03; 95% CI: -4.47, 4.53), and BESS-Total (1.80; 95% CI: -7.48, 11.08). However, there was perfect agreement between rating methods for the Firm DL stance although no errors were recorded. Conclusions: The agreement between scoring methods was poor. The bias estimates suggest the MobileMat recorded greater errors on most stances; however, wide confidence intervals indicated that a large range of disagreement occurred in most analyses. These findings suggest that the MobileMat[™] and human-rating are potentially capturing different types of errors. As a result, human-rated and MobileMatTM-rated BESS scores may not be comparable and one method should be used to measure BESS errors for consistency.

Development of an IRT-Based Concussion and Symptom Knowledge Scale

Warmath D, Piehlmaier D, Winterstein AP: University of Wisconsin, Madison, WI

Context: Concussion knowledge is an important determinant of concussion reporting behavior. Current measures of knowledge, however, suffer from several challenges to validity, reliability, length, difficulty, and consistency. This is especially true across sports, genders, and ages. **Objective:** This study seeks to develop a sports-agnostic, gender-neutral, psychometrically valid indicator of concussion knowledge (CK) and concussion symptom knowledge (CSK) with a sufficient range of difficulty. Design: We use item response theory (IRT) modeling to construct measures with known item difficulty based on the pattern of responses to concussion and symptom knowledge questions. Setting: Data was collected in three waves of online surveys with national samples age 18 to 24. Patients or Other Participants: Participants in the online survey were young adults age 18 to 24 who participated in a range of sports at various levels of competition. The sample was selected from the Survey Sampling International panel with 1,491 total participants. Interventions: A set of CK and CSK items were derived from the extant literature and refined to remove gender and sports references as well as to reflect the language young adults would understand. A total of 19 CK items and 18 CSK items were selected for the survey. Cognitive interviews were conducted prior to data collection. Main Outcome Measures: Log-Likelihood, Bayesian Information Criteria (BIC), and Akaike Information Criteria (AIC) were used to evaluate the quality of the scale. Results: Tests of unidimensionality revealed that CK and CSK are distinct latent constructs. A set of two-parameter models (2PL) were estimated separately for CK and CSK (CK: BIC for one-parameter model (1PL) = 5748.852, BIC for 2PL = 5266.711; CSK: BIC for 1PL = 5533.494, BIC for 2PL = 4256.154). Items that were ill-fitting (2 for CK and 1 for CSK) or redundant (5 for CK and 4 for CSK) were dropped sequentially. Confirmatory factor analysis showed reasonable fit of the two latent factor solution (χ^2 (274) = 855.063; RMSEA = 0.072; CFI = 0.842; TLI = 0.827). The one-factor solution showed worse fit (χ^2 (275) = 1100.926; RMSEA = 0.086; CFI = 0.775; TLI = 0.751). Conclusions: CK and CSK are measured as two psychometrically valid scales that offer greater precision and generalizability than existing knowledge scales. They have the advantage of known difficulty levels for each item and the scale overall. The scales behaved as expected for demographic, attitudinal and behavioral measures derived from the current literature. Progress in research to improve concussion reporting will benefit from rigorous and precise measures of concussion knowledge and concussion symptom knowledge that can be used across a range of settings and athletes. These scales provide such measures.

Comparisons in the Usage of the USA Football "Heads Up Football" Phone App Between Youth Football Player Safety Coaches and Coaches Cabell GH, Campbell K, Kroshus E, Lee JGL, Dompier TP, Kerr ZY: University of North Carolina, Chapel Hill, NC; University of Washington, Seattle, WA; East Carolina University, Greenville, NC; Lebanon Valley College, Annville, PA

Context: The Heads Up Football (HUF) intervention created by USA Football aims to improve safety in youth football by providing coaches with the necessary skills to instruct players on proper tackling technique, concussion awareness, and equipment fitting. This intervention is led by Player Safety Coaches (PSC), and relayed to the rest of the coaching staff and subsequently players in a top-down teaching method. To provide supplemental safety information to PSC and regular coaches, USA Football also created a HUF phone app. **Objective:** This study examined differences in use of the HUF phone app by PSC and regular coaches to assess how its effectiveness at providing coaches with important HUF supplemental information. Design: Crosssectional study. Setting: Youth football leagues during the 2015 season. Patients or Other Participants: Online questionnaires were sent to all 100,288 PSC and regular coaches registered in a HUF league. Responses were received from 1,643 (1.6%) individuals, of whom 329 were PSC and 1316 were regular coaches. Most were male (regular coaches: 97.9%; PSC: 95.1%), white, non-Hispanic (regular coaches: 73.9%; PSC: 70.8%), and aged 40-49 years (regular coaches: 54.3%; PSC: 53.1%). Interventions: An online, self-administered questionnaire examined HUF phone app use by PSC and regular coaches, and how the PSC and regular coaches used different sections of the app. These sections pertained to safety information, proper equipment fitting, and proper tackling technique. The questionnaire was developed with feedback from USA Football and a pilot sample of ten coaches before being distributed. Main Outcome Measures: Prevalence ratios (PR) and 95% confidence intervals (CI) examined the differences between PSC and regular coaches in both overall HUF phone app use and specific HUF phone app section use. Results: During the 2015 season, PSC were 74% more likely to use the HUF phone app than regular coaches (56.2% vs. 32.3%, PR = 1.74, 95% CI: 1.54-1.97). Of those using the HUF phone app, PSC were more likely than regular coaches to use specific content, including: Concussion Signs and Symptoms (75.7% vs. 62.4 %, PR = 1.21, 95% CI: 1.09-1.35); Safety Checklists (63.2% vs. 46.4%, PR = 1.36, 95% CI: 1.17-1.59; How to Tackle (70.8% vs. 61.6%, PR = 1.15, 95% CI: 1.02-1.29); and Concussion Awareness (70.8% vs. 61.9%, PR = 1.14, 95% CI: 1.02-1.14). Conclusions: While large proportions of PSC and coaches did not use the HUF phone app, more PSC used the HUF phone app and key safety sections than regular coaches. Top-down instruction is key in the HUF intervention; without easy access and reinforcement of information, many coaches may not be correctly teaching the central concepts of HUF to their players, which could diminish injury risk reduction benefits. Efforts should explore how to best disseminate safety information to all stakeholders in a youth football setting.

Test-Retest Reliability of the Immediate Post-Concussion Assessment and Cognitive **Test in United States Service** Academy Cadets: A Report From the Concussion Assessment, Research and Education Consortium Houston MN, O'Connor KL, D'Lauro C, Cameron KL, Campbell DE, Allred CD, Johnson BR, Kelly TF, McGinty GT, O'Donnell PG, Peck KY, Svoboda SJ, Pasquina PF, McAllister T, McCrea M, Broglio SP: United States Military Academy, West Point, NY; University of Michigan, Ann Arbor, MI; United States Air Force Academy, Colorado Springs, CO; United States Coast Guard Academy, New London, CT; Walter Reed National Military Medical Center, Washington, DC; University of Indiana, Bloomington, IN; Medical College of Wisconsin, Milwaukee, WI

Context: Concussion is common among military service members. In response to advancing clinical practice guidelines regarding concussion management, service members, like athletes, complete a baseline assessment prior to participating in high-risk activities. While several studies have established test stability in athletes, no investigation to date has examined the stability of baseline assessment scores in military cadets. Objective: To evaluate the test-retest reliability of the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) among military cadets from year-to-year. Design: Reliability study. Setting: United States Service Academies. Patients or Other **Participants:** 10,603 cadets (19.69 ± 1.41) yr, 69.72 ± 3.66 in, 167.67 ± 28.26 lbs) enrolled in the Concussion Assessment, Research and Education (CARE) Consortium at three United States Service Academies. Cadets diagnosed with a concussion (n = 800) and those that changed their concussion history (n = 315) between baseline assessments were removed from the data set yielding a sample of 9,488. Interventions: All cadets participating in the CARE investigation completed the standard baseline battery of assessments that included the ImPACT. At the time of this analysis, 3,965 had completed a baseline ImPACT in year one (Y1) and year two (Y2) and 195 cadets had completed a baseline in Y1 and year three (Y3). Main Outcome Measures: Baseline assessments were used to assess test stability from Y1 to Y2 and Y1 to Y3 of the CARE Consortium. Dependent variables included verbal memory, visual memory, motor speed, and reaction time. Pearson product moment correlations (r) and intraclass correlation coefficients $(ICC_{3,1})$ were used to measure the stability from Y1 to Y2 and Y1 to Y3. ICC values range from 0.0 to 1.0 with higher values representing more stable performance. Test-retest reliability strength was interpreted as poor (<0.50), moderate (0.50-0.75), good (>0.75-0.90), and excellent (>0.90). Reliable change indices (RCI) using 95% confidence intervals were calculated to determine the percentage of cadets that showed significant change between baselines. Results: Motor speed (r = 0.663, ICC = 0.662, RCI = 9.55) was the most consistent ImPACT measure from Y1 to Y2 followed by visual memory (r =0.517, ICC = 0.517, RCI = 22.9), reaction time (r = 0.433, ICC = 0.422, RCI = 0.19), and verbal memory (r = 0.418, ICC = 0.418, RCI = 19.49). Across composite scores, the percentage of cadets who exceeded the RCIs was small (2.35% Declined and 2.48% Improved). From Y1 to Y3, motor speed (r = 0.590, ICC = 0.590, RCI = 10.52) remained the most consistent followed by reaction time (r = 0.510, ICC = 0.490, RCI = 0.18), visual memory (r = 0.478, ICC = 0.478, RCI = 23.80), and verbal memory (r = 0.448, ICC = 0.448, RCI = 18.98). The percentage of cadets (3.21% Declined and 3.85% Improved) that exceeded the RCI values from Y1 to Y3 increased slightly. Conclusions: ImPACT scores demonstrated less than optimal stability from yearto-year in uninjured participants with the strength of the values ranging from weak to moderate. These results suggest that baseline cognitive performance as measured by the ImPACT may fluctuate over a 3-year period but have a nominal effect.

Smartphone Virtual Reality to Augment the Balance Error Scoring System

Rausch MA, Simon JE, Starkey C, Grooms DR: Ohio University, Athens, OH

Context: Balance testing is one method to determine if postural stability has been compromised following a concussion. New technology may offer a mechanism to improve balance testing to detect postural control impairment. **Objective:** To determine if a virtual reality (VR) modification added to the standard balance error scoring system (BESS) can perturbate postural stability to a greater degree than the traditional BESS. Design: Crossover study design. Setting: Laboratory. Patients or Other Participants: Thirty participants were recruited to participate in the study (25.4 \pm 8.1 years, 173.48 \pm 12.5 cm, and 79.11 ± 17.48 kg). All participants had no history of head, brain, eye, trunk, or lower extremity injury. Participants were excluded from this study if they had an injury to those areas or a history of motion sickness, or suffer from vestibular, ocular, or sensory disorders such as vertigo, amblyopia, or sensory processing disorder. Interventions: The participants performed the standard BESS test for three conditions (eyes open, eyes closed, and virtual reality). The virtual reality condition was implemented using a Google Cardboard V2 (Minkanak) virtual reality headset and an LG V10 phone, with a rollercoaster scenario (FIBRUM). The number of errors that occurred during each condition was counted. Center of pressure velocity was also capture from a force plate during all conditions. Participants completed two trials for each condition and scores were averaged for statistical analysis. Main Outcome Measures: The independent variables were condition (eyes open, eyes closed, and virtual reality), surface (firm and foam), and stance (double-leg, tandem, and single-leg). The dependent variables were BESS errors and total CoP velocity. A multivariate repeated measures ANOVA was conducted for the BESS errors and a second repeated measure ANOVA for CoP velocity. Follow up repeated measures ANOVAs were conducted for each dependent variable. Results: The multivariate repeated measures ANOVA for BESS errors was significant for condition*surface*stance (p < .001). Follow up repeated measures ANOVA indicated a main effect for all conditions and all interactions (p < .001) with the VR condition significantly increasing total errors (20.93 vs. 11.42, p < 0.05). The multivariate repeated measures ANOVA was significant for total CoP excursion was significant for condition*surface*stance (p < .001). Follow up repeated measures ANOVA indicated a main effect for all conditions and all interactions (p < .001) with the VR condition significantly increase total CoP velocity (52.96 cm/s vs. 37.73 cm/s, p < 0.05). <u>Conclusions</u>: The VR addition was able to induce more postural instability than eyes closed. As technology quickly advances and becomes cheaper, clinicians may be able to incorporate this modification in their practice with minimal technical expertise.

Collegiate Student-Athlete Athletic Eligibility Does Not Influence Concussion Reporting Intentions and Behavior Weber ML, Courson R, Schmidt JD: The University of Georgia, Athens, GA

Context: As many as 50% of concussions are not reported. Many factors influence a student-athlete's decision to conceal or report a concussion, although few have been examined. Student-athletes in their last years of eligibility may conceal concussions more because they have invested more in their collegiate athletic career. Conversely, first year student-athletes may desire to prove themselves causing them to conceal concussions. Objective: To determine if concussion reporting intentions and behaviors differs across years of athletic eligibility. Design: Cross-sectional. Setting: Clinical Research Laboratory. Patients or Other Participants: Eight hundred and twenty-eight Division I, II, and III collegiate student-athletes (males = 380, females = 488; age 19.69 ± 1.36 yrs) from a convenience sample completed a concussion education module (72.63% consent rate). Student-athletes responded whether they had completed 0 (n = 231), 1 (n = 206), 2 (n = 204), or 3 (n= 187) years of eligibility. Interventions: Student-athletes answered questions regarding indirect and direct concussion reporting intentions and behaviors within the module. Student-athletes rated their indirect (8 items; sample item "I would stop playing and report my symptoms if I sustained an impact that caused me to see stars") and direct (3 items; sample item "I intend to report") intentions on a 7-point Likert-scale with 1 = strongly disagree and 7 = strongly agree. Indirect behavior items were "yes" or "no" responses for 8 items about suffering symptoms of a concussion and 2 items regarding whether they reported those symptoms. Student-athletes were then categorized as "no experience" (excluded from analysis), "reporter", or "non-reporter" for indirect behavior. For direct behavior, student-athletes reported the number of concussions or "bell-ringer/dings" experienced separately, and those events reported. Direct behavior was calculated as a ratio of concussions sustained/reported and then "bell-ringer/ dings" sustained/reported. Main Outcome Measures: No dependent variables were normally distributed (p < 0.001), therefore Kruskal-Wallis tests were administered to compare concussion reporting intention (indirect and direct) and direct behaviors regarding concussion and "bell-ringer/ding" reporting across years of eligibility (alpha = 0.05). Indirect behaviors were analyzed using a Chi-square to determine if year of eligibility was associated with being a "reporter" vs. "non-reporter." Results: Student-athletes did not significantly differ across years of eligibility in indirect reporting intentions (0y: 5.25 \pm 1.58, 1y: 5.42 ± 1.37 , 2y: 5.52 ± 1.37 , 3y: 5.41 ± 1.39 ; p = 0.383), direct reporting intentions (0y: 6.14 ± 1.14 , 1y: 6.16 ± 1.07 , 2y: 6.15 ± 1.08 , 3y: $6.02 \pm$ 1.14; p = 0.397), direct concussion reporting behavior (0y: 0.79 ± 0.42 , 1y: 0.85 ± 0.37 , 2y: 0.70 ± 0.45 , 3y: $0.74 \pm$ 0.42; p = 0.533), or direct "bell-ringers/ dings" reporting behavior (0y: 0.47 \pm 0.49, 1y: 0.32 ± 0.45 , 2y: 0.43 ± 0.47 , 3y: 0.31 ± 0.45 ; p = 0.387). Year of eligibility was not associated with indirect reporting behavior (0y: 1.33 ± 0.48 , 1y: 1.25 ± 0.44 , 2y: 1.35 ± 0.48 , 3y: 1.49 \pm 0.51; p = 0.154). **Conclusions:** Year of eligibility did not influence a student-athlete's intention or decision to report or conceal a concussion. This information is useful for clinicians indicating that concussion reporting practices may be addressed similarly in student-athletes regardless of year of eligibility.

Dual-Task Screening for Identification of Persisting Concussion Effects on Cognitive Control in College Football Players

Carney MB, Jones KE, Wilkerson GB, Acocello S: The University of Tennessee at Chattanooga, Chattanooga, TN

Context: Current concussion assessment methods may not be adequate to recognize deficits in an athlete's ability to rapidly respond to changing demands in a competitive sport environment, which may elevate risk for musculoskeletal injury. Dual-task performance of motor and cognitive tasks may be a sensitive indicator of an individual's susceptibility to sport-related injury. **Objective:** To assess the potential value of dual-task testing for identification of suboptimal neuromechanical control that may be due to previous concussion. Design: Prospective cohort study. Setting: Athletic Facility. Patients or Other Participants: 66 Division I-FCS football players (20.1 \pm 1.3 yrs; 105.54 \pm 20.77 kg; 187.65 \pm 5.59 cm) were assessed immediately prior to the start of preseason practice sessions. Interventions: Concussion history was derived from a survey response. Unilateral postural sway was assessed by 30-s single-leg balance tests that were performed both with and without a concurrent flanker test (20 sets of 5 congruous or incongruous arrows; participant verbally indicates the direction of the central arrow). Visuomotor reaction time (VMRT) was derived from a Dynavision® D2 system, with 3 testing modes: Proactive (illuminated buttons remain lit until manually contacted), Reactive (buttons illuminated for 750ms, simultaneous oral recitation of scrolling text), and Proactive + Flanker ('Proactive' mode with concurrent verbal response to 20 750ms flanker trials). Main Outcome Measures: Postural sway measures included center-of-pressure (COP), average velocity, medial-to-lateral movement standard deviation (COP M-L Std Dev), max deviation, and path length. VMRT measures included average RT and number of hits (reactive mode only). Outer/Inner RT and hit ratios were calculated using an average of the outer 2 rings divided by the average of the inner 3 rings. Receiver operating characteristic and logistic regression analyses were used to develop models that provided maximum discrimination between those with and without a history of concussion. The odds ratio (OR) and its 95% credible lower limit (CLL₉₅) were calculated. Results: Discriminatory power was greatest for VMRT tests that imposed a concurrent visual-cognitive demand (Proactive + Flanker Outer/Inner $RT \ge 1.44$: OR = 10.75, $CLL_{95} = 3.57$; Reactive Outer/Inner Hits ≤ 0.79 : OR = 4.90, $\text{CLL}_{05} = 1.72$). Concurrent flanker test administration also increased the discriminatory power of COP M-L Std Dev (flanker: cut-off \ge 0.271, OR = 6.77, $\text{CLL}_{95} = 1.80$; no flanker: cut off ≥ 0.201 , OR = 3.57, $CLL_{95} = 1.14$). Logistic regression analysis identified strong interaction between COP M-L Std Dev and Proactive Outer/Inner RT, both with and without concurrent flanker test (with flanker: OR = 47.00, Sensitivity = 50%, Specificity = 98%; without flanker: OR = 4.33, Sensitivity = 50%, Specificity = 81%). Conclusions: The addition of the flanker task to visuomotor and balance testing greatly increased classification accuracy. Persisting concussion effects on neuromechanical responsiveness may be an important factor that elevates injury risk. Our findings suggest that dual-task injury risk screening tests may identify players who would derive greatest benefit from a risk-reduction intervention designed to address performance deficiencies.

Free Communications, Poster Presentations: Factors Influencing Baseline Concussion Assessments

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Stroboscopic Vison for Sensory Organization

Kim KM, Kim JS, Chang EW, Grooms D: University of Miami, Coral Gables, FL; Inha University, Incheon, South Korea; Ohio University, Athens, OH

Context: The Sensory Organization Test (SOT) is a gold standard to assess relative sensory contributions to postural stability, but its clinical utility is limited due to high equipment cost, lack of portability, and only assessing static balance. The use of stroboscopic glasses to intermittently interrupt vision has the potential to perturb visual feedback to a similar degree as the Sway-Referenced Vision (SRV) condition of the SOT, with far more clinical applicability. **Objective:** To determine if stroboscopic vision (SV) can induce postural instability to the same degree as SRV of SOT. Design: Crossover Setting: Laboratory Patients or Other Participants: Eighteen young adults without any history of vision and balance disorders, and lower extremity injuries participated (9 females; age = 22.1 ± 2.1 yrs; height = 169.8 ± 8.5 cm; mass = 66.5± 10.6 kg). Interventions: All participants performed 3 trials of bipedal stance for 20 seconds in 3 visual conditions: (1) full vision (FV), (2) SRV for which the 3-sided visual surround of the SOT was used to affect the fidelity of visual feedback, and (3) SV that was created by specialized evewear that intermittently cycled between opaque and transparent for 100 milliseconds at a time to also impact visual feedback. A bipedal stance with FV was performed, followed by either SRV or SV in a random order. All stances were completed on both stable and unstable surfaces. Main Outcome Measures: The study outcomes were Time-to-Boundary (TTB) parameters of center-of-pressure excursion recorded during 20-sec standing balance to compute TTB measures such as mean and

standard deviation (SD) of the minima in the anteroposterior (AP) direction. A lower TTB value reflects poorer postural control. Separate one-way repeated ANOVA was performed with the alpha level set at <.05. Results: For balance on stable surface, there were significant differences between 3 visual conditions for mean ($F_{(2.34)} = 3.73$, p = .034) and SD measures ($F_{(2,34)}^{(2,34)}$ = 3.63, p = .037). Postural control with either SRV (mean: $30.0 \pm$ 9.9 sec, SD: 22.5 ± 7.3 sec) or SV (mean: 26.9 ± 13.6 sec, SD: 20.0 ± 9.4 sec) was significantly worse than with FV (mean: 35.3 ± 12.6 sec, SD: 26.6 ± 10.7 sec), but there were no significant differences between SRV and SV. Similarly, for balance on unstable surface, significant differences were also found for mean $(F_{(2,34)} =$ 16.56, p < .001) and SD measures ($F_{(2.34)}$ = 7.34, p = .002). Postural control with SRV (mean: 12.2 ± 3.9 sec, SD: 11.1 ± 3.1 sec) or SV (mean: 12.4 ± 4.4 sec, SD: $9.6 \pm$ 5.7 sec) was significantly worse relative to FV (mean: 17.6 ± 4.9 sec, SD: 15.2 \pm 4.6 sec), but the SV again did not significantly differ from SRV. Conclusions: SV was found to induce similar postural control instability as SRV on both stable and unstable surfaces. The ability of SV to challenge postural control to a similar degree as the more expensive and immobile SRV test allows clinicians to utilize a technology of much lower cost and technical expertise to assess postural stability. This is especially impactful for sports medicine application as SV can be used during dynamic and interactive tasks that SRV is unable to accommodate.

Zero-Inflated Poisson Models Reveal Differences in Symptom and Mood Measures Not Found Using Traditional Statistical Models

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Context: Symptomatology and mood self-report measures taken at baseline and post-injury are typically analyzed using statistical models that assume normally distributed outcomes. These scales are positively skewed with responses clustered at zero for healthy controls and pre-injury baseline measures, violating the normality assumption. Failure to self-disclose symptoms may occur for reasons unrelated to symptom presence or absence. Zeroinflated Poisson (ZIP) models assume a distribution matching the one generated by healthy symptom scores, and predict effects on both count of scores and on presence of excess zeros. Objective: To compare results from models testing sex and concussion history effects on clinical outcomes using standard general linear models (GLMs) compared to ZIP models. Design: Secondary data analysis. Setting: Clinical research center. Patients or Other Participants: 638 (age = $20.1 \pm$ 1.3 yrs, male = 370) Division I college student-athletes. Interventions: Participants completed the Brief Symptom Inventory 18 (BSI-18; $N_{valid} = 414$; male = 262; age = 20.6 ± 1.4 yrs), Graded Symptom Checklist (GSC; $N_{valid} = 494$; male = 273; age = 19.9 ± 1.3 yrs), and provided concussion history during a healthy preseason baseline. Main Outcome Measures: GSC total symptom frequency, BSI-18 sum score, and BSI-18 subscale sums measuring anxiety, depression and somatization were calculated. We regressed binary concussion history (0, 1+) and sex (male, female) on all outcomes using both GLMs and ZIP models. Results: All

outcomes were positively skewed with most scores clustered at zero (GSC: 45%; BSI-18 variables: 56-75%). For GSC total symptom frequency, both models indicated females had more symptoms (ZIP count model: Wald $X^2(1) = 22.88$, P < 0.001; GLM: $F_{1,490} = 4.65$, P = 0.03; $M_{diff} = 1.38 \pm 0.14$), and both had interactions showing that the sex difference was only present for those without concussion history (ZIP: z = 4.78, P < 0.001; GLM: $F_{1.490} = 5.87, P = 0.02; M_{diff} = 1.84 \pm 0.39).$ Only the ZIP model indicated that concussion history predicted more symptoms in males only (z = 3.07, P = 0.002; M_{diff} = 0.30 ± 0.10). Additionally, the ZIP model suggested males have more excess zeros (Wald $X^2(1) = 21.01$, P < 0.001); whereas, the GLM does not test this question. All BSI-18 ZIP models revealed males were more likely to have excess zeros (P < 0.01), but did not have lower scores (P > 0.05). For the anxiety subscale, concussion history predicted higher scores (Wald $X^{2}(1) = 4.89, P = 0.03, M_{diff} = 0.10 \pm 0.15),$ and female scores were higher for those without concussion history (Wald $X^2(1) =$ 10.28, P < 0.01, $M_{diff} = 0.75 \pm 0.26$). For all BSI-18 GLM subscale models except depression, we found higher scores for females (P<0.01), but no concussion effects nor interactions (P > 0.05). Conclusions: For both symptom and mood scales, ZIP models remedied normality assumption violations. We found significant effects of concussion history and sex not found using GLM models. We tested both factors predicting scores, and factors influencing the likelihood of endorsing a zero, over and above the true absence of the item. These models should be considered for similar clinical measures collected on healthy controls to avoid biases and erroneous conclusions caused by misspecified models.

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Acute Effects of Sleep **Deprivation on Neuro-Ophthalmologic Function Using King-Devick Test** Coon SG, Ferris M, Krueger R, Meyer M, Kawata K: Indiana University, School of Public Health, Bloomington, IN

Context: Sleep deprivation is prevalent in young populations, where 70% of these cohorts fail to meet optimal sleep duration of 7 to 9 hours per night. King-Devick Test has emerged as a quick and valid assessment to inspect neural-ophthalmologic function by testing horizontal saccadic eye movement and cognitive efficiency. **Objective:** To determine the acute effects of sleep deprivation on King-Devick Test performance time. **Design:** Repeated Measures Design. Setting: Sleep Lab. Patients or Other Participants: Thirty participants ages 18-26 who regularly sleep at least 7 hours per night. Interventions: The independent variables were time (3 time points) and group (sleep deprivation "SD" and control). Potential participants wore a wristworn activity/sleep tracker (ActiGraph)

for 7 days prior to the study to objectively validate one's sleep duration. Those who slept an average of 7 hours or more proceeded to the study. One day prior to and during the testing days, participants were prohibited from taking daytime naps and consuming alcohol and caffeine. Participants were randomly assigned to either SD or control group. King-Devick test was conducted at 3 time points (Test 1, 7:00AM Day 1; Test 2, 7:00PM Day 1; Test 3, 7AM Day 2). Between Tests 2 and 3, the SD group slept from 2:30AM to 6:00AM $(\sim 3.5h)$, while the control slept from 10:00PM to 6:00AM (~8h) in the sleep lab. Main Outcome Measures: The time participants required to read all three tests cards of the King-Devick Test was captured during each test session. Results: Two-way repeated measures ANOVA showed that there was a statistically significant Group x Time interaction for King-Devick speed, F_(2, 56) = 3.565, p = 0.035. Follow-up repeated measures ANOVAs within each group over time showed significant main effect for time [SD, $F_{_{(2,32)}} = 7.122$, p = 0.003; Control, $F_{_{(2,24)}} = 18.878$, p < 0.001]. Posthoc analysis with Bonferroni correction

revealed that the control group continued to improve their saccadic performance over time [Control: Time1 (44.43 ± 7.88), Time 2 (41.8 \pm 7.31), Time 3 (40.53 \pm 7.56): Time 1 vs. 2, p = 0.017; Time 1 vs. 3, p < 0.001; Time 2 vs. 3, p = 0.014], while such improvement was obliterated by acute sleep deprivation [SD, Time 1 (41.56 \pm 6.91), Time 2 (38.99 \pm 6.25), Time 3 (41.04 \pm 6.99): Time 1 vs. 2, p < 0.001; Time 1 vs. 3, p = 1.00; Time 2 vs. 3, p = 0.033]. Follow-up independent samples t-tests comparing between-group difference at each time point revealed a significant group difference at Time 3. Conclusions: Multiple administrations of the King-Devick test induces considerable learning curve, but sleep deprivation mitigates such learning curve, indicating that acute sleep deprivation may cause substantial decrease in neuro-ophthalmologic efficiency. One night of sleep deprivation causes considerable neurological stress, reinforcing the current recommendation of sleeping at least 7 hours per night.



Acute Effects of Sleep Deprivation on King-Devick

Time of Day Impacts on Near **Point of Convergence**

Ferris M, Andersen SG, Krueger R, Meyer M, Kawata K: Indiana University, Bloomington, IN

Context: Near point of convergence (NPC) is part of an ocular-motor assessment that has garnered significant attention as a means to gauge the severity of neuronal stress. However, the stability of NPC at different time of day remains unclear. **Objective:** To test the hypothesis that there will be a significant NPC increase (worsening) at night compared to morning. Design: pre-post test. Setting: Clinic. Patients or Other Participants: Thirty participants ages 18-26 volunteered for this study and signed the IRB informed consent form. Interventions: The independent variable for this study was time (2 time points: 7AM and 7PM). Potential participants wore a wrist-worn activity/

sleep tracker (ActiGraph) for 7 days prior to the study to objectively validate one's sleep duration. Those who slept an average of 7 hours or more were included in the study. NPC was obtained at 7:00AM and 7:00PM. Main **Outcome Measures:** To measure near point of convergence, the participants were seated in a well-lit room, the end of accommodative ruler was placed on participants' upper lip, and a target was glided toward their eyes at a speed of 1 cm/sec. Measurements were recorded when the participant reported experiencing diplopia or malalignment of the eye was observed. Two measurements of each participant were taken at each test session. Data was analyzed using a 2-tailed paired sample t-test. Results: There was a statistically significant increase (worsening) in NPC at 7PM $(6.49 \pm 2.30 \text{ cm})$ compared to 7AM $(5.21 \pm 2.11 \text{ cm}) [t_{(29)} = 14.802, \text{ p} <$ 0.001]. Conclusion: Results indicate

that after a period of wakeful time, oculomotor function begins to decline. Clinical Application: While near point of convergence emerges as a tool for concussion and subconcussion assessment, the time of day needs to be considered when interpreting the data.



Time of Day Impact on Near Point of Convergence

Differences in Baseline Cervical Sensory-Motor Integration in Colligate Contact Sport Athletes Vs Non-Contact Controls Cheever KC, Wright WG, Sitler

M, Tierney RT: Temple University, Philadelphia, PA

Context: Cervical spine stress through direct head impact exposure and indirect impacts to the body (e.g., whiplash) are high in contact sports. These repetitive stresses can degrade peripheral parts of the cervical spine sensorimotor system. This degradation may result in altered head-neck position sense putting athletes at risk of injuries such as concussion. Additionally, preliminary findings suggest cervicogenic symptoms such as neck pain and headache are strong predictors of future concussion risk, however the reasons for this risk remain unexplored. A deficit in kinesthetic awareness due to degradation of the peripheral structures of the cervical spine may ultimately affect the ability to align and brace the head prior to concussive impacts. Objective: The purpose of this study was to explore potential cervical sensory-motor deficits between contact and non-contact athletes. Design: Two group cross-sectional design. Setting: The investigation was performed in a university research lab. Patients or Other Participants: A total of 49 university club sport athletes volunteered (26 male 19.96 ± 1.6 yrs, $191.12 \pm$ 43.7 lbs, 70.84 \pm 2.7 in; 23 female 19.78 \pm $1.4 \text{ yr}, 159.2 \pm 34.6 \text{ lbs}, 64.70 \pm 2.66 \text{ in}).$ Interventions: The primary independent variables were contact sport exposure and sex. Participants were divided into two groups; contact sport athletes (rugby team) and non-contact controls. Main Outcome Measures: The primary outcome measure was neck reposition sense which was measured using a virtual reality head mounted display. The Unity programming language was used to create the virtual environment in which visual targets were presented to test head-neck position sense. Neck repositioning error was calculated as the error between the presented target and the participant's position when instructed to return to the position of the target following a specified head movement without the help of the displayed target. The Head mounted display showed excellent agreement with the Qualisys motion capture system (ICC_{2,1} = .99). <u>**Results:**</u> A One-way ANOVA reveled a difference in neck reposition error in flexion, extension, right rotation and left rotation between contact and non-contact controls (F (1, 45) =5.287, p = .026). Total neck reposition error was moderately correlated with symptoms reported (r = 0.402) and contact group status (r = 0.334). Total neck reposition error was calculated as the sum of the average error for flexion, extension, right rotation and left rotation. Conclusions: In the present study we identify impairments in cervical proprioception in contact sport athletes compared to healthy controls. Preliminary findings suggest that these observed deficits in cervical kinesthetic awareness may be related to both contact sport exposure and the presence of baseline symptoms. Chronic exposure to head and neck impacts may affect the structures of the cervical spine, which could reduce an athlete's sensorimotor coordination and thus the ability to avoid future head injury. Future prospective investigations are warranted to explore the role of cervical dyskinesia in head and neck injury risk.

Exploring Racial Disparities in Performance on Baseline Concussion Measures

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Context: Baseline concussion assessment often includes measures of neurocognitive and ocular abilities. A large amount of neurobiopsychosocial variance in baseline performance has yet to be explained and racial differences on baseline measures have been understudied. Understanding how racial differences may contribute to ocular and neurocognitive performance may aid in the interpretation of deviant scores and help clinicians to identify athletes at risk for poorer outcomes after injury. **Objective:** To determine if racial disparities exist between Black and White high school athletes on baseline neurocognitive and ocular concussion measures Design: experimental design Setting: Participants reported to their respective high schools to complete pre-season baseline concussion testing Patients or Other Participants: A total of 655 high school athletes (433 white, 222 black, 148 female, 507 male) from 10 high schools participated in this study. The mean age was 15.45 ± 1.21 . Interventions: Athletes self-reported their race on the demographic section of their pre-participation examination. The Immediate Post Concussion Assessment and Cognitive Test (ImPACT) was administered in a group setting in a supervised, quiet room at each school by a licensed athletic trainer. In addition, the King-Devick test was completed individually with each athlete. The independent variable was race (black and white). Main Outcome Measures: To determine differences between black and white high school athletes on the KD time and ImPACT composite scores of verbal memory, visual memory, visual motor processing speed, reaction time and symptom score, a series of analysis of covariance (ANCOVA) statistical analyses were conducted, with sex as a covariate. Statistical analyses were conducted with the *p*-value set at .05. Results: The results of this study revealed significant differences between black and white high school athletes on baseline verbal memory (p < .001), visual memory (p < .001), reaction time (p < .001) .001) and symptom score (p = .01). White athletes performed better than black athletes on verbal memory, visual memory, and reaction time. Black athletes reported higher baseline symptom scores than white athletes. There were no significant differences between black and white athletes on visual motor processing speed (p = .29) or KD time (p = .09). <u>Conclusions:</u> Black high school athletes demonstrated disparities on some baseline neurocognitive measures. While much of the concussion-related research has yet to study racial differences, neurobiopsychosocial factors associated with race may influence how an athlete performs on ocular and neurocognitive concussion measures. These results suggest capturing a baseline on each individual. Cognitively normal black athletes may be misdiagnosed when compared to white athletes, or normative values, in the absence of a baseline assessment.

Effect of Attention-Deficit/ Hyperactivity Disorder and Learning Disability on Baseline Vestibular/ Oculomotor Concussion Assessment

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Context: Attention-deficit/hyperactivity disorder (ADHD) and learning disability diagnoses have been suggested as modifiers and risk factors for concussion outcomes. These premorbid conditions may impair baseline outcomes on vestibular/oculomotor assessment, however very little evidence to date exists to confirm these effects, despite common dysfunction related to the vestibular and oculomotor systems following concussion. Objective: The purpose of this study was to examine the effects of ADHD and learning disability (LD) on vestibular/oculomotor baseline concussion assessment. Design: This study implemented a cross-sectional design. Setting: This study was conducted at a series of youth football and soccer sport venues, in a designated research area. Patients or Other Participants: A total of 60 youth athletes, between the ages of 8 and 14 years, participated in the study. Participants with ADHD/ LD (n = 30) and match controls (n = 30)were recruited from a youth sports concussion program. The mean age of the participants was 11.33 ± 1.6 years, with a mean height of 151.3 ± 12.7 cm, and 98.2 ± 31.1 lbs. Of the 30 participants diagnosed with ADHD/LD, 27 were male and 3 were female. Interventions: The independent variable in this study was the diagnosis of ADHD and/or LD. Individuals who were diagnosed with ADHD/LD were matched with healthy controls on sex, age, sport, height, and weight. Participants were administered a baseline King-Devick (KD) and Vestibular/Ocular Motor Screening (VOMS) assessment prior to the start of their respective season. A series of Mann-Whitney U tests were conducted to examine differences on KD time and VOMS scores between the ADHD/ LD group and match controls, with the P-value set at .05. Previous research has reported a high reliability on the KD test, with intraclass correlations of 0.97 between measurements in the absence of concussion (Galetta, Barrett, & Allen et al., 2011). The VOMS has displayed a high internal consistency (Cronbach a = 0.92) for symptom provocation scores (Mucha et al. 2014). Main Outcome Measures: The dependent variables of this study were KD time (seconds) and VOMS domain symptom scores. To examine the effects of ADHD/LD on baseline performance, a series of Mann-Whitney U tests were conducted. Results: Individuals diagnosed with ADHD/LD performed worse on the KD test (P = .005) and had higher symptom provocation scores on the saccadic domains (P range = 0.02-0.10), convergence (P = 0.04), vestibular ocular reflex (VOR) domain (P = 0.03) and visual motion sensitivity (VMS) domain (P = 0.04) of the VOMS. <u>Conclusions:</u> Findings suggest worse baseline concussion assessment scores on vestibular/oculomotor assessment in youth athletes with ADHD and/or LD. These differences further emphasize the adamancy of individualized baseline testing and special consideration for those with diagnosed, premorbid conditions.

Effect of Mouthguard and Field-Type on Complex Concussions Wan HM, Moffit DM, Meyers MC: Idaho State University, Pocatello, ID

Context: There is controversy whether mouthguards can prevent or reduce the severity of concussion even though research has not supported that belief. Mouthguards do prevent orofacial injuries and have been a common piece of safety equipment for contact and non-contact sports. The types of mouthguards (custom-fitted or self-fitted) may also influence concussion prevention and other injuries. However, the relationship between mouthguard type and concussion severity has not been investigated extensively. Other variables, such as fieldtype (natural vs artificial), could affect concussion severity as well. Objective: To investigate whether mouthguard and/ or field-type have an impact of the severity of concussion. Design: Prospective cohort Setting: NCAA Division I/FBS football teams. Participants: Thirty-four NCAA Division I/FBS university football teams were evaluated during the 2006-2013 competitive seasons. Patients or **Other Participants:** Thirty-four NCAA Division I/FBS university football teams were evaluated during the 2006-2013 competitive seasons. Interventions: Mouthguard type, playing field surface, and severity of concussions were recorded and analyzed. Main Outcome Measures: Descriptive statistics were calculated to identify frequency and percentages of concussions based on mouthguard type (custom-fitted, self-fitted), surface (natural, artificial), and concussion severity (simple, complex). Tabular-frequency distributions were calculated via SPSS. Likelihood ratio (LR) values were reported with 95% confidence intervals (95% CI). Results: A total of 1,237 games were played. Six-hundred twenty-eight (50.8%) were played on artificial turf and 609 (49.2%) were played on natural grass. A total of 420 concussions were recorded with 208 (LR = 49.5, 95% CI: 44.8-54.3) on artificial turf and 212 (LR = 50.5, 95% CI: 45.7-55.2) on natural

grass. Of the 208 concussions on artificial turf, 119 (LR = 57.2, 95% CI: 7.7-13.5) were wearing a dentist-fitted mouthguards with 22 (LR = 18.5, 95% CI: 12.5-26.4) receiving complex concussions. Eightynine (LR = 42.8, 95% CI: 36.3-49.6) of the 208 concussions on artificial turf were wearing self-fitted mouthguards with 29 (LR = 32.6, 95% CI: 23.7-42.9) receiving complex concussions. Of the 212 concussions on natural grass, 102 (LR =48.1, 95% CI: 41.5-54.8) were wearing a dentist-fitted mouthguards with 34 (LR =33.3, 95% CI: 24.9-42.9) receiving complex concussions. One-hundred and ten (LR = 51.8, 95% CI: 45.2-58.5) of the 212 concussions on natural grass were wearing self-fitted mouthguards with 43 (LR = 39.1, 95% CI: 30.5-48.4) receiving complex concussions. The majority of concussions were categorized as simple (292/69.5%). Conclusions: The results from these data demonstrate that there is no discernable difference between concussion risk on artificial versus natural turf, primarily due to most concussions were attributed to player-to-player contact. However, the type of mouthguard is important to consider. Wearing self-fitted mouthguards increase complex concussion risk 18-76% when occurring on natural grass and artificial surfaces, respectively. Further research to elucidate the self-management of mouthguard use is warranted and athletic trainers should consider other influences when examining concussion severity.

Baseline IMPACT Scores Differ for Future Concussed Vs Non-Concussed by Sex

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Context: Pre-injury symptoms are predictive of time to clinical recovery following sport-related concussion. Somatization (preoccupation with somatic symptoms) has been invoked as an explanation. Symptom burden evinced at baseline may carry over to post-concussion, resulting in prolonged recovery. No reports have been published concerning the possibility that patients diagnosed with concussion may have elevated baseline symptom report. **Objective:** To determine if high school athletes who are diagnosed with concussion have elevated symptom report levels at baseline compared to those who do not experience a concussion. Design: Prospective cohort study. Setting: High school athletic training facilities. Patients or Other Participants: 1229 adolescent athletes: concussed (male = 143, female = 50, age = 15.2 ± 1.3 years), and non-concussed (male = 777, female = 143, age = 15.2 ± 1.9) participating in 10 sports. Interventions: Participants were selected from a database housing >70,000 Immediate Post-Concussion Assessment and Cognitive Testing (IMPACT) results from 84 high schools in Arizona. 193 concussed adolescents with baseline results within the one year prior comprised the Concussed group. 1036 subjects propensity-matched by sex, sport, and age comprised the Non-concussed group. Generalized linear (negative binomial) models compared baseline symptom severity for Concussed vs Non-concussed subjects. Sex was included as a factor. Mean scores and 95% confidence intervals, as well as effect sizes (ES: Cohen's d), are reported. Main Outcome Measures: Baseline total symptom severity scores (TSS) were calculated for IMPACT symptom domains, Physical, Cognitive, Emotion and Sleep, by summing endorsements of relevant items, rated 0 = none-to-6= severe. **Results:** Significant interactions between Concussion and Sex were

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identified for Physical and Emotional (p < 0.001), Cognitive (p = 0.001), and Sleep (p = 0.003). Concussed males showed higher mean (M) endorsement of Physical symptoms, M = 2.43 (95%) CI: 2.00, 2.95) than non-concussed, M = 1.21 (95% CI: 1.10,1.33), p < 0.001, ES = 0.58; whereas concussed females were lower, M = 1.28 (95% CI: 0.88,1.85) than non-concussed, M = 2.05 (95%) CI: 1.77,2.38), p = 0.020, ES = -0.19. Concussed males showed higher endorsement of Cognitive symptoms, M = 1.17 (95% CI: 0.94,1.47) than non-concussed M = 0.67 (95% CI: 0.60, 0.75), p < 0.001, ES = 0.40; concussed females, M = 0.58 (95% CI: 0.37.0.92) did not differ from non-concussed M=0.86 (95% CI: 0.72, 1.03), p = 0.111, ES =-0.13. For Emotion, concussed males showed higher endorsement, M = 1.38(95% CI: 1.11, 1.71) than non-concussed M = 0.93 (95% CI: 0.84,1.03), p = 0.001, ES = 0.30; however concussed females were lower, M = 0.80 (95%) CI: 0.53, 1.21) than non-concussed M = 2.07 (95% CI: 1.78,2.40), p < 0.001, ES = -0.31. Concussed males showed higher endorsement of Sleep symptoms, M = 1.90 (95% CI: 1.55, 2.33) than non-concussed M = 1.22 (95% CI: 1.11, 1.34), p = 0.001, ES = 0.36; concussed females, M = 1.28 (95% CI: 0.88,1.85,) did not differ from non-concussed, M = 1.65 (95% CI: 1.41, 1.92), p = 0.216,ES = -0.10.92.1% of the concussed and 94.4% of the non-concussed reported no prior concussions. Conclusions: Elevated symptom report, in part personological, is essential to concussion diagnosis. An incident typically associated with concussion, e.g., a blow to the head might, more readily, result in a concussion diagnosis among athletes with high, persistent symptom report, even though the elevated symptoms have little to do with the impact. The unexpected difference between males and females requires further study.

Differences in Measures of Reaction Time Between Recreationally Active Individuals With and Without Attention Deficit Hyperactivity Disorder

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Context: Participants with Attention Deficit Hyperactivity Disorder (ADHD) have shown cognitive impairments that may affect reaction time. Stimulant medications are often involved in the management of ADHD. Little is known about reaction time performance in individuals with ADHD when using stimulant medication, and how that compares to individuals without ADHD. **Objective:** To compare measures of reaction time between individuals with and without ADHD. Design: Cross-sectional between groups design. Setting: Research laboratory. Patients or Other Participants: Participants included 34 recreationally active college-aged volunteers in two groups: 13 with self-reported ADHD and prescribed stimulant medication, and 21 without ADHD diagnosis (control). Interventions: Upon arrival, participants performed two tests, Mode A and Mode D, on the Dynavision D2 (Dynavision International LLC, 2016). Participants completed three practice trials, followed by five test trials in Mode A, a simple visual task. Mode D consisted of three tasks, Direct (MD-D), Circle (MD-C) and Horizontal (MD-H). MD-D was an anticipated reaction task, MD-C was a complex visual task with circular pattern, and MD-H was a complex visual task with horizontal pattern. Participants completed one practice trial, and seven test trials per task. Two sessions of testing took place 48-72hrs apart (53.64 + 10.33 hrs). ADHD participants performed one session while on their medication (ON), and one session without medication (OFF). Control group performed both sessions without the use of medication. Main Outcome Measures: Reaction times were determined for all

tests (MA, MD-D, MD-C and MD-H), with reaction time variability (RTV) determined for the ADHD group only. Between-group comparisons for reaction time were examined with a mixed model repeated measures ANOVA using SPSS 23.0 software (SPSS Inc. Chicago, IL). Effect sizes were reported using Cohen's d (ES). Paired-sample t-tests examined RTV between sessions for all tests. Alpha levels were set a priori at 0.05. Results: Control group demonstrated faster reaction times for MA (ADHD = 0.90 + 0.12, CON = 0.78 + 0.13; p = 0.01; ES = 0.94),MD-D (ADHD = 0.65 + 0.09, CON = 0.56 + 0.13; p = 0.015; ES = 0.63), MD-C (ADHD = 0.87 + 0.11, CON = 0.74 + 0.14;p = 0.011; ES = 0.43), and MD-H (ADHD = 0.78 + 0.11, CON = 0.69 + 0.15; p = 0.05, ES = 0.31). There was a statistically significant decrease in RTV for MD-D when on their medication (ON = 0.082, OFF = 0.145; p = 0.05). <u>Conclusions:</u> This study suggests that in a recreationally active population, participants with a self-reported diagnosis of ADHD have slower reaction times than those without ADHD regardless of medication use. Medication appears to improve reaction time variability when the task is anticipated. Future research should investigate ADHD in collegiate athletes in regards to reaction time, reaction time variability (RTV) and the effect of medication on performance.

Relationship Between Self-Reported Fatigue, Sleep Quantity, and Baseline Neurocognitive Test Scores Garrett BM, Register-Mihalik JK, Bradney DA, Bowman TG: Lynchburg College, Lynchburg, VA; University of North Carolina, Chapel Hill, NC

Context: Concussion baseline testing is important for athletic trainers because it provides patients' normal cognitive, physical, and behavioral states. Concussion baseline testing might be difficult for athletes who are mentally or physically tired and provide an inadequate measure of typical function. Capturing baseline data that does not represent best performance may result in inappropriate clinical decisions post-injury. Objective: To assess the association between start fatigue scores and number of hours slept on concussion vital signs (CVS) neurocognitive testing subsection scores. Design: Cross sectional study Setting: Computer lab Patients or Other Participants: A total of 159 (N = 71 females, N = 86 males, N = 2 unspecified; age = 19.17 ± 1.150 years) voluntarily consented to participate in the study. Participants played soccer (N = 72), basketball (N = 2), or lacrosse (N = 83). At the time of data collection, we had 78 freshman, 36 sophomores, 27 juniors, 15 seniors, and 3 unspecified. 7 African Americans, 148 Caucasians, 1 one who identified as another race participated. Interventions: Concussion Vital Signs neurocognitive testing subsection scores (reaction time, visual memory, verbal memory, executive function) served as the independent variables. Executive function uses a high ordered brain function to measure attention, behavioral planning, response inhibition, and the manipulation of information in problem-solving tasks. Verbal memory measures of neurocognitive function include memory for words, word recognition, verbal learning, immediate and delayed recall. Visual memory measures visual learning, geometric shapes recognition, memory for geometric shapes, and immediate and delayed recall. Reaction time measures how quickly participants can react to a simple complex direction set. Main Outcome Measures: Start fatigue ratings and self-reported number of hours slept the night before baseline testing served as the dependent variables. We determined start fatigue on a scale that ranged from 0-100, 100 being completely awake and 0 being extremely exhausted. We used multiple linear regression to determine the relationship between the 4 subscales of CVS and each of the two dependent variables. Results: Start fatigue scores were 72.70 ± 18.50 (range = 15-100) and the number of self-reported hours of sleep the night before was 6.70 ± 1.40 (range = 4-11). We found a non-significant regression equation (F = 4, 149 = .300, P = .870) using the 4 CVS subsection scores to predict participants' self-reported pre-fatigue rating. There was also a non-significant regression equation (F = 4,149 = 1.300, P = .270) between self-reported number of hours of sleep the previous night and the 4 CVS subsection scores. Conclusions: Variations in start fatigue ratings do not alter neurocognitive performance as measured by the CVS subsection scores. Our findings are different than previous findings that found poor sleep quality and quantity produced significantly lower neurocognitive test scores. More studies are necessary to fully understand the effect of fatigue on baseline neurocognitive functioning.

The Effects of Socioeconomic Status on Baseline Concussion Testing Scores

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Context: Baseline neurocognitive testing has been recommended to provide more accurate representation of the pre-concussion cognitive status of individual athletes.1 Socioeconomic status is an aspect that is not controlled for when obtaining baseline scores, which may lead to inaccurate findings if comparing scores to normative data. Understanding the role of socioeconomic status in baseline testing is important for the accurate analysis of test scores and proper evaluation of patients. Minimal data has investigated socioeconomic status on baseline testing scores in secondary school athletes. Objective: To investigate the effects of free or reduced lunch on baseline concussion scores in secondary school athletes. Design: Cross sectional. Setting: Computer lab of 2 public secondary schools. Patients or Other Participants: 1,788 secondary school athletes (age = 14.96 ± 1.11 years, height = 171.25 ± 17.83 cm, mass = 66.82 ± 21.63 kg). **Interventions:** Free or reduced lunch eligibility served as the independent variable. Main Outcome Measures: Participants took Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) within the past 5 years. Components of ImPACT included word discrimination, design memory, X's and O's, symbol match, color match, and three letter memory. Each of these components are combined into 5 composites. Results: Of the 1,788 participants in this study, 1,255 were not eligible for free or reduced lunch, whereas 563 were eligible. Free or reduced lunch eligibility significantly altered the combined dependent variables (multivariate $F_{4,1783}$ = 18.60, P < .001, $\eta^2 = .04$). Follow up ANOVAs showed that free or reduced lunch eligibility altered verbal memory (P = <.001), visual memory (P = <

.001), visual motor (P = < .001), and reaction time (P = < .001). Those who were eligible for free or reduced lunch had lower verbal memory scores (81.33 \pm 12.72) compared to those who were not eligible (84.68 ± 11.88) . Those who were eligible for free or reduced lunch had lower visual memory scores (71.29 \pm 13.83) in comparison to those who were not (74.94 ± 14.34) . Qualified student-athletes for free or reduced lunch had lower visual motor scores (34.68 \pm 7.88) compared to those who were not qualified (37.60 ± 7.45) . Participants eligible for free or reduced lunch had higher reaction times $(.65 \pm .12)$ in comparison to those who were not eligible $(.61 \pm .11)$. <u>Conclusion</u>: Our results indicate socioeconomic status, when measured by free or reduced lunch eligibility, significantly altered visual, verbal, and reaction time components of baseline neurocognitive testing. If normative data is used instead of independent baselines, potential modifiers such as socioeconomic status should be taken into account when analyzing concussion scores to provide accurate diagnoses. Keywords: ImPACT, concussion, baseline modifier.

Reference Values for the Headache Impact Test-6 Questionnaire in Young and Physically Active Individuals Roach SP, Houston MN, Peck KY, Malvasi SR, Sturch BM, Svoboda SJ, Cameron KL: Keller Army Community Hospital, West Point, NY

Context: Standardized concussion assessment tools capture total symptoms and symptom severity and can be used prior to activity to establish individual baseline values. However, very few document the impact symptoms may have on daily function. The Headache Impact Test-6 (HIT-6) is a patient-reported outcome developed to specifically describe the impact of headache on daily life. However, baseline norms have not been established for the HIT-6 in physically active populations. **Objective:** To determine reference values for the HIT-6 in young physically active individuals as well as examine the influence of sex and concussion history on HIT-6 scores. Design: Cross-sectional. Setting: US Service Academy. Patients or Other **Participants:** 1034 male $(20.14 \pm 1.38 \text{ y},$ 70.77 ± 3.06 in, 172.33 ± 22.12 lbs) and 311 female $(19.85 \pm 1.22 \text{ y}, 65.56 \pm 3.21 \text{ })$ in, 141.20 ± 16.39 lbs) cadets completed the HIT-6 during concussion baseline testing. 313 cadets reported a history of ≥ 1 concussion. Cadets with a current concussion or those who had not been cleared to return to activity for >1 month were excluded. Interventions: Cadets completed the HIT-6 as part of their concussion baseline screening. The HIT-6 is a 6-item questionnaire that addresses the impact of headache on pain, vitality, psvchological distress, social, role and cognitive functioning over the past month. Each item is scored on a 5-point Likert scale that spans from "never" to "always" (score range=36-67). Main Outcome Measures: HIT-6 total score served as the dependent variable. Reference values (mean ± standard deviation, 95% confidence intervals, and percentiles) were stratified by sex and concussion history. Mann-Whitney U tests were

used to examine the impact of sex and concussion history on HIT-6 scores. Alpha was set *a-priori* at p<0.05. When differences were detected, z values (r = z/\sqrt{n}) were used to estimate effect size (ES). ES strengths were interpreted as small (0.01-0.39), medium (0.40-0.69), and large (0.70-1.00). Results: Reference values are reported in Table 1. In participants with no history of concussion, HIT-6 scores were significantly higher in females compared to males (p < 0.001, ES = 0.14). In participants with a history of concussion, HIT-6 scores were also significantly higher in females compared to males (p < 0.001, ES = 0.24). Within sex, no differences were detected between those with and without a concussion history (males, p = 0.578; females, p = 0.131). **Conclusions:** This is the first study to report HIT-6 reference values for young and physically active individuals at risk for concussion. Based on our findings sex may play a role in HIT-6 scores as females reported slightly higher scores than males. However, based on the reference values the headache disability level reported by both sexes was quantified as having little-to-no impact on daily function and the overall effect was small. Thus, this difference may not be clinically meaningful. Future studies should examine the influence of headache and migraine history on HIT-6 scores and evaluate responsiveness over time following concussion.

Test-Retest Reliability and Minimal Detectable Change of the Head Injury Scale

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Context: It has been reported that approximately 3.6 million concussions occur annually. As many as 50% of all concussions may go unreported. At this time, concussion diagnosis and management relies heavily on an individual's self-report of signs and symptoms and clinician experience. The Head Injury Scale (HIS) is a 16-item, self-report scale of some of the most commonly reported post-concussive symptoms. The HIS may be used as a symptom inventory baseline or as a post-injury measure. The reliability of the clinical tool has yet to be tested. A highly reliable tool is necessary to evaluate potential concussions and track improvements over time. Objective: To evaluate the test-retest reliability (α), standard error of measurement (SEM), and minimal detectable change (MDC) of the HIS among a sample of healthy individuals. Design: Test-retest design. Setting: Laboratory setting. Patients or Other Participants: A total of 25 healthy individuals (12 male and 13 female, age 21.8 \pm 1.9 years, height 172 \pm 10.5 cm, mass $77.2 \pm 20.4 \text{ kg}$) participated. Subjects were excluded from the study if they reported a concussion in the previous 6 months. Interventions: The HIS was administered to 25 healthy individuals at two time points separated by ten days. Participants were instructed to complete the questionnaire with instructions to address each symptom based on how they had felt over a 24hour period. Each symptom was rated on a scale of 0-6. Zero being had never experienced the symptom to six suggesting that the given symptom has been continuous through the same time period. Main Outcome Measures: Cronbach's Alpha (α), SEM, and MDC values were calculated for all output scores. Individual symptoms, symptom clusters and total composite scores were evaluated. Results: Of the 16 symptoms, 11 were reported to have good to excellent reliability ($\alpha = 0.76-0.98$), four were reported to have moderate to good reliability ($\alpha = 0.53 - 0.74$) and one was reported to have poor reliability $(\alpha = 0.34)$. Among the symptom clusters each reported excellent reliability. In addition, the composite HIS scores were reported to have excellent reliability ($\alpha = 0.89$). SEM ranged from 0.06 to 0.63 and MDC ranged from 0.09 to 0.89. Conclusions: Overall, the HIS demonstrates excellent test-retest reliability when evaluated among healthy individuals separated by ten days. With an MDC less than one and small SEM (>0.63), we can be confident that the change clinicians see over time using this measure is meaningful. Our findings provide justification to the use of this scale to assess symptoms, and any change in score post-concussion should be a true measurement of improvement.

Horizontal Dynamic Visual Acuity Test on C3 Logix Provokes Symptoms in Healthy Collegiate Athletes Kattiria SY, Wheeler BM, Decoster LC, Hollingworth AT, Valovich McLeod TC: New Hampshire Musculoskeletal Institute, Manchester, NH; A.T. Still University, Mesa, AZ

Context: Concussions can impair the vestibular ocular reflex (VOR), which is the ability to focus on an object during head movement. The horizontal dynamic visual acuity test (HDVAT) assesses impairment of the VOR. The C3 Logix iPad application includes an HDVAT for use in baseline-follow-up paradigms to identify VOR deficits post-concussion. However, HDVAT assessment at baseline may elicit concussion-like symptoms in otherwise healthy athletes from stressing the VOR. It is important to understand how healthy athletes respond to HDVAT before assigning clinical importance to post-injury-testing symptom provocation. **Objective:** To determine if the C3 Logix HDVAT provokes symptoms in healthy collegiate athletes. Descriptive study. Setting: Controlled laboratory. Patients or Other Participants: Volunteer sample of 198 healthy NCAA athletes (122 Males; 76 Females; 20.04 + 1.26 years old; 176.86 + 10.47 cm; 81.31 + 16.03 kg). Interventions: Participants provided consent, completed a health history form, and were administered the C3 Logix HDVAT. The HDVAT includes "static" and "dynamic" portions. In the static visual acuity (SVA) portion, participants read and recited letters of decreasing size while looking straight at the iPad with their heads still, similar to visual acuity testing using a Snellen Chart. The dynamic visual acuity (DVA) portion instructed participants to rotate their heads 30° in each direction while reciting the letters. Participants wore an external apparatus to control the extent of head rotation. A metronome cued the pace of motion at one full side-toside rotation per second. Participants verbally rated symptoms (headache,

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dizziness, nausea, fogginess) on a 0-10 scale thrice: Baseline, Post-SVA and Post-DVA. A Total Symptom Score (TSS) was calculated by adding the four scores, yielding a 0-40 scale. Main Outcome Measures: Dependent variables included item and total symptom scores with differences analyzed with a mixed model ANOVA (p < .01 after Bonferroni correction). Results: No differences were noted between Baseline (.359 + 1.378) and Post-SVA TSS (.434 + 1.522; P = .367) or individual symptom scores (P > .20). Significant differences between Baseline and Post-DVA were identified for TSS (.359 + 1.378, 95% CI: .092-.625; 1.177 + 2.424, 95% CI: .910-1.440; P < .001; Cohen's d = .42), headache (.157 + .748, 95% CI: .046-.267; .227 + .833, 95% CI: .117-.338; P = .001; Cohen's d = .09, dizziness (.040 + .332, 95% CI: 0.0-.158; .662 + 1.330, 95% CI: 0.0-.779; P < .001; Cohen's d = .64), and fogginess (.091 + .418, 95% CI: .023-.159; .167 + .559, 95% CI: .099-.234; P = .004; Cohen's d = .15). No difference was found between Baseline and Post-DVA for nausea (.071 + .499, 95% CI: 0.0-.153; 121 + .680, 95% CI: .039-.204; P = .033). Conclusions: While there was a statistically significant increase in symptoms during the HDVAT in healthy collegiate athletes, the small to medium effect sizes make the clinical significance of the change questionable. Clinicians may use the C3 Logix HDVAT as part of a comprehensive management approach to concussion. However, it may be advisable for clinicians to note when athletes have considerable symptom provocation in response to baseline testing, so they can consider that when evaluating post-concussion follow-up testing.

Horizontal Dynamic Visual Acuity Testing Considerations for Management of Sport-Related Concussion

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Context: Impairment of the vestibular system can result from concussion. Therefore, post-concussion assessment of the vestibular system is vital. Testing the vestibular ocular reflex (VOR), the ability to focus on an object while moving the head, provides clinical information about vestibular function. The C3 Logix concussion test battery includes a Horizontal Dynamic Visual Acuity Test (HDVAT) to identify VOR deficiencies. However, HDVAT can provoke symptoms in some healthy athletes. Understanding the impact of symptom provocation and past medical history (PMH) on HDVAT performance would allow clinicians to draw appropriate conclusions from post-concussion testing. **Objective:** To determine whether symptom provocation or past medical history affect HDVAT performance in healthy athletes. Descriptive study. Setting: Controlled laboratory. Patients or Other Participants: 198 NCAA athletes volunteered (122 Males; 76 Females; 20.04 + 1.26 years old; 176.86 + 10.47 cm; 81.31 + 16.03 kg). Interventions: Participants provided informed consent and completed a health history form including assessment of pre-existing conditions (e.g., motion sickness, concussion, etc.), before completing the HDVAT. The HDVAT requires test-takers to read and recite letters from eye charts in two conditions: first with static head position (STATIC), then while rotating their head 30° in each direction (DYNAMIC). Under both conditions, participants read decreasingly-sized letters. Participants wore headgear that ensured appropriate head range of motion. A metronome cued the pace of head

turns at a rate of one full side-to-side rotation per second. Researchers verbally asked, then recorded, symptom scores (0-10) for headache, dizziness, nausea and fogginess three times: at baseline, after STATIC, and after DYNAMIC. A total symptom score (TSS) was calculated by adding the four scores, yielding a 0-40 scale. Main Outcome Measures: Dependent variables included TSS and HDVAT performance score. The performance score is the number of STATIC lines read minus DYNAMIC lines read, scored directly in C3 Logix. Pearson and Spearman's rho correlation analyses were used to describe relationships between performance and past medical history, and performance and symptom provocation. Results: There was a weak correlation (r = 0.048) found between performance score (1.50 + .977)and post-HDVAT symptom scores (1.18 \pm 2.42; p = 0.499). Weak correlations were also found between performance and corrective lenses ($[\rho] = -0.003$, p = 0.967), hearing impairment ($[\rho]$ = -0.065, p = 0.367), learning disability $([\rho] = 0.03, p = 0.682)$, motion sickness $([\rho] = 0.047, p = 0.517)$, vertigo $([\rho]$ = -0.055, p = 0.488), migraine ([ρ] = 0.067, p = 0.35), psychological disorder $([\rho] = -0.044, p = 0.538)$, and previous concussion ($[\rho] = -0.059$, p = 0.409). Conclusions: Previous medical history and symptom provocation during C3 Logix HDVAT testing did not appear be related to test performance in this healthy, collegiate population. The C3 Logix HDVAT may be valuable as part of a comprehensive concussion protocol. It may be helpful to repeat this study in different healthy and injured populations to expand generalizability.

Sports-Related Concussion Incidence and Time-Loss in High School Athletes With and Without a History of Concussion Bretzin AC, Petit KM, Savage JL, Anderson MN, Covassin T: Michigan State University, East Lansing, MI

Context: Sports-related concussions (SRC) are a growing concern of high school athletic administrators. In efforts to understand SRC occurrence and time-loss from injury, the Michigan High School Athletic Association (MHSAA) implemented a Head Injury Reporting System (HIRS) to record SRCs. **Objective:** To determine the clinical incidence and relative risk (RR) of SRC between the 2015-16 and 2016-17 years. A secondary aim was to determine differences in time-loss between athletes with and without previous SRC. Design: Descriptive epidemiology. Setting: Michigan high schools. Patients or Other Participants: High school athletes participating in MHSAA sanctioned events. Interventions: Certified athletic trainers, school administrators and coaches from the MHSAA input SRC data into the HIRS over two years. A SRC was defined as a head injury resulting from participation in a practice, scrimmage, or game and required removal from participation after exhibiting signs and symptoms of a SRC. The independent variable was history of SRC. Main Outcome Measures: Total number of athletes and SRCs, injury date, authorized return date, and previous history of SRC were recorded for athletes participating in all sports. Time-loss was calculated as the days between injury date and authorized return. Clinical incidence was determined for each of the sports by dividing the total number of SRCs by the total number of participants each season. RR was assessed by dividing clinical incidence in 2015-16 by 2016-17. Frequencies were used to determine the number of athletes that had ≥1 previous SRC in each sport during each year. A one-way ANOVA was used to evaluate differences in time-loss between athletes with ≥ 1 previous SRC

and athletes with no previous history. The p value was 0.05. Results: A total of 4,452 (284,227 athletes) and 4,144 (283,679 athletes) SRCs were reported in the 2015-16 and 2016-17 seasons, respectively. There was no increased risk (RR = 0.9, 0.85 - 0.93) for participating in 2016-17 (clinical incidence = 1.40, 1.35 - 1.44) compared to 2015-16 (clinical incidence: 1.57,1.52-1.62). The sports with the greatest clinical incidence for SRC in 2015-16 and 2016-17 were football (clinical incidence = 4.90, 4.72-5.16; clinical incidence = 4.50,4.29-4.72), ice hockey (clinical incidence = 3.76, 3.11-4.42; clinical incidence = 3.64, 3.01-4.26), and girls' soccer (clinical incidence = 3.04, 2.75-3.33; clinical incidence = 2.76, 2.48-3.03), respectively. There was an increased risk in girls' lacrosse in 2016-17 (RR = 1.81, 1.16 - 2.18) compared to 2015-16, all other sports remained stable. Of the athletes that sustained a SRC each season, 10.5% (2015-16) and 16% (2016-17) had ≥ 1 previous SRCs. There were significant differences in time-loss between athletes with ≥ 1 previous SRC (14.6 ± 12.4) and no history of concussion (12.7 ± 14.1) in 2016-17 (F = 8.306, p = .004), yet there were no significant differences between groups in 2015-16 (F = 1.635, p = .201). Conclusions: Other than girls' lacrosse, the risk of sustaining a SRC remained stable between years. Additionally, these findings suggest athletes with previous SRC history may take longer to return compared to athletes with no history; however, more research is warranted due to inconsistencies between years.

Baseline Sex Differences for the Sport Concussion Assessment Tool 5 (SCAT5) in Collegiate Athletes

Petit KM, Anderson MN, Savage JL, Bretzin AC, Covassin T: Michigan State University, East Lansing, MI

Context: Sex differences have been shown to exist between males and females for both baseline and post-injury concussion assessments; with females reporting more symptoms and performing worse on various neurocognitive assessments. The Sport Concussion Assessment Tool (SCAT5) was recently updated, therefore, it is important to determine if sex differences still exist on the new domains of the SCAT5 (i.e. 10-word list). Objective: To determine baseline sex differences for the SCAT5 in Division-I collegiate athletes. Design: Cross-Sectional Study Setting: Division-I University Patients or Other Participants: A convenience sample of 147 collegiate athletes (male = 66, female = 81, age = 19.2 ± 1.3 years old, years in college = 1.9 ± 1.1) from 11 different varsity sports were included in the study. Interventions: Participants completed the SCAT5 prior to the start the 2017-18 athletic season. The SCAT5 is comprised of patient demographics, symptom score, cognitive screening (Standard Assessment of Concussion (SAC)), neurological, and the modified balance error scoring system (mBESS). SAC score can further be broken down into four categories: orientation, immediate memory, concentration, and delayed recall. The independent variable is sex. Main Outcome Measures: Mean scores and standard deviations for both males and females were calculated for the total number of symptoms (out of 22), overall symptom severity (out of 132), orientation (out of 5), immediate memory (out of 30), concentration (out of 5), delayed recall (out of 10), total SAC score (out of 50), and the mBESS score (out of 30 errors). ANOVAs were conducted to determine if sex differences exist. Alpha level was set a priori at

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.05. Results: There were no differences between males and females for the number of symptoms reported (M = 1.68 ± 2.51 , F = 1.96 ± 3.51 , p = .586), or the total symptom severity (M = 2.71 ± 4.55 , F = 3.79 ± 8.49 , p = .355). Males and females also had similar scores for each SAC component (orientation (M = 4.95 ± 0.21 , F = 4.98 ± 0.16 , p = .493) immediate memory (M = 20.48 ± 3.53 , $F = 20.60 \pm 2.92$, p = .822) concentration (M = 3.61 ± 1.19 , F = 3.32 ± 1.11 , p = .135) delayed recall (M = 6.70 ± 2.05 , $F = 6.68 \pm 2.04$, p = .958)), as well as overall SAC score (M = 35.74 ± 5.40 , F $= 35.58 \pm 4.74$, p = .847). Similar results were also found for the mBESS with no sex differences on errors scored. (M = 4.05 ± 3.78 , F = 4.07 ± 3.95 , p = .965). Conclusions: This study suggests that males and females yield similar baseline results on every component of the SCAT5. These results conflict with previous research that suggests differences exist at baseline between males and females. Clinicians should continue to perform individualized baseline assessments to act as a reference during post-concussion evaluation.

Normative Values for the New Child Sport Concussion Assessment Tool 5 in Youth Soccer Athletes

Covassin T, Savage JL, Petit KM, Anderson MN, Bretzin AC: Michigan State University, East Lansing, MI

Context: The newly revised Child Sport Concussion Assessment Tool 5 (Child SCAT5) is a sport-related concussion assessment that is best used with a baseline test. However, there is currently no research conducted on normative values among youth soccer athletes using the revised Child SCAT5. Objective: To examine normative values on the Child SCAT5 in a sample of youth soccer athletes. A secondary purpose is to examine baseline sex differences in the Child SCAT5. Design: Cross-Sectional study. Setting: Controlled soccer facility. Patients or Other Participants: A total of 99 youth soccer athletes (male = 61, female = 38, age = 10.2 + 1.8years, previous concussion = 5(6.8%)) volunteered to participate in the study. Interventions: The independent variable was sex. Participants completed the Child SCAT5 on the field prior to practice. The Child SCAT5 consists of child and parent total symptom severity (21 symptoms), Standardized Assessment of Concussion child (SAC-C), and the modified Balance Error Scoring System (mBESS). The SAC-C includes immediate memory (i.e., 10 word list), concentration (i.e., digits backwards starting with 2 up to 6, days in reverse order), and delayed recall (10 words). The Child SCAT5 takes approximately 10-15 minutes to complete. None of the participants sustained a sport-related concussion during the study period. The data was analyzed using descriptive and inferential statistics. Main Outcome Measures: Dependent variables included the immediate memory (out of 30), concentration (out of 6), delayed recall (out of 10), mBESS (out of 30), and symptom severity score (out of 63: Likert scale from 0-3). A series of ANOVAs were performed for each of the subscales of the Child SCAT5 to determine sex differences. The alpha level was set a priori at .05. Results: Normative values for the Child SCAT5 include 3.20 ± 4.8 for parent symptoms, 4.58 ± 4.9 for child symptoms, 18.2 ± 4.5 for immediate memory, 3.54 \pm 1.1 for concentration, 4.97 \pm 3.7 for mBESS, and 5.93 ± 1.9 for delayed recall. There was a significant sex difference for the parent severity symptom score ([Female: Male] $M = 1.79 \pm 2.9$: $M = 4.08 \pm 5.5 p = .02$). Parents of male soccer athletes scored higher at baseline on the parent symptoms of their child compared to female soccer athletes. There were no significant differences at baseline on the child symptom score $(M = 3.9 \pm 4.2; M = 4.9 \pm 5.3 p = .33),$ immediate memory (M = 18.8 ± 4.6 : M $= 17.9 \pm 4.5 p = .36$), concentration (M $= 3.55 \pm 1.3$: M $= 3.52 \pm 1.0 p = .91$), mBESS (M = 4.84 ± 4.3 : M = $5.06 \pm$ 3.3 p = .77) and delayed recall (M = 6.03 ± 1.9 : M = $5.87 \pm 1.9 p = .70$) between females and males. Conclusions: Overall, this study provided normative references for youth soccer athletes on the Child SCAT5. There were no sex differences on the mBESS and SAC-C, however there were sex differences on the parent symptom severity score. Due to developmental differences in youth athletes, it is recommended that clinicians administer the Child SCAT5 for post-concussion comparisons.

Free Communications, Poster Presentations: Foot and Ankle Cases

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer

Review Authors – Last Names N through Z: 11:15AM-12:00PM

Return to Play Following Talus Fracture Within High-Impact Sport Participation

Riordan SM, Martin BM, Clanton TO: The Steadman Clinic, Steadman Philippon Research Institute, Vail, CO

Background: A fracture of the talus can result in a variety of complications including avascular necrosis and post-traumatic arthritis.1 The incidence increases with fracture severity.^{1,2} Hyper-dorsiflexion resulting from a fall (29%) is one of the top three mechanisms of injury.^{1,2} Not only do these athletes suffer varying types of talus fractures, but also may have various other bone and soft tissue injuries.2,3 Previous literature supports stable fracture fixation and early active range of motion with postponement of FWB status for 12 weeks. However, multiple case studies report impact loading activities by 7 weeks.4,5,6 Since the talus plays a large role in AROM of the foot, the limited literature on talar fracture rehabilitation is concerning. Patient: A 17 year old skier reported to his athletic trainer, after performing an aerial maneuver into a foam pit and loading his left ankle on the edge of the pit. The hyper-dorsiflexion mechanism elicited a pop and immediate pain along the anterior ankle. Persistent pain, effusion, and tenderness to palpation over the AITFL prompted the athlete's visit to the ER. Ankle radiographs showed an age-indeterminate fracture of the medial talar process. In the orthopedic clinic he had 5 degrees of dorsiflexion, 40 degrees plantarflexion, diffuse swelling, and a positive external rotation test. Tenderness to palpation over the AITFL prompted an MRI study which revealed a comminuted fracture of the medial talar neck and head, extending into the talonavicular joint. MRI also revealed a sprained AITFL, a Salter-Harris I fracture of the lateral malleolus, and ATFL/CFL/ deltoid sprains. A CT performed four days later confirmed the findings of the MRI, describing the fracture as coronal-oblique through the talar neck with 2-4mm of subchondral step-off present. Intervention or

Treatment: Following informed consent, the parents and the athlete decided on operative management with ankle arthroscopy and limited debridement followed by talus ORIF. Due to the nature of his sport, skiing half pipe and terrain park, conservative treatment of the fracture was not appropriate. He was splinted, followed by a boot and asked to maintain a NWB status for six weeks. The athlete worked on core exercises and upper extremity strengthening with his athletic trainer. At six weeks, he was permitted to begin a WB progression, followed by a two week boot wean with transition into a GameDay ankle brace. The athlete was FWB at 8-10 weeks post-operative with rehabilitation limited to strengthening, ROM, and proprioception exercises until four months post-operative. Return to sport is expected at 6 months, but there is no current literature to guide return to play following a talus fracture. Outcomes or Other Comparisons: Previously documented literature on talus fracture in an impact loading, competitive athlete reports full return to athletics at four months, participation without restriction at seven months, and full pain-free functional ability at ten months following injury.5 The specific rehabilitation process was not reported. Conclusions: Since talar fractures account for less than 1% of fractures to the foot and ankle,¹ some athletic trainers may go an entire career without seeing or rehabilitating this injury. A clear plan is necessary based on severity of injury, stability of fixation, risk of AVN. and good principles of bone healing and resumption of load. We advocate meeting specific rehabilitation goals rather than following a strict timeline. Clinical Bottom Line: Many complicated diagnoses are without current literature on return to activity, further complicating the process for the athletic trainer. This case study can shed light on the full rehabilitation process of a high impact athlete dealing with a post-operative talus fracture.

Cuboid Syndrome: A Case of Unexplained Foot Pain Myers A, Wills J, Raymond C, Wallace J: Youngstown State University, Youngstown, OH

Background: Cuboid Syndrome, or occasionally referred to as a subluxed cuboid, is an injury to comprehend and recognize in both athletic and non-athletic populations. Cuboid Syndrome most commonly occurs during an event where an inversion stress is placed upon the ankle and presents as lateral foot/ankle pain. However, Cuboid Syndrome may also present with no traumatic mechanism of injury and may be difficult to identify upon early presentation and therefore often goes misdiagnosed or mistreated. Patient: The patient is a 21 year old female NCAA Division I collegiate swimmer who presented with lateral foot pain from an unknown origin and mechanism of injury. The patient's chief complaint was lateral foot pain that did not subside following any treatments or interventions over the course of a 6 week time frame. She was weight bearing and capable of participating in swimming practice throughout most of the injury. Upon initial examination, no significant findings were discovered and after a period of 4 weeks she was referred to an orthopedic surgeon for further evaluation. X-Rays and MRI were performed with no significant findings. Upon research investigation by the Athletic Trainer (AT), it was suggested to the team chiropractor that she may be suffering from Cuboid Syndrome. During a chiropractic appointment 6 weeks after initial presentation, audible cavitation and an immediate improvement in pain was observed following manipulation of the cuboid. The patient was officially diagnosed with Cuboid Syndrome. Intervention or Treatment: Over the course of 6 weeks following the initial presentation of pain the patient was treated multiple days per week with various therapeutic modalities and a strengthening program. Power Plate®, Game Ready®, Dynatron® soft tissue oscillation, Laser Light Therapy (LLT), Kinesio Taping (KT), arch and ankle supportive tape applications, and isometric exercises for the ankle and midfoot were applied to the patient with no significant improvement of symptoms reported. Once the patient was officially diagnosed with Cuboid Syndrome, weekly chiropractic appointments in which manipulation of the cuboid was performed, the patient began to see an improvement of symptoms. Approximately 12 weeks post-initial presentation, the patient was released from all medical care and cleared for full participation. Outcomes or Other Comparisons: The discussed patient suffered from Cuboid Syndrome symptoms a total of 12 weeks. Following conventional therapeutic modality use and an active rehabilitation program, the sports medicine team involved manual medicine techniques at week 6. With this treatment plan the patient began to see improvement. Manual medicine techniques were a crucial part of recovery for this patient and should be utilized in most, if not all, instances of Cuboid Syndrome. Cuboid Syndrome commonly goes misdiagnosed and mistreated; therefore this patient's outcome is not uncommon among cases of reported Cuboid Syndrome or cuboid subluxation. Conclusions: Cuboid Syndrome, once diagnosed, can be resolved through conservative treatments involving chiropractic sessions, manual medicine techniques, and therapeutic modalities for pain management. The main hindrance clinicians' face when a patient suffers from Cuboid Syndrome is initial diagnosis and thus prolonging recovery and proper treatment techniques. Clinical Bottom Line: Cuboid Syndrome should be taken into consideration in patients' presenting with lateral foot/ankle pain with no clear mechanism of injury upon early examination and/or no response to early treatments or interventions.

Anterior Process Fracture of the Calcaneus in a Collegiate Women's Soccer Player: A Case Report

St. John KC, Curtis N, Smith JJ, Baer DJ: West Chester University of Pennsylvania, West Chester, PA

Background: This level 3 case study explores an anterior process fracture of the calcaneus. Anterior process fractures of the calcaneus represent between 3% and 23% of all calcaneal fractures. The mechanism for a calcaneal anterior process fracture is typically inversion and plantarflexion of the ankle. Other mechanisms include forceful abduction of the forefoot as well as excessive dorsiflexion. However, in this case, the athlete had an unusual mechanism of an axial load in a neutral position. Calcaneal anterior process fractures are frequently misdiagnosed as lateral ankle sprains. Diagnostic imaging, including x-rays and MRI failed to identify the fracture, causing a delay in a precise diagnosis. Patient: A 22-year-old female NCAA Division-II collegiate soccer player suffered a right ankle injury during a soccer match. The mechanism of injury was landing with a flat right foot causing an axial load and resulting in ankle and foot pain. She reported no forceful inversion, eversion, or rotation motion. She continued participation for the rest of the game, but had an antalgic gait. Following the game, her chief complaint was lateral, right mid-foot pain. She was tender to palpate over the bifurcate ligament, the posterior aspect of the lateral malleolus, and the cuboid. Range of motion assessment revealed pain with active dorsiflexion and inversion. Mild swelling was present over the dorsum of the right foot and lateral ankle. Mid-foot squeeze test, ankle anterior drawer test, and talar tilt were all negative. The athlete had no documented history of previous right ankle injury. Intervention or Treatment: Immediate X-rays were negative. The injury was treated as a lateral ankle sprain and midfoot sprain. The athlete was immobilized and rehabilitated for 2 weeks. She

completed the season despite continued pain from her injury. After the season, symptoms persisted for 6 weeks; MRI results revealed a cystic fluid collection at the calcaneocuboid joint on the dorsal and plantar sides. She was immobilized for an additional 3 weeks, but symptoms persisted so the team physician referred her to a foot and ankle specialist. A subsequent CT scan revealed an anterior process fracture of the calcaneus. Typical management of this injury is immobilization for 6 weeks. Outcomes or Other Comparisons: The result of this case study shows the importance of correct diagnosis of an anterior process fracture of the calcaneus in a timely matter. As a result of the CT scan, the anterior process fracture of the calcaneus showed no sign of healing. The athlete underwent surgery to excise the displaced fragment. Conclusions: This case presented the challenge of determining a definitive diagnosis. The injury mechanism was atypical which may have contributed to the delayed diagnosis. This subtle injury can sometimes be missed on standard lateral and anterior/ posterior x-ray views of the foot; therefore, oblique x-rays are recommended. Additionally, CT scan or MRI may be necessary to confirm the diagnosis. Delayed diagnosis and management likely contributed to a nonunion of the fractured calcaneus, which required surgical excision. Clinical Bottom Line: Athletic trainers and other healthcare providers should be familiar with the signs and symptoms of a calcaneal anterior process fracture because it can be easily misdiagnosed, leading to unresolved pain and possible surgical intervention. If an athlete has prolonged pain around the calcaneocuboid joint with an associated lateral ankle sprain, it may be recommended to consider an anterior process fracture of the calcaneus in the differentials.

Stress Fracture of the Cuboid in a Women's Soccer Player Knittle S, Gray C: Ithaca College, Ithaca, NY

Background: Cuboid stress fractures are considered rare occurrence, especially in athletics. A higher suspicion is warranted with patients presenting with point tenderness and pain with ambulation on the lateral side of the foot. Patient: A 19-year-old women's Division III soccer player presented in the Athletic Training Clinic following two days of practice on a turf field. She was approximately 4 weeks into the season including a rather grueling 10day preseason spent mostly on a natural grass field. She had been seen in the clinic prior for a right hamstring strain that had limited her practice for eight days. Shortly after gradually returning to full practice she presented with pain, which was described as a feeling of "pressure", in her right foot primarily over the 4th metatarsal, base of the 5th metatarsal, and cuboid bones. The patient stated she could not remember any specific event that caused the onset of this pain. During the history, the patient did mention that she wore orthotics all day and had recently bought a new pair and was still breaking them in, but they did not relieve her pain and when observing her gait, pes planus was also noted. She reported an increase in pain with palpation and axial compression of the 4th and 5th metatarsals and when she went up onto her toes. Due to the discomfort in her cuboid and a history of previous ankle sprain, cuboid mobilizations were performed but did not decrease her pain. Intervention or Treatment: The patient was referred to the team physician for a suspected stress reaction in her metatarsals and was fitted in a CAM walking boot and started rehabilitation to strengthen foot intrinsic muscles. The physician ordered x-ray which was negative and an MRI was ordered which reported the presence of a grade 4 stress fracture of the cuboid. Outcomes or Other Comparisons: The patient was casted and is currently non-weight bearing for approximately 4-6 weeks. Conclusions: Isolated cuboid stress fractures are extremely rare, most commonly presenting with other tarsal injuries such as a Lisfranc. They tend to be a result of either repetitive motions or higher energy injuries resulting in, what is referred to as a "crush" fracture. Typically stress fractures have a gradual onset and do not present with a sudden report of acute pain. Of the few reported cases of cuboid stress fractures, more were reported in children, or in overuse sports like running, ballet, and gymnastics with repetitive trauma. Many of the signs and symptoms presented followed the common presentation for a stress fracture. With this patient, her tenderness attributed to the 4th and 5th metatarsals was likely due to the articulation with the cuboid Treatment involves a period of immobilization, followed by a gradual progression of loading. Cuboid fractures typically heal without complication and it is expected that this patient will make a full return to sport. Clinical Bottom Line: It is important for athletic trainers to be aware of atypical presentations of foot injuries they may encounter. While key features for a cuboid stress fracture have not been documented in many case reports, knowledge of this uncommon injury can help lead athletic trainers to a higher level of suspicion, especially when the signs and symptoms fail to resolve with conservative treatment. Radiographic findings of cuboid stress fractures typically present as normal, with MRI being the gold standard for confirmation. Patients presenting with a suspected cuboid stress fracture and negative x-ray, may need further imaging with MRI. If not recognized and treated early enough, prolonged, high loading, repetitive activity can lead to a complete cuboid fracture requiring surgical intervention.

Weakening Plantar Plate and Dislocation of 2nd Phalange in Male College Tennis Player Level III Case Study Zengel O, Neiper D, Ryan C, Cleaves G: Kean University, Union, NJ; Drew University, Madison, NJ

Background: The plantar plate is formed from plantar aponeurosis and plantar capsule, and is the distal insertion of the plantar fascia at the metatarsophalangeal joint (MTPJ). Made of fibrocartilage, its purpose is to withstand forces from the metatarsal heads and ball of the foot and to resist hyper extension of the MTPJ. Plantar plate injuries result from repetitive overload from abnormal foot loading patterns. Plantar plate is usually surgically repaired. Patient: A 20-year-old male tennis player with Morton's toe suffered a weakening left plantar plate at the 2nd MTPJ which led to chronic dislocations during activity. Complained of pain on the distal dorsal aspect of the foot over a period of 2 months. Evaluation revealed athlete was point tender with edema on the dorsal side of the 2nd metatarsal bone. Symptoms gradually worsened. A metatarsal bar was unhelpful to manage the pain. Upon being referred again the athlete was given an MRI which showed a slight tear in the lateral collateral ligament (LCL) of the 2nd metatarsophalangeal joint. The athlete was put in a walking boot for 4 months with no improvements. A second MRI confirmed a tear of the LCL and inflammation of the plantar plate. Further clinical evaluation showed that the 2nd - 4th toes could dislocate due to severe joint laxity throughout the body. Intervention or Treatment: Initially the athlete was kept in a walking boot. Cryotherapy and electrical stimulation was used to reduce edema and overall pain. The athlete was taped before participation to prevent the anterior dislocation of his 2nd phalange and to give support to the plantar plate. Surgery was discussed to repair the plantar plate and LCL but was postponed for his fall tennis season. **Outcomes or Other Comparisons:** Chronic plantar plate injuries are usually experienced by middle aged women due to narrow feet and abnormal foot patterns. The athlete's history of joint laxity is thought to be the cause of the accelerated weakening of the left plantar plate. Conclusions: Athletic trainers often become comfortable treating the same injuries every day and sometimes miss a differential diagnosis. Sometimes injuries present as something completely different or patients are predisposed. Plantar plate injuries are not common and can be treated with various interventions depending on the athlete's clinical symptoms and pain level. Clinical Bottom Line: Plantar plate injuries are not typically seen in tennis players especially so young. While cases of plantar plate weakening are not unheard of, dislocations to the area are a direct result of the weakness. Conservative treatment prior to deformity occurring is best for management. Use of different taping techniques and a metatarsal pad are recommended but the best permanent solution is surgical intervention to shorten the 2nd phalange, repair the plantar plate and LCL.

Bilateral Unfused Apophysis at the Base of the 5th Metatarsals Fitzpatrick M, Cordone J, Gardner E, Norkus S: Quinnipiac University, Hamden, CT; Yale University, New Haven, CT

Background: According to the literature, an unfused apophysis at the base of the 5th metatarsal or an Os Vesalianum is extremely rare. Most reported cases are incidental diagnoses that are asymptomatic in nature. The athlete studied presented with symptomatic bilateral Os Vesalianum within a nine month period; both of which required surgery. The atypical insertion of the peroneus brevis tendon and calcaneal-metatarsal ligament on the ossicle also posed a challenge regarding surgical options. Patient: The athlete is a 21-year-old male lacrosse player who presented with a sharp pain along the lateral foot and base of his right 5th metatarsal on February 15, 2017. Upon evaluation, the athlete was tender to palpation at the base of the 5th metatarsal and had pain and difficulty with weight-bearing. An X-ray revealed an unfused apophysis or Os Vesalianum. He was given non-steroidal anti-inflammatory drugs, intermittently placed in a boot, and modified in practice to try and play his senior season; however, his pain increased over the course of the next 3 weeks. On March 10, 2017 an MRI of the right foot was then obtained which revealed an accessory ossicle from an unfused apophysis at the base of the 5th metatarsal with edema on both sides of the unfused "joint." The peroneus brevis tendon attachment was split 50% between the accessory ossicle and the 5th metatarsal. Intervention or Treatment: Initial treatment was conservative to decrease pain and inflammation. The athlete was given non-sterodial anti-inflammatory drugs, intermittenly placed in a boot, and was modified in practice. On March 15, 2017 an X-Ray guided injection of cortisone and anesthetic were administered into the "joint" with little improvement. With minimal relief after a month and a half of conservative

treatment, the athlete underwent surgery to resect the unfused apophysis on March 31, 2017. The surgery involved removal of the peroneus brevis tendon and calcaneal-metatarsal ligament that were attached to the ossicle, resection and removal of the unfused piece of bone, and then reattachment of the tendon and ligament to the remaining 5th metatarsal bone. Marrow cells from the hip were then injected into the area to facilitate healing. Rehabilitation after surgery followed that of an avulsion fracture re-attachment. He was placed in a boot immediately after the post-operative splint and was in a supportive sneaker within a month. He progressed well with range of motion and strengthening exercises and was jogging 2 months after surgery. Jogging patterns were strictly linear, with no pivoting or cutting until 3 months' post-operative to protect the ligament and tendon healing. He has since returned to recreational sports with no complaints. According to the literature, most reported cases of symptomatic Os Vesalianum are initially treated conservatively. However, conservative treatment is not often successful and is followed up by surgery. As reported in the literature, the preferred surgical intervention is a resection of the ossicle. In the case of this athlete, the atypical split insertion of the peroneus brevis tendon on both the accessory ossicle and base of the 5th metatarsal posed a challenge regarding surgical options. The split tendon was first removed from both the ossicle and the base of the 5th metatarsal before reattachment. Outcomes or Other Comparisons: There is no current literature discussing specific treatment and rehabilitation for bilateral Os Vesalianum. In the few cases documented where surgical invervention was warranted, there are no complaints of pain or discomfort post-opertatively. <u>Conclusions:</u> The unique presentation of this case relates back to the athlete's history. He has a previous history of peroneal tendonitis and an identical Os Vesalianum on the opposite foot, 9 months prior to the onset of this injury. Notably, the previous injury took 3 years to manifest before surgical intervention; however, for this injury, there were only 6 weeks between the onset of pain and surgery. Most reported cases of an unfused apophysis occur in growing adolescents, therefore bilateral presentation at the age of 21 is quite rare. The atypical insertion of the peroneus brevis tendon and calcaneal-metatarsal ligament on the ossicle also posed a challenge regarding surgical options. Similar cases of an unfused apophysis report an internal fixation of the bones as an appropriate intervention. However, since the peroneus brevis inserted on the accessory ossicle and 5th metatarsal; a resection was the only feasible solution. Clinical Bottom Line: Prior to imaging, the athlete's pain along the lateral foot is consistent with that of peroneal tendonitis, stress fracture, or Jones fracture. Both adolescent and adult populations could present with pain at the base of the 5th metatarsal, therefore if pain persists after conservative treatment, imaging may be warranted to rule out an Os Vesalianum.

Ankle Dislocation Without Associated Malleolar Fracture LaMarche J, Wilson S: Nebraska Wesleyan University, Lincoln, NE

Background: A 19-year-old male collegiate offensive lineman with no previous outstanding medical incidents and a family history of Ehlers-Danlose Syndrome (EDS) suffered a closed lateral ankle dislocation of the left leg during a football game. A helmet struck the posterior aspect of the left ankle, imparting significant valgus force onto the talocrural joint, causing a severe dislocation greater than 90 degrees. Differential Diagnosis: Upon initial inspection, gross deformity was obvious. The patient was evaluated and reduced on the field by the physician. Initial examination concluded likely malleolar fractures on both the medial and lateral side, as well as a deltoid ligament rupture. Possible vascular damage and/ or nerve damage did not appear to be present. The patient was transported to a local emergency room where diagnostic radiographs were taken. Treatment: Radiographs confirmed a deltoid ligament rupture, as well as tearing of the interosseous membrane of the lower leg, but no malleolar fracture. Instead, there was a transverse fracture of the proximal fibula at the end-point of the interosseous membrane tear. The patient was immobilized overnight, and surgery was performed the following morning. The deltoid rupture and interosseous membrane damage were repaired using two screws placed through both malleoli, affixing the deltoid ligament properly back onto the medial malleolus. The fibular fracture was non-displaced and did not need fixation. The patient was then placed in a below-the-knee cast for six weeks, non-weight bearing. Following this period, a walking boot was used for 4 weeks while the patient began range of motion exercises. Strengthening and proprioceptive exercises were done for the ankle, knee, hip and metatarsophalangeal joints on the affected side after transitioning from the walking boot. The patient was eventually progressed to load bearing activities, straightline running, and agility exercises. Six months post-surgery, the screws were removed, and a Tightrope device was put in place to prevent future gapping. The patient was then immobilized in a walking boot for an additional two weeks before clearance for all activity. The patient returned the following week for spring practice without restriction and continued into the summer conditioning program. No restrictions or stabilizing aids have been necessary, and no lingering issues have been observed. Uniqueness: Ankle dislocation without associated malleolar fracture is a very rare injury. Often when an ankle dislocation occurs it is due to weak or underdeveloped bones that bend to avoid fracture, however this case may have been due to the possible presence of EDS. EDS is a rare genetic disorder that causes alteration in collagen throughout the body and has been estimated to affect 1 in 5,000 people worldwide. Of the many types, the patient has a family history of the joint hypermobility classification, which is strongly associated with frequent dislocations due to laxity of the surrounding tissues. Hypermobility EDS is even more rare among males, as more than 90% of patients are female. Conclusions: A 19-year-old college football offensive lineman with a family history of EDS suffered a lateral ankle dislocation due to severe valgus force on the posterior aspect of the left foot. It was assumed that the patient fractured both malleoli, but upon viewing the x-rays, no malleolar fractures were present. The absence of these fractures likely sped up the rehabilitation process significantly and led to a decrease in long-term issues stemming from this injury. It is important for clinicians to understand and recognize this disease as a possible, although unlikely, cause of a patient's ligamentous laxity. It is also important to be able to identify other signs and symptoms of EDS.
Accessory Muscle Within the Tarsal Tunnel About the Ankle Gerig J, Golec S, Wallace JS: Youngstown State University, Youngstown, OH

Background: A 19 year old, female Division I college volleyball player with complaints of anterior left foot pain initially presented with moderate, manageable pain. However, the pain became unbearable to severe within months. The athlete initially complained of pain when sprinting and jumping and then was gradually unable to bear weight. Sharp localized pain was experienced when palpated the anterior, mid-foot, as well as when actively and passively placing the foot in plantar flexion. Differential Diagnosis: Based on the athlete's history of no previous ankle injuries, the mechanism of injury and initial clinical examination, she was initially suspected to have a stress fracture within the mid-foot. Following the team physician's examination an x-ray was taken to see what bone was problematic. X-ray results returned negative and within normal limits. Upon negative x-ray results an MRI was completed to see if all ligamentous and soft tissues were intact. Impressions of the MRI showed an accessory muscle within the high tarsal tunnel with significant effacement of the fat about the neurovascular structures. Treatment: The athlete was treated using cryotherapy techniques for tendinitis and inflammation of the accessory muscle within the high tarsal tunnel that had been discovered. The athlete was placed in a walking boot and was NWB for a total of 6 weeks. When she was cleared to resume activity, jumping exercises were limited and she was unable to sprint. A cold compression unit was administered after each practice. Rest was the primary treatment utilized to subside the tendinitis symptoms and the decision to rest was assessed on the patient's day-to-day pain. After three months of working to conservatively treat the pain, a cortisone shot was administered for the inflammation. The cortisone shot gave the athlete the most pain relief of all treatments. Uniqueness: The anomalous muscle found within the tarsal tunnel is called the flexor digitorum accessorius longus and has been reported to be present in 2%-8% of cadaver-based studies. Athletic movements predispose active populations to inflammation of the muscle due to repetitive motions about the ankle joint. The muscle then becomes inflamed and irritated. Using a boot during initial phases of treatment can temporarily modify pain. Conclusions: Volleyball is a sport that includes a high volume of jumping and agility movements. This collegiate female volleyball athlete was a hitter and played a position in which she was expected to perform a high volume of jumps. Due to the nature of the sport and her primary position it put her at risk for her to develop tendonitis in this flexor digitorum accessorius longus muscle, which she was unaware she had until this diagnosis. It is important as athletic trainers to explore all options when trying to examine, diagnose and treat each athlete's injury. Although most human anatomy is the same, we cannot forget individual differences and the possibility that an athlete could have anatomical variations that can predispose them to different injuries. Therefore, it is important to get to know each athlete and to not limit ourselves to only the knowledge we gain from courses and textbooks. As athletic trainers, we must think critically and creatively and do additional research to explore new options if we get stumped. It becomes important to never ignore pain even if nothing seems to be adding up. There are always exceptions to the rules and we must be willing to work outside of our comfort zone to best help our athlete-patients.

Lateral Ankle Triad in a Collegiate Football Athlete Alexander E, Felton SD, Craddock

JC, Shervington K: Florida Gulf Coast University, Fort Myers, FL; Reinhardt University, Waleska, GA

Background: This Level 4 Case Report presents an athlete that was a 19-yearold 185.42 cm and 97.52kg) male NAIA football athlete. Athlete's prior medical history included right chronic ankle instability resulting from three severe lateral ankle sprains. Athlete also had history of peroneal tendon tear 15 months prior. Athlete reported to the athletic trainer following practice complaining of pain and stiffness on the lateral aspect of his right ankle. Athlete stated pain was worse in the morning and improved throughout the day. Symptoms had been occurring for approximately a week. Initial evaluation revealed swelling and difficulty with weight bearing. Athlete was point tender over right lateral malleolus, anterior talofibular ligament, calcaneofibular ligament, peroneal tendon, and sinus tarsi. Lack of Active ROM and strength with ankle dorsiflexion, plantarflexion, inversion, and eversion. (+) Anterior Drawer Test for Pain and Laxity, (+) Squeeze Test for Pain, (+) Talar Tilt Test for Pain, (+) Kleigers Test for Pain, (+) Inversion Stress Test. Differential Diagnosis: Anterior Talofibular Ligament Sprain, Calcaneal Fibular Sprain, Peroneus Longus Strain, Peroneus Brevis Strain, High Ankle Sprain, Ankle Synovitis, Peroneal Tendon Tear. Treatment: Athlete started conservative treatment with no significant decrease in swelling or relief of pain after a week and a half. Athlete was then referred to university physician due to no change in signs and symptoms. Athlete underwent a physician evaluation including MRI and Musculoskeletal Diagnostic Ultrasonography. The MRI demonstrated significant fluid present on the anterolateral aspect of the right ankle surrounding the lateral malleolus and sinus tarsi area, overlying the anterior talofibular ligament. The Diagnostic Ultrasonography indicated a Grade 2 tear in the Anterior Talofibular Ligament, the Calcaneofibular Ligament, and the Peroneal Tendon. Athlete was then conservatively treated with NSAIDs to assist with pain and a compression wrap to reduce swelling. Athlete was also placed on crutches until he underwent Ankle Arthroscopy, Lateral Ligament Repair, and Peroneal Tendon Reefing. Athlete was placed in a non-weightbearing cast for 6 weeks. After the removal of the cast the athlete underwent rehabilitation. Athlete has a projected return to play after full weight bearing, full ROM, and no pain. Uniqueness: Lateral ankle sprains are a common injury in collegiate athletes. Researchers have reported that approximately 20 to 40 percent of acute ankle sprains progress to chronic issues. It has been reported there are approximately 27,000 ankle sprains daily in the United States. Of those 27,000 approximately 15 to 20 % experience persistent pain or instability. Research also suggested that only 60% of peroneal tendon disorders were accurately diagnosed on the first clinical evaluation. This case is unique because there is not much research on the treatment of the Lateral Ankle Triad to assist in returning the athlete back to competition post-surgical. Conclusions: This case highlighted the diagnosis and treatment of an athlete dealing with the Lateral Ankle Triad. This case further highlighted the success of Ankle Arthroscopy, Lateral Ligament Repair, and Peroneal Tendon Reefing after consultation with university physician and failed attempts at conservative treatment.

Patient With a Right Ankle Haglund's Deformity Llanos CE, Felton SD, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: The Level 4 CASE report presents a female hospital nurse that was 33-years-old, 63.5 kg, 160 cm. The patient's prior medical history included right ACL grade II sprain 2 years ago, non-surgical rehabilitation performed for this injury. The patient is 6 months postpartum, with no complication during pregnancy and normal delivery. The patient came into physical therapy office with complaints of ankle and foot pain. The patient had no specific mechanism of injury to the ankle, the major complaint was after high impact, squatting exercises or prolonged standing at work during long hour shifts. Initial evaluation revealed, tender in the area where the Achilles tendon attaches to the heel. Patient presents with a palpable bony lump in the back of the distal Achilles tendon. Patients stated she has had that lump for a long time after many years of ballet. Full ankle ROM and Strength with right ankle plantar flexion, inversion, and eversion. Limited dorsiflexion compared to uninvolved side. Knee flexion and extension ROM within normal limits. Balance, coordination, and sensation were intact. The patient also presents bilateral forefoot varus and high arches. (+) Silfverskiold's Test for gastrocnemius and Achilles tendon tightness, (-) Thomson's Test, (-) Bump Test. The patient was then referred to an ankle and foot specialist medical doctor where lateral radiographs were taken and revealed retrocalcaneal exostosis of the affected ankle. Differential Diagnosis: Plantar Fasciitis, Achilles Tendon Tendinopathy, Os Trigonum, Calcific Heel Spur, Osteochondritis Dissecans, Retrocalcaneal Bursitis, Calcaneal stress fracture. Treatment: According to the recent literature, Haglund's syndrome is often treated conservatively by altering the heel height in shoewear (inserts), orthosis, physical rehabilitation, and anti-inflammatory drugs, surface change for aerobic training (swimming, bicycling, aquatic exercises). If the patient has a high arch a heel lift (insert) could be helpful to decrease pressure on the heel. Surgical excision of the bony exostoses of the calcaneus is only required in resistant cases. Conservative treatment was implemented; emphasis on gastrocnemius myofascial release, hamstrings, gastrocnemius, soleus, and Achilles tendon dynamic and static stretches. Gastrocnemius and soleus eccentric strengthening exercises for tissue elongation. Local perilesional steroid injections are also used in refractory cases. Uniqueness: Haglund's deformity is an enlargement of the posterosuperior prominence of the calcaneus. This syndrome produces posterior impingement of the heel, which is caused by a posterosuperior calcaneal exostosis. Haglund's syndrome is a combination of soft tissue and bony abnormalities and can cause retrocalcaneal pain consisting of inflammation of the regional soft tissues, and thickening of the Achilles tendon. The major factor of Haglund's Deformity is high arches. When high arches are present the heel is tilted backward into the Achilles tendon because the Achilles tendons attach to the calcaneus. A bony protrusion develops and the bursa becomes inflamed due to the constant friction of the back of the calcaneus to rub against the Achilles tendon. Another cause of this Deformity can be the tightness of the Achilles tendon due to gastrocnemius myofascial stiffness compressing on the retrocalcaneal bursa. Pathologic conditions behind the calcaneus are common and may initiate during early childhood. This case is unique because the stress on the ankles and feet during ballet years growing up. Another unique factor that can lead to this condition is the hormonal changes in the body postpartum. Conclusions: This case report highlighted the diagnosis and treatment of a 33-year-old female suffering from a right ankle Haglund's Deformity. The case further highlighted the various treatments options and rehabilitation protocol. Successful findings post-treatment and exercise modification over the course of 8 weeks. The patient is asymptomatic and able to perform pain-free ADLs. Pt was able to reach the prior level of function and prior fitness level.

Delayed Treatment and the Subsequent Effects in a Mid-Shaft Fifth Metatarsal Fracture: A Case Study

Decker D, Bartz-Smith S: Grand Valley State University, Allendale, MI

Background: A 5'10" 17 year old male high school soccer player was injured in mid-June during club soccer season. He dragged the ball with his left foot in an attempt to move around an opposing defender. He described that his foot awkwardly slipped off the ball and went into inversion where he felt a crack. He immediately had pain on the lateral aspect. He did not seek medical attention until late July when he saw his high school athletic trainer who referred him to a physician. Differential Diagnosis: Lateral ankle sprain, fibular avulsion fracture, Jones fracture, and metatarsal fracture. Treatment: X-rays were ordered which revealed a stress fracture of the mid-shaft fifth metatarsal. He was placed in a walking boot for three weeks from August 1st to August 21st. He followed up with his physician on August 21st and was fully cleared to play. That day, he saw his athletic trainer who recommended that he go through warm-ups and then check back. Due to pain after warm-up the athletic trainer recommended that he not play, however the coach played him anyways. During the game his foot came into direct contact with another player causing severe pain. The athletic trainer removed him from the game. Sideline evaluation performed by the athletic trainer revealed that the athlete was point tender over the lateral aspect of his foot. After the examination the pain subsided to a dull ache. The next day the athlete was reevaluated by the athletic trainer and was placed into in a boot. After two weeks there was no improvement in pain level and therefore the athletic trainer referred him back to the physician on September 11th. X-rays revealed a stress fracture of the midshaft fifth metatarsal and surgical repair was recommended. The physician informed him that he could finish the season as long as he could withstand the pain. He was instructed him to wear his walking boot unless participating in sport. Treatment consisted of metal inserts in his cleats, cold whirlpool, towel curls, picking up marbles with his toes and using a bone stimulator. Five weeks later, on October 15th he returned to his physician who stated that the bone had shown signs of healing and he no longer recommended surgery. Following this visit the athlete returned to full participation. Uniqueness: Mid-shaft fifth metatarsal fractures typically take 6-8 weeks to heal; this injury took approximately 16 weeks. A lack of qualified healthcare professionals in youth sports organizations may lead to patients either not seeking treatment or delaying their treatment resulting in suboptimal patient outcomes. Conclusions: The athlete returned to full participation but due to multiple factors including a delay in seeking medical attention and not following medical advice his return to play timeframe was more than doubled. The athlete played half of his varsity season in an injured state. Lack of access to quality healthcare providers in youth sports organizations can have negative impacts in returning athletes to competition and their pre-injury state.

Free Communications, Poster Presentations: General Medical Conditions: Case Studies

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Salivary Biomarker Response in Elite Wrestler Throughout a Competitive Season

Ransone JW, Calvi JL, Bach C: Nebraska Athletic Performance Laboratory, University of Nebraska, Lincoln, NE

Context: Wrestling is a vigorous and physically demanding sport activity creating psychological and emotional stress load. **Objective:** The aim of the current investigation was to quantify the salivary biochemical markers including testosterone (T), cortisol (C) and secretory immunoglobin A (SIgA) as indicators of the balance between anabolic and catabolic processes quantifying the homeostatic response in subject's training as a point of exercise periodization and potential adaptive processes to training. Design: Longitudinal repeated measures, mixed design. Setting: Controlled laboratory environment. Patients or Other Participants: Volunteer sample of ten collegiate wrestlers (age = 22.11 ± 1.1 years, height = 177.8 ± 3.1 cm; weight = 77.6 ± 20.9 kg) including 5 NCAA I All Americans signed an informed consent form, completed a health history questionnaire and physical examination. This study was approved by and carried out in accordance to the Declaration of Helsinki. Interventions: Salivary samples were passive collected via unstimulated passive drool (@ 0.75 mL) at 24 hours before competition and 48 hours post competition. Samples were transported to a -20°C freezer within 20 minutes of collection. On the day of analyses, saliva samples were thawed and centrifuged at 3500 rpm for 15 minutes to remove mucins and the resulting supernatant stored at -80°C until further assay analysis. Main Outcome Measures: All biomarker concentrations were determined using indirect enzyme-linked immunosorbent assay (ELIZA) kits. Intra-assay coefficients were 4.33%, 4.20%, and 4.47%, and inter-assay coefficients were 2.15%, 6.47%, and 11.26% for C, T and S-IgA, respectively. A comparison alpha level of p < 0.05 was used to determine statistical significance. Conceptualizing the change in T, C, TC ratio and S-IgA over the competitive season, a series of hierarchical linear models were utilized. Results: A full model with eight predictor variables (five individual variables and three interaction terms) were entered into the model. Testosterone model showed evidence of nesting, ICC = .70, p = 0.02. Cortisol concentrations showed nesting, ICC = 0.16, p = 0.05. A full model was run on C concentrations. The initial empty model showed the presence of nesting of TC ratio values, ICC = .27, p = 0.04, and indicated that Day was a significant predictor of TC ratio, F(1, 183) = 3.16, p = 0.08. The initial empty model showed the presence of nesting of s-IgA values, ICC = 0.16, p = 0.096. Conclusions: Our analyses revealed a significant Pre-Post T and T/C ratio as a significant positive predictor, indicating the post-competition levels were higher than the pre-competition levels. Pre-Post C and interaction with time (Day X Pre-Post) were not significant. Significant SIgA concentrations (Day X Bouts) showed a significant positive prediction, indicating that over time as bouts increased. The exploration of salivary biomarkers could prove as a objective non-invasive method to understand demands of intense competitive exposures.

The Use of Botulinum-Toxin-A Injections in the Treatment of Chronic Exertional Compartment Syndrome: A Level 3 CASE Study

Donovan JJ, Tanksley EC, Howard JS: Appalachian State University, Boone, NC

Background: Chronic exertional compartment syndrome(CECS) is associated with repetitive, overuse mechanisms, causing swelling within the compartment due to lack of fascial stretching, resulting in pain and dysfunction. Typical care for CECS consists of rest/rehabilitation or surgical fasciotomy. Unfortunately, both of these treatments have high rates of recurrence and unsuccessful outcomes. Dissatisfaction and frustration with treatment may result in patients seeking alternative, less established, treatments outside of the established medical team, such as treatment with Botulinum-toxin-A(BoNT-A) injections. Patient: A 21-yearold female, senior field hockey athlete had a chief complaint of lower leg cramping, diffuse shin pain and calf tightness that had persisted for 3-years. The patient had been treated for bilateral tibial stress reactions diagnosed via MRI, with little symptom resolution. Previous treatments under multiple physicians included rest (including NWB), therapeutic exercises, non-impact training, cryotherapy, orthotics, soft-tissue mobilization and consultation with a dietitian, all with limited success. CECS had been considered as an alternative diagnosis; however, repeated intracompartmental pressure measures were negative. Out of a desire to participate in her senior season the athlete explored outside treatments and identified a physician offering a "new" treatment for CECS. Upon consultation, the patient was diagnosed with CECS in the superficial posterior and lateral compartments via MRI. The patient also had a computed tomographic angiography with venous-phase imaging(CTA/CTV) performed which

demonstrated mild arterial and venous compression of the superficial femoral vein bilaterally. Intervention or Treatment: The athlete received two rounds of ultrasound-guided BoNT-A injections. The BoNT-A was injected into the muscle belly and heads of the gastrocnemius and into multiple locations in the soleus in June 2017. At follow-up in July, imaging showed a decrease in arterial compression, but no significant change in venous compression, and the second round of injections were performed. After each treatment the athlete was prescribed 2 days complete rest, 1 week of exercise-as-tolerated followed by 3 days rest. BoNT-A is a neurotoxin that impedes the neurological impulses that result in muscle contraction. The muscle fibers subsequently decrease in diameter. Theoretically, this reduces compartmental volume, decreasing intramuscular pressure thereby restoring neurovascular function to the limb, and hopefully resulting in symptom relief. A potential complication of BoNT-A injections, is muscle atrophy, which was discernable in our patient. The muscles in her lower leg atrophied to the point where she was unable to complete running tasks due to weakness and pain. Outcomes or Other Comparisons: There was no improvement in the patient's primary complaints of pain and weakness 4-months following treatment. Although, immediate effects were seen directly in the decompression of neurovascular structures, the patient's overall condition never improved. In limited reporting, BoNT-A treatment effects have been reported to occur within 3-months of injections with a 94% success rate(Isner-Horobeti 2013). However, similar to this patient, strength deficits were observed in 69% of patients. Conclusions: Most cases of CECS are treated nonsurgically with rehabilitation, orthotics and activity modification, or surgically with a fasciotomy. However, in this case, a series of intramuscular BoNT-A injections was administered. While the goal of treatment was to reduce muscle tone, to lower overall lower leg pressure, there has been no significant improvement in the patient's pain or ability to participate in sport, and she has experienced considerable muscle atrophy. <u>Clinical Bottom Line:</u> CECS is a challenging condition to treat. BoNT-A injections may be an emerging treatment. Patients with conditions that fail to respond to treatment may seek care beyond the standard medical team. It is important that the athletic trainer work with the patient and providers to support the patient and provide care regardless of the success or failure of outside treatments.

Bilateral Hand Compartment Syndrome in a Former High School Multi-Sport Athlete Vaniman AL, Moore MT: Northern Michigan University, Marquette, MI

Background: Common mechanisms of injury for compartment syndrome includes burn, direct trauma, intensive use of muscle, etc. The patient's uniqueness was idiopathic compartment syndrome of the hands, secondary to autoimmune disorder diagnosis of scleromyositis. Scleromyositis is an autoimmune disorder that attacks the fascia of the body and is contingent on increased collagen production. Objective findings may abnormal coloration of the affected body part due to vascular deficiencies. Common co-morbidities include Raynaud's phenomena, arthritis, myositis or scleroderma. Treatments for this patient totaled 18 compartmental fasciectomies/fasciotomies over a course of five years related to her scleromyositis which is unique considering her age and activity level. Patient: Patient is a 21-year old female college senior participating in intramural soccer. The patient was a former high school tri-athlete who participated in repetitive impact sports for multiple years (soccer, cross-country, basketball). Patient has a previous history of compartment syndrome in her anterior and superficial posterior compartment of the lower limb and superficial volar compartment of the forearms. Patient presented with paresthesia throughout her hands and fingers, excluding the thumb. She had loss of grip strength and dexterity in fine motor skills, particularly with the thumb, with complaints of severe achy pain throughout the hand. She had slowed blood reperfusion with Allen's test with both ulnar and radial arteries. Patient also experienced slowed capillary refill (3+ seconds). Grip strength was low recorded at 47-55 lbs of force at neutral with various widths from 2-4 cm. Pulses were normal and equal bilaterally and no reported pain with hand spreading. She had no mechanism of injury reported. Differential diagnosis included carpal tunnel syndrome, median nerve compression at elbow, ulnar or cubital tunnel syndrome, brachial plexus pathology, thoracic outlet syndrome or spinal stenosis. Referral to rheumatologist and immunologist for differential

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diagnostic testing revealed scleromyositis, and Raynaud's phenomena. Intervention or Treatment: Clinical history indicated elevated hand compartment pressure although no testing was performed due to increased patient pain. Hand surgeon completed three decompression fasciotomies of the thenar, hypothenar, and interosseous compartments bilaterally via longitudinal incisions. Pre-surgical evaluation included Sollerman hand function test, hand-grip dynamometer, manual muscle testing, goniometry, blood pressure, reflexes, myotomes and dermatomes, pulse oximeter, heart rate, hand and forearm girth measurements. The patient underwent the same qualitative and quantitative testing pre surgery and every two weeks to monitor results post-surgery. Physician protocols to initiate rehabilitation required the patient to be a minimum two weeks post surgical and pain free. At four weeks, when patient was pain free a rehabilitation regimen was initiated. Rehabilitation consisted of nerve flossing (ulnar, median, radial), passive/restive ROM exercises of the wrist, 6-way wrist movements (flexion, extension, radial/ulnar deviation, supination, pronation), water cup pick up for dexterity, and the use of progressive resistive exercise putty. Gentle scar tissue massage and Gua Sha was utilized as tolerated. Additional components of this case included essential psychological support and coordination between the health care teams. Outcomes or Other Comparisons: Patient's sensation normalized after week five, range of motion and strength returned to functional levels after 8-10 weeks. Patient has continued with rehabilitation and is expected to gain full strength and function over time. Conclusions: In this case, diagnosis of the injury was extremely complex without a direct mechanism of injury, and rare symptoms. Diagnosis was unclear until referral to rheumatologist, immunologist, and hand surgeon for differential diagnostic testing. Clinical Bottom Line: When diagnosing a patient, referral for clinical lab testing and other diagnostic tools to the appropriate medical professional team could be the defining factor in proper diagnosis and treatment for your patient. Continuation of support for the patient psychologically and clinically is essential throughout this process.

Fibrous Dysplasia of the Sphenoid Bone in a Collegiate Rugby Player

Bull AT, Hoots KM, Scifers JR: Moravian College, Bethlehem, PA

Background: Fibrous dysplasia is a benign condition which results from mutation of the GNAS-1 gene. This mutation can lead to the overproduction of the cAMP regulating protein, which, in bones, increases proliferation and abnormal differentiation of osteoblasts, resulting in the disruption of normal bone matrix creation and replacement of mature bone with fibrous tissue. FD is a very rare disease, affecting only about 1 in 4,000-10,000 individuals. FD accounts for 2.5% of all bone tumors and 7% of benign bone lesions. Patient: Patient is a 22-year-old, male, club rugby athlete suffering an acute, mild head trauma during a rugby match. A fellow team member referred the patient to the athletic trainer secondary to signs of memory loss. During the athletic trainer's initial evaluation, the patient reported a past medical history of concussion and demonstrated shortterm memory loss, including no recollection of head trauma, with retrograde amnesia. No other symptoms of head injury were present at this time. His amnesia persisted hours after the injury. The patient was restricted from activity and the athletic trainer requested permission to contact the patient's mother. The mother reported that the patient suffered from a congenital deformity of the skull. The patient was then referred to a neurologist for assessment. The neurologist referred the patient to the emergency department for diagnostic imaging, including a CT scan. During his visit to the emergency department, the patient began complaining of a frontal headache with an intensity of 7/10 and continued retrograde and antegrade amnesia. Intervention or Treatment: The patient was diagnosed with a sport-related, mild traumatic brain injury. CT scan revealed an incidental finding of monostotic fibrous dysplasia (FD) of the sphenoid bone. The patient

was instructed to refrain from attending class for one week. Three weeks after injury, the patient initiated concussion rehabilitation under the direction of both a physical therapist and an occupational therapist. Outcomes or Other Comparisons: The sphenoid is the second most commonly involved bone of the skull to be diagnosed with FD, following only the ethmoid. Most frequently report symptoms are facial pain and numbness, headache, proptosis, diplopia, and hearing loss, none of which were seen in this case. CT scan is most diagnostically accurate imaging tool for identifying FD. The clinical behavior and progression of FD demonstrates great variation. As a result, few clinical guidelines exist regarding management of this condition. Commonly employed treatments range from surgical repair to conservative care and rehabilitation, as seen in this case. Conclusions: Although concussions are not rare occurrences within an athletic population, the occurrence of a concussion allowed the athletic trainer to identify the secondary, highrisk diagnosis. Athletic trainers should be aware of this condition in an athletic population, and be able to identify those individuals at risk. At this time, the patient continues to be restricted from sport activity. Clinical Bottom Line: Fibrous dysplasia, although rare, is a condition that athletic trainers should become familiar with due to risks associated with patients' participation in collision and contact sports.

Return to Play Following Appendicular Knotting and Subsequent Appendectomy and Cecectomy in a Collegiate Baseball Player

Cage SA, Gallegos DM, Warner LK, Warner BJ: University of Texas, Tyler, TX; University of North Carolina, Greensboro, NC; University of Texas, San Antonio, TX; MVP Orthopedics, Glendale, AZ; Grand Canyon University, Phoenix, AZ

Background: A 23-year-old collegiate baseball player reported to the emergency department of the local hospital following a week of upper right abdominal quadrant pain. Patient reported that the pain seemed to originate "right under his ribcage". Patient had been taking over the counter Advil to alleviate pain, but symptoms had become unbearable prompting him to report to the emergency department. Initial evaluation revealed palpable tenderness in the upper and lower right abdominal quadrants. Differential Diagnosis: Appendicitis, Abdominal Muscle Herniation, Intestinal Obstruction. Treatment: Upon admission to the hospital, diagnostic imaging was ordered to determine the pathology. Chest x-rays were unremarkable, leading the radiologist to recommend diagnostic ultrasound to further evaluate the abdomen. Diagnostic ultrasound of the abdomen revealed a thickened appendix and an abnormal appearing bowel. At this point, a CT scan was ordered, revealing a significantly distended appendix along with generalized edema surrounding the appendix. Following the diagnosis of acute appendicitis with a possible rupture, patient consented for laparoscopic surgery. Surgery began uneventfully with 5 mm ports being made at the umbilicus and right and left lower quadrants. At the initiation of surgery, a large structure was found adjacent to the distal ileum that the surgeon was unable to identify. Attempts to mobilize the cecum, ileum and appendix were unsuccessful due to a large amount of fibrosis present. The surgeon deemed it was unsafe to continue laparoscopically and the decision was made to continue with

an open procedure. Upon extension of the portal in the lower right quadrant, dissection began through subcutaneous tissues and abdominal muscles. Careful examination of the operative field showed a distended and firm appendix adherent to the cecum, especially posteriorly. Further examination revealed that the appendix was in fact strangling the cecum. Additionally, what appeared to be the appendiceal cecal junction was necrotic. At this point a cecectomy was indicated, leading to transection of portions of the small bowel, mesentery and transverse colon. The specimen was then removed before all defects were closed via suture and the abdomen was irrigated. Patient was held for recovery and observation for five days prior to being discharged in stable condition. Patient was instructed to maintain a low fat diet until follow-up evaluation and prescribed Lortab for pain. Patient was also placed on lifting and activity restrictions for the next four weeks. Two weeks post surgery evaluation revealed significant healing and decrease in pain. Patient was then instructed to follow-up with team physicians upon arrival to campus. Uniqueness: A search of scholarly articles revealed only three previous instances of appendicular knotting causing intestinal obstruction or strangulation. In these studies, the involved structure was the ileum, not the cecum. While the literature did not provide a consensus, all articles agreed that appendicular knotting was a rare condition. Also, in spite of intestinal involvement in this case, the patient never experienced nausea or vomiting. Conclusions: While relatively common surgical procedures often have generalized guidelines within sports medicine, it is important to note that complications may occur. It is paramount for clinicians to be able to adapt return to play protocols to accommodate for unforeseen variations in surgical procedures. When doing so, it is critical that thorough evaluation and re-evaluation of return to play protocols occur.

Management of a Collegiate Tennis Player With Newly Diagnosed Dermatomyositis: A Case Study

Warner BJ, Foster AL, Goza JP, Warner LK, Cage SA: Grand Canyon University, Phoenix, AZ; The University of North Carolina, Greensboro, NC; The University of Texas, Tyler, TX; Jacksonville College, Jacksonville, TX; MVP Orthopedics, Glendale, AZ

Background: A 21-year-old collegiate tennis player reported to pre-participation physical examinations with a diagnosis of dermatomyositis. The patient had been diagnosed the previous summer following gastrointestinal distress and development of a lesion on the upper left superior chest. Patient reported these symptoms to her dermatologist, who confirmed the diagnosis of dermatomyositis via biopsy. Upon reporting to the athletic training staff, the patient was immediately screened by team physicians. Differential Diagnosis: Dermatomyositis confirmed through histological analysis of biopsy prior to pre-participation physical examinations. Treatment: Following evaluation by team physicians and a thorough review of medical history, it was determined that the patient was safe to begin team activities. With the assistance of team physicians, coaching and athletic training staff were educated on the patient's condition, and made aware of the protocol that was to be used. Prior to non-traditional season workouts, the patient was counselled on proper precautions to follow. Throughout the school year, patient made sure to maintain adequate hydration, wear appropriate clothing to protect against UV light, and to apply and reapply sun screen with a minimum SPF 50. Clothing suggestions included long sleeves, a baseball cap and tights, although the patient did not wear tights except during cold weather. After educating all appropriate athletic training and coaching staff on the patient's condition, the team physician also informed a local dermatologist within her medical network who would act as a point of contact if the patient began to experience worsening symptoms and was unable to seek out expedient care from the diagnosing physician. Additionally, the patient began a regimen of drinking turmeric root tea in the mornings and evenings per her diagnosing physician's instruction. Patient also underwent routine follow ups with her primary care physician and dermatologist. During the season, patient experienced no adverse reactions as a result of dermatomyositis, and did not sustain any other musculoskeletal injuries. Following completion of her competitive season, patient was instructed to continue her current precautions when taking part in activities where she may be exposed to UV light. Uniqueness: While dermatomyositis is a well-documented condition, there is little literature to provide recommendations and considerations for athletic participation with dermatomyositis. A scholarly search of PubMed and Google Scholar with the terms "dermatomyositis" and "athlete" yielded results for physically active patients, but not intercollegiate athletes or tennis players specifically. Due to this fact, the clinician had to use available information and consultation with physicians to develop a best practice plan for the patient. Conclusions: While many conditions are commonly reported in literature, there can be a lack of information with regard to the effect these conditions have on the physically active population. When faced with a condition like dermatomyositis, it is the responsibility of the clinician to conduct a thorough literature review and consult with appropriate specialists to develop a best practice plan. In the absence of information about a patient's specific activity, a clinician must be innovative enough to use the available evidence to best meet their patient's needs.

Radioiodine Treatment for the Management of Graves' Disease in a Division I Soccer Athlete Hile AM: West Virginia University, Morgantown, WV

Background: This Level 4 CASE report involves an 18 year old female soccer goalkeeper with a recent diagnosis of hyperthyroidism. At her freshman physical she complained of a long history of hand tremors, fatigue, lightheadedness, tachycardia, inability to gain weight and hair loss. Lab work and diagnostic testing revealed she had Graves' Disease. The athlete began a combination of medication including antithyroid agents, beta-blockers and antihistamines. She was granted conditional medical clearance to compete in soccer from the team physician. During her first season the athlete experienced significant challenges and frustrations competing on a daily basis. Despite being on beta-blockers she struggled with a racing heartbeat that made nearly all cardiovascular exercise a challenge. Although symptoms decreased following the introduction of antithyroid medication, her complaints of hand tremors and fatigue remained. She also struggled on several occasions with heat intolerance. In addition she suffered from a diffuse pruritic rash and itching secondary to her antithyroid agent which is a common side effect of the medication. Following her first season of collegiate soccer this athlete expressed a strong desire to explore options to decrease her symptoms and improve her overall quality of life. Differential Diagnosis: Possible interventions identified were to continue conservative treatment and manage her disorder through a combination of medication and modified activity, surgical removal of the thyroid gland and supplement with thyroid hormones or radioiodine treatment to ablate her thyroid gland and supplement with thyroid hormones. Treatment: In consultation with our team physician and an endocrinologist the athlete elected to undergo radioiodine treatment to shrink and permanently destroy her thyroid gland. In the procedure the athlete swallowed

a pill orally and was kept in semi isolation for 72 hours to avoid contaminating others. For 8 weeks following the procedure the athlete discontinued all medication and engaged in only activities of daily living avoiding strenuous physical activity due to an inability to regulate her heart rate. Following this rest period the endocrinologist prescribed thyroid hormone and checked Free T4 and TSH levels every four weeks to adjust and regulate medication. The athletic trainer directed a gradual progression rehabilitation protocol moving from walking, biking, other cardiovascular machines, running and sport specific training based on the athlete's tolerance and symptoms. This athlete made a full return to soccer and has experienced a significant decrease in her daily symptoms. She currently tolerates cardiovascular conditioning and practice without many of the previous complaints and challenges including cessation of the hand tremors, less feelings of fatigue and elimination of the rash and itching. She continues to wear a heart rate monitoring device during all training and conditioning sessions that is monitored by the athletic trainer to make any needed modifications. Uniqueness: The presence of Graves' Disease in collegiate athletics is uncommon and presents challenges to the athletic trainer. Our clinical team could not find a similar case of an elite athlete pursing this treatment and therefore needed to create our own protocol and guidelines for return to play. The athletic trainer was also charged with providing an emotional support network for an athlete making a permanent life changing treatment decision. Conclusions: This case demonstrates not only an elite athlete successfully competing with Graves' Disease but further establishes that an athlete can undergo radioiodine treatment and return to a high level of sport activity. This case is important in establishing a management protocol for Graves' Disease and for return to activity following radioiodine treatment. Additionally the case highlights that athletic trainers are called upon to manage illnesses and rehabilitation well beyond the scope of traditional athletic injuries.

Diagnosis and Management of Spontaneous Pneumoperitoneum: A Case Report

Tucker M, Gabler CM: Utah Performance Institute, West Haven, UT; Weber State University, Ogden, UT

Background: Pneumoperitoneum is air trapped within the peritoneal cavity. It can either be caused by an intra-abdominal perforation or an insufflation of gas $(CO_2 \text{ or } O_2)$ during a laparoscopy. This case involved a 17 year-old, female high school volleyball and basketball player who originally presented with symptoms of rib pain and dyspnea during September 2015 after having a laparoscopic appendectomy in June 2015. At that time, one week of rest, ice and compression were administered by her athletic trainer, but the symptoms continued and began to worsen during subsequent athletic activity. The athletic trainer then referred her to a physician who diagnosed her with pneumoperitoneum, and prescribed an anti-inflammatory medication and rest until the symptoms resolved. Her symptoms spontaneously reoccurred during the 2015-2016 basketball season, and continued into the following 2016 volleyball season. Differential **Diagnosis:** Upon clinical examination by the athletic trainer, there was a palpable deformity over the left rib cage, muscle spasms of the overlying musculature, no crepitus, and negative tests results for a rib fracture. These initial findings led to differential diagnoses of either a rib dislocation or strained abdominals. However, the deformity spanned over the majority of the rib cage, and the athlete's discomfort did not subside when her abdominal muscles were in a relaxed position, which are uncharacteristic signs of rib dislocations and abdominal strains, respectively. After referral to a physician, a chest radiograph and CT scan were performed, which led to the new differential diagnoses of pneumoperitoneum, subphrenic abscess, Chilaiditi syndrome, or linear atelectasis of the lungs. All of these pathologies can simulate free air under the diaphragm on a radiograph, and present similarly on a CT scan. However, the combination of the surgical history, signs and symptoms in this case were unique to the diagnosis of pneumoperitoneum. Treatment: During spontaneous episodes of pneumoperitoneum, continual direct pressure was applied to the left rib cage by the athletic trainer for 2-3 minutes while the athlete was instructed to take deep breathes. This allowed the distended rib cage to return to its normal position. An ace bandage was then applied around the rib cage to maintain direct pressure and increase comfort. The majority of the athlete's symptoms subsided within 10 minutes of these treatments, and were completely relieved within 24 hours. The athlete also reported to the athletic training room weekly for myofascial release treatments on the overlying muscles to relieve muscle spasms. An ice bag was applied 20-30 minutes to the left rib cage after volleyball practice in attempt to control pain. External rotation and trunk extension were determined to be one of the main causes of her reoccurring symptoms. To reduce the occurrence of symptoms, the athlete and volleyball coaches were advised to limit the amount of repetitive serving and hitting done during practice. When symptoms arose spontaneously, the athlete was removed from activity for the remainder of that day, and was allowed to return to activity once asymptomatic. Uniqueness: Pneumoperitoneum is a common phenomenon occurring after abdominal surgery, and approximately 90% of cases require surgical management. However, the athletic trainer in this case was able to manage the athlete's symptoms conservatively and avoid removal from athletic participation for an extended period of time. Furthermore, 96% of residual pneumoperitoneum resolves itself within one week, but this athlete experienced spontaneous symptoms for more than one year. Conclusions: Spontaneous pneumoperitoneum is a rare condition that is difficult for clinicians to diagnose. Taking a thorough history can help discern between postoperative and spontaneous pneumoperitoneum. Understanding the difference between the two is important in determining whether surgical treatment can be avoided, and symptoms can be managed conservatively, as was demonstrated in this case.

Acute Onset Bell's Palsy in a Seventeen-Year Old, Female High School Basketball Player: A Case Study Kershaw ZT: Old Dominion

Kershaw ∠1: Old Dominior University, Norfolk, VA

Background: A seventeen-year-old, female high school basketball player with acute onset Bell's Palsy. The patient presented with acute symptoms including altered speech, partial left-sided facial nerve paralysis, drooping and swelling of the oral commissure, as well as left sided drooping of lateral corner eyelid. The patient had equal motor and neurological functioning of upper and lower extremities. The patient had no known previous history of reported symptoms or associated ongoing medical conditions. Differential Diagnosis: An onsite evaluation by the Athletic Trainer attempted to rule out life threatening conditions and determined possible differential diagnoses that, in addition to idiopathic Bell's Palsy, included stroke, acute allergic reaction, brain tumor, and Lyme's disease. Treatment: Emergency room referral resulted in a confirmed diagnosis of idiopathic Bell's Palsy. Patient was prescribed a corticosteroid (Prednisone) regimen for acute management of the sudden onset Bell's Palsy episode. Patient completed dosage of prescribed Prednisone over a two-week period, and was returned back to full participation with no restrictions five days following initial onset. Progress and determination of readiness to return to sport was analyzed using clinician based outcomes; House-Brackman Scale, Sunnybrook Facial Grading System, and patient reported outcome; Facial Disability Index. Uniqueness: Bell's Palsy is a rare condition that affects about 20 to 30 people per 100,000 annually, causing full or partial paralysis of the facial nerve. Although an episode of Bell's Palsy in a patient of this age with no previous neurological dysfunction is likely rare, the immediate identification and referral was advantageous in the accurate treatment of the patient; resulting in quick recovery with no long-lasting effects. Conclusions: In the case of an onset of

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idiopathic Bell's Palsy, it is essential for the Athletic Trainer to be able to recognize the onset of associated signs and symptoms, and to facilitate immediate referral to expedite appropriate treatment. The ability to quickly implement corticosteroid treatment can improve the overall recovery timeline and outcomes for the patient. The use of patient and condition specific clinician and patient reported outcomes can efficiently assist the clinician in appropriately identifying progress throughout the recovery process.

Surgical Complications Lead to Running Restrictions in a Softball Pitcher: A Level 4 CASE Study

Watson EL, Samer NM, Howard JS: Appalachian State University, Boone, NC

Background: A 19yr old female softball pitcher suffered a surgical complication after having a microdiscectomy of L4 and L5 to correct herniated disks in March 2016. Four days after the surgery the patient was brought to the emergency department for severe abdominal pain, upon further assessment it was discovered that during surgery a "hole" was created in the patient's left iliac artery and vein, causing blood to pool in the abdomen. Emergency surgery was performed the next day to place an emergency stent. For fall 2016 the athlete was cleared to return to full activity. In January 2017, after three days of intense running the patient was hospitalized due to extreme weakness, headache, sensitivity to light, compromised sensation to left leg, nausea and "feeling like she was going to pass out". Differential Diagnosis: Thrombosis, fatigue, dehydration, or syncope. Further testing determined the patient, was not getting optimal blood flow through the stent, resulting in insufficient oxygen delivery to her muscles. Treatment: The patient expressed desire to continue softball. The athletic trainer facilitated a meeting between coaches to discuss the patient's restrictions and whether she could still participate in her junior season. It was determined that she could remain on the team but would be monitored closely for symptoms. She was put on a running restriction to try to allow her body to "catch up" on blood flow. She was restricted to running no more than 200 yards at a time, heart rate(HR) was not to exceed 200 bpm. If either distance or HR was exceeded the patient was to rest and be monitored until HR was ≤ 120 bpm. The patient's HR was monitored via an activity tracker. Any practice, conditioning or lifting was done with medical supervision in case of sensations of numbness, tingling, fatigue or nausea. After 8 months of following activity restrictions, she developed a thrombosis in the left calf subsequent to fitness testing. Two days later a vascular surgeon performed an arteriogram and endarterectomy of the stent to remove scar tissue. Surgery revealed that the arterial stent was 50% blocked. Two weeks after surgery the patient had symptoms of paresthesia of the left toes again. Bilateral Doppler revealed no blockages in either leg. The patient's family has a history of blood clots and she was referred to a hematologist to test for genetic clotting disorders. Results were negative for any clotting disorders. She was then referred to a cardiologist to determine the need for exercise restriction. She wore a heart monitor for two weeks and had no significant findings. After meeting with the cardiologist, the running restrictions were removed and the patient was cleared for full participation. Uniqueness: A rare surgical complication created a unique set of circumstances that required an interprofessional team to investigate and manage. In a college athletics not being able to run more than 200 yards at a time and having to monitor HR at all points during exercise can be very frustrating and limit participation. However, the patient's position, as a softball pitcher, made these restrictions possible. Conclusions: Complex post-operative complications can occur and require extensive interprofessional collaboration. It is important that the patient's goals, even when challenging, are taken into consideration and all options to meet these goals are considered, while still protecting the patient's safety. Without an athletic trainer knowledgeable about the patient's history and advocating on her behalf, the patient would not have received adequate healthcare. The athletic trainer was an important member of the athlete's support system and healthcare team, enabling her to complete her softball career.

Managing the Healthcare of a Division I Softball Player With Lupus

Workman P, Benson A: Louisiana State University, Baton Rouge, LA

Background: A 15 year old softball player of African American and Puerto Rican decent presented to the hospital with the inability to move and was in a lucid state. Leading up to this event the patient complained of extreme fatigue and joint swelling and was seen by her pediatrician. Blood tests were performed in the emergency room including a CBC, Renal Function Panel, Iron, Sedimentation Rate, DNA DS and C3/C4 Complement. Results showed highs and lows in all of the above-mentioned categories with the primary concern being the renal function. The patient was diagnosed with Lupus. Differential Diagnosis: Kidney Failure, Chronic Fatigue, Rheumatoid Arthritis Treatment: Although a diagnosis was discovered relatively quickly, the management of the disease was difficult for this young competitive athlete. The medications cellcept, plaquenil and prednisone were prescribed however the patient began to present with new symptoms such as: dyspnea on exertion, chest pain, shortness of breath, chronic headaches and rashes. She signed with a Division I softball program where her condition was non-disclosed and her care was handed over to the AT. Upon evaluation of bloodwork It was determined that the patient was non-compliant with taking the medications. The patient had extreme fatigue and joint pain. In order to combat the patient's symptoms and resistance to treatment major modifications were made to her diet to remove inflammatory agents which included: eliminating dairy, a decrease sugar consumption, no red meat and removal of gluten. Additionally a neurologist, nephrologist, dermatologist, dentist, dietician, team physician, rheumatologist and psychologist were added to the medical team and her medications were modified. Blood work began to be drawn tri-weekly. An inhaler was added to combat her breathing issues. As the joint swelling progressed it was noted that the patient began to show ulcers in her mouth and migraines began when the patient was dehydrated. Her kidney function was less than optimal; therefore a hydration plan was added. The medical team determined that her lupus was active and her kidneys were not functioning appropriately. It was recommended that she receive a 1-day IV chemotherapy treatment that contained an alkaline agent to decrease the protein in her kidneys. She returned to participation within 48 hours of chemotherapy and her overall well being improved. Based on the success of the chemotherapy treatment the patient has received 5 treatments over 5 months to normalize her kidney function. During her first year of eligibility she did not play continuously and the medical team spent the time managing her disease. She played all but one game her second year however after a 3 game series her joints began to swell and fatigue set in; therefore an extra day off was given at the end of each series. Modifications in practice activities were made in order to decrease stress on the joints. Examples included: eliminating running that involved cutting and stairs, decreasing reps, adding long sleeve shirts to limit the exposure time to sun. Inactivity on an off days caused extreme joint stiffness and fatigue upon returning to practice therefore the patient was asked to perform a light walk, bike or swim on her "off day". Lab work is consistently run and medication modifications continue to be made. Uniqueness: Although this patient suffered from a debilitating autoimmune disorder, the modifications made were able to manage the patient's symptoms and allow them to participate in sport at a high level. Conclusions: It is important to include varying medical personnel in a patients treatment plan and an athletic trainer can serve as an outstanding coordinator of care and patient advocate especially when a medical case is complicated. With constant monitoring, Lupus is a treatable chronic autoimmune disease.

Diagnosis and Return to Play of an Acute Small Intestine Perforation in a Collegiate Soccer Goalie: A Case Study Presentation

Condon TA, Johnston KJB, Holt L, Aguilar AJ, Ciocca M: University of North Carolina at Chapel Hill, Chapel Hill, NC

Background: A 22-year-old, male collegiate soccer goalkeeper sustained a blow from a teammate's knee to the left lower abdominal quadrant while defending a ball. After contact, the athlete immediately collapsed to the ground, complaining of nausea and severe pain in his abdomen. He was apprehensive to move, and palpation revealed abdominal rigidity. Heart rate and respiratory rate were within normal limits, and there were no signs of discoloration or deformity. He was assisted off the field, and transferred to the sports medicine clinic by the head athletic trainer to be examined by the team physician. Differential Diagnosis: Hepatic hematoma or laceration, splenic hematoma or laceration, renal laceration, abdominal wall hematoma, rib fracture. Treatment: At the clinic, the athlete's physical examination demonstrated the following: BP=124/72, HR=80, RR=16, Oxygen Sat=96%. He presented with normal cardiac and respiratory rhythms. An abdominal examination showed normal bowel sounds, and palpable tenderness diffusely in the right and left lower-middle quadrants with guarding present. A negative rebound test was found. Abdominal x-rays were negative for free air, and urinalysis was negative for blood. The athlete reported feeling better, and was given a sports drink to consume. He proceeded to vomit immediately after finishing the drink, and was referred to the ER for further evaluation. His symptoms worsened as he waited for additional testing. Diagnostic ultrasound imagining of his abdomen did not display any abnormalities. CT scan showed air in abdomen, but no significant trauma to organs. After continued worsening symptoms, the decision was made to perform a laprascopic surgery, which found a single 1.5 cm perforation of the proximal jejunum, and hematoma of his distal transverse colon. They sutured the wound and he was sent to recovery for 48 hours prior to being released. Phase-I (2-weeks) involved the athlete progressing back to normal ADLs, which included pain free walking, normal eating habits and bowel movements. Phase-II (2-weeks) included light cardio, basic core exercises, and slow progressing to light kicking, diving and jumping in a controlled setting. Phase-III (2-weeks) included progressing to advancing kicking, jumping and diving in a control setting, introducing more advance goalkeeper drills. Phase-IV (1-week) included the introduction into control, limited practice, progressing the goalkeeper drills, and ensuring the athlete is able to perform all skills required by a goalkeeper. Total time loss was 7 weeks, 1 day. Uniqueness: Organ lacerations are extremely rare, and require immediate referral if suspected. Most commonly the liver, spleen, and kidneys are injured following blunt trauma rather than the small intestine. A review of the literature showed less than 10 cases of jejunal rupture due to blunt trauma in sport, with only 3 cases occurring in soccer, none of which were goalkeepers. Due to the limited cases of small intestine perforation in sport, there is a lack of data about how to best manage recovery and RTP. Returning to sport after such injury can be difficult, particularly with no previously established guidelines. Conclusions: The identification of an internal organ injury can be challenging without proper imaging and testing, and a delay in diagnosis can be life threatening if not treated within an appropriate time. Being able to identify internal injuries and the need for further referral is an important role for athletic trainers. Furthermore, being able to safely and effectively RTP an athlete from such injury imposes another challenge. Though this event is a rare occurrence, it is important to begin collecting case patterns in order to establish the guidelines for safe interventions, and progressive steps for the RTP of a small intestine injury.

Anthropometric and Somatotype Characteristics Among Adolescent Males Participating in Sanctioned Soccer Organizations: A Systematic Review

Teets A, Rhode A, Berry DC, Pollard-McGrandy A: Saginaw Valley State University, University Center, MI

Context: In soccer, anthropometric characteristics (AC), especially somatotype, is important for determining playing position and other physiological demands. Evaluating AC allows healthcare professionals to effect sports preparation and maintenance of training programs while somatotyping guides more scientifically to periodize exercise programs and nutritional demands. **Objective:** Identify anthropometric characteristics and somatotyping among adolescence males participating in sanctioned soccer organizations [elite/recreational], and analyze the differences between playing position and age groups. Data Sources: Articles identified from: PubMed, MEDLINE, ProQuest using search, ["heath carter method" AND "anthropometric" OR "anthropometry" AND "somatotypes" AND "organized soccer" OR "soccer"] from January 2010-to-August 2017, resulting in 268 articles. Study Selection: Following initial screening (duplicates = 72, title, abstract), 13 articles were reviewed. Four articles met inclusion criteria: (1) peer-reviewed, cross-sectional studies, (2) adolescent males (10-21 y.o.), participating in organized soccer (elite/recreational), (3) full-report, (4) English language, (5) outcome utilized the Heath-Carter formula (somatotyping technique to appraise body shape/composition using a 3-number tier system; eg., 2-3-4). Data Extraction: Two reviewers independently assessed studies' level of evidence (LOE) and quality using the Oxford Center for Evidence Based Medicine (2011) and STrengthening the Reporting of OBservational Studies in Epidemiology (STROBE) instruments. Data of interest: subjects, AC and somatotyping (descriptive and inferential statistics). Four studies met the inclusion criteria (LOE = 3). STROBE scores range from 16-25 (0-32 technique; average = 21.5 \pm 2.2). Pooled sample size = 579, age = 15.35 ± 0.58. Data Synthesis: All studies agree AC and somatotyping differ by age groups and player position. One study found endomorphy and ectomorphy decreased, while mesomorphy increased from U12 (Child-Control = 5.5-4.5-2.1) to attain adult soccer somatotyping (Adult-Control = 3-4.9-2.3). Another study found that endomorphy and mesomorphy decreased, while ectomorhy increased during adolescence (age = 10-13), (10-y.o. = 2.3-4.8-3.2; 11-y.o. = 1.9-4.5-3.4; 12-y.o. = 2.2-4.4-3.8; 13-y.o. = 2.2-4.3-3.8; however, no significant difference in group somatotypes was noted (p < 0.05). Somatotypes among player position in one study found goalkeepers (GK), defenders (DF), and forwards (FW) demonstrated balanced-mesomorph characteristics. Midfielders (MF) showed ectomorphic-mesomorh characteristics (2.3-4.1-2.9). Mean somatotype was balanced mesomorph (mean = 2.6-4.3-2.9). In comparison, GK, DF, and FW in another study were mesomorphic-ectomorph. Midfielder displayed an ectomorphic-mesomorph somatotype (2.2-2.9-2.8); however, positions were not statistically significant (p < 0.05). Limitations include: (1) sampling bias, (2) lack of intra and interrater measurement reliability (3) single point data collection, (4) small sample size. Conclusions: Results suggest AC and somatotyping vary with age and position. A majority of the players possessed high mesmorphic and ectomorphic characteristics suggesting those are desirable for this population; however, variations between countries suggest social and living environment may influence somatotyping within this population. Further studies should assess risk of injury based on the AC and somatotyping. Developing normative AC and somatotying data sets for specific sport populations are limited but are necessary to determine preparedness for the sports, playing position, and hopefully identifying relationships between body type and risk of injury.

Athletic Trainers' Perceived Versus Actual Knowledge of Vocal Cord Dysfunction: Signs and Symptoms, Diagnosis, and Treatment Rippon L, Weyand J, Antosiewicz S, Gerena-Levy J, Laurente A: Seton Hall University School of Health and Medical Sciences, South Orange, NJ

Context: Research suggests athletic trainers lack knowledge of vocal cord dysfunction exercise-induced laryngeal obstruction (VCD-EILO) and struggle to identify signs and symptoms, diagnosis, and treatment of the condition. VCD-EILO is a disorder where the vocal folds move towards each other restricting the amount of air entering during inhalation, and often misdiagnosed as exercise induced asthma. Objective: To determine disparity between perceived and actual knowledge of VCD-EILO among certified athletic trainers, and assess the effects of an educational intervention to improve knowledge of the condition. Design: Pre and posttest pre-experimental design. Setting: Online survey. Patients or Other Participants: Two-thousand certified athletic trainers were randomly selected from 10 districts of the NATA and received the survey via email; 194 responded (9.7% response rate) with 121 females, a median age of 25-34 years and 6-10 years' experience. Interventions: Survey included 7 demographic questions, 9 perceived knowledge questions which was modified from the validated and generalizable Flynn and Goldsmith 5-item subject knowledge assessment tool, and 6 actual knowledge questions in multiple choice format. Subjects then reviewed informational pamphlet about an VCD-EILO published on the NATA website and completed the same survey posttest. Main Outcome Measures: Perceived knowledge was assessed using a 7-point Likert scale; a score of 37 was highest-level of perceived knowledge. Positively stated questions strongly agree score equaled 7 points and negatively

stated questions strongly agree equaled 1 point. Actual knowledge was measured by number of correct responses, with a maximum score of 16. Relationships between perceived and actual knowledge scores were determined with Spearman Rho correlation. Differences between perceived knowledge scores and actual knowledge scores were compared using dependent t test. Differences between pre-test and posttest perceived knowledge responses were analyzed using Wilcoxon signed rank. Results: Positive relationships were identified between pretest perceived and actual knowledge ($r_{a} = 0.60, P$ < 0.001) and posttest perceived and actual knowledge ($r_{a} = 0.32, P < 0.001$). Mean perceived knowledge scores increased 7.4 points (t = -17.5, P < 0.001, 95% CI = -8.3 to -6.6) [pre = 22.6/37 (61%); post = 30/37 (81%)], and mean actual knowledge scores increased 3.9 points (t = -15.8, P < 0.001, 95% CI = -4.4 to -3.4) on posttest [pre = 5.4/16 (33.75%); post = 9.3/16 (58%)]. Pretest perceived knowledge scores were 27.25% higher than actual knowledge and posttest perceived knowledge scores were 23% higher than actual knowledge scores. Mean posttest scores improved in knowledge of signs and symptoms (t = -16.4, P < 0.001, 95% CI = -2.8 to -2.2) [pre = 2.8/7 (40%); post = 5.8/7 (83%)], treatment (t = -9.18, P < 0.001, 95% CI = -10.81 to -07.92) [pre = 2.4/4 (60%); post = 3.4/4 (85%)], and diagnosis (t = -3.6, P < 0.001, 95% CI = -0.45 to -0.14) [pre = 1.7/5 (34%); post = 2.1/4 (52.5%)]. <u>Conclusions</u>: The informational packet did significantly increase knowledge. However, subjects still displayed low knowledge of the condition and a significant knowledge gap at posttest. More education is needed within the athletic training profession on VCD-EILO in order to decrease healthcare costs associated with misdiagnosis and improve patient outcomes through interprofessional collaboration.

Free Communications, Poster Presentations: Head Impact Biomechanics

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Head Impact Biomechanics in Youth Football: A Preliminary Comparison Between Age-Matched Tackle and Flag Football Players

Lynall RC, Anderson MN, Johnson RS, Lempke LB, Schmidt JD: University of Georgia, Athens, GA

Context: Football at all levels of play has come under increased scrutiny due to the potentially high head impact exposure. Youth football in particular has received much attention, and several groups have recommended players under the age of 14 only participate in flag football. Few studies have detailed the head impact burden in youth tackle football and there are no reports describing head impacts in youth flag football. **Objective:** To compare head impact exposure and magnitude between agematched youth tackle and flag football players. Design: Prospective cohort. Setting: On-field. Patients or Other **<u>Participants</u>**: Youth tackle (n = 14,age = 9.8 ± 0.7 , height = 136.93 ± 7.27 cm, mass = 35.92 ± 9.47 kg) and flag football players (n = 14, age = 9.7 \pm 0.5, height = 139.68 ± 7.05 cm, mass $= 39.10 \pm 10.15$ kg). Interventions: Both cohorts wore head impact sensors (Triax Sim-G) during practices and games throughout the 2017 season. Study personnel captured data at all sessions (practice or game). Main **Outcome Measures:** Impact frequency and magnitude (linear [g] and rotational acceleration [rad/s²]). Athlete exposure was defined as one player participating in one session. Impact rates (IR) were calculated and are presented as impacts per 10 athlete exposures. Overall, game, and practice IR were compared between cohorts using impact rate ratios (IRR). IRR with corresponding 95% confidence intervals (CI) not containing 1.0 were considered statistically significant. Due to the preliminary nature of the study, acceleration values were split into low- and high-magnitude categories (linear split at 40g, rotational split at 4,600rad/s²). Magnitude category frequencies were compared between groups using chi square tests (p < 0.05), and 90th percentile acceleration values are presented. Results: Seventytwo flag football (5.14 impacts/player) and 390 tackle football (27.86 impacts/ player) head impacts were recorded. Overall, tackle players (IR = 17.57) experienced 2.27 times the impact rate (95% CI: 1.76, 2.92) as flag players (IR = 7.74). There was no difference in game impact rate between cohorts (flag IR = 8.07, tackle IR = 10.11; IRR = 1.25; 95% CI: 0.88, 1.78), but tackle players (IR = 23.05) experienced a significantly greater practice impact rate compared to flag players (IR = 7.22; IRR = 3.19; 95% CI: 2.14, 4.77). Tackle 90th percentile linear acceleration was 57.29 g (median = 31.51 g), comparedto 53.32 g (median = 31.78 g) for flag. 90th percentile rotational acceleration was 8,300.00 rad/s² for flag players $(\text{median} = 4,350 \text{ rad/s}^2)$ and 7,850.00 rad/s² (median=3,800 rad/s²) for tackle players. There were no linear or rotational acceleration magnitude category frequency differences between cohorts $(p \ge 0.52)$. Conclusions: Tackle youth football players sustained more head impacts per exposure and more overall impacts than their flag counterparts, but the frequency of low and high magnitude impacts was similar between the cohorts. This is the first investigation of youth flag football head impact biomechanics. Though commonly considered a non-contact sport, we observed numerous head impacts to flag players, both in the reported data and anecdotally during observation. Further investigation is needed to understand the head impact burden in all versions of youth football.

Influence of Sex, Sport, and Event on Head Impact Biomechanics in College Soccer and Lacrosse Student-Athletes Combs PR, Ford CB, Teel EF, Amalfe SA, Putukian M, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC; McGill University, Montreal, Quebec, Canada; Princeton University, Princeton, NJ

Context: Recent studies have associated sport-related concussions with late-life cognitive and psychological dysfunction in retired American football athletes. Data pertaining to other popular collision and contact sports are lacking. It is imperative to gain a better understanding of repetitive head impacts experienced by all athletes to better inform behavior modification and policy changes designed to decrease head injury risk. **Objective:** To quantify the sex, sport, and event-type differences in head impact biomechanics (severity and frequency) sustained by male and female soccer and lacrosse athletes. Design: Prospective cohort. Setting: Multi-site clinic and field study. Patients or Other Participants: Our convenience participant sample included 141 Division I NCAA soccer (73 males; 68 females; age = 20.59 ± 1.22 yrs; height = 68.98 ± 3.67 cm; mass = 156.56 ± 20.73 kg) and 155 lacrosse (80 males; 75 females; age = 20.73 ± 1.26 yrs; height = 69.31 ± 3.57 cm; mass = 164.49 ± 27.61 kg) student-athletes. Interventions: Student-athletes' head impact biomechanics were measured by X2 Biosystems xPatch head impact sensors during this two-year study. Impacts were assigned individually to participants based on sex (male/female), sport (lacrosse/soccer), and event-type (competition/practice). Random intercepts general linear mixed models were used to determine the effect of sex, sport, and event on peak head linear acceleration. We used repeated-measures negative binomial Generalized Estimation Equations models to test the sex, sport and event-type effects on the impact frequency falling within categorized impact severities. Main Outcome Measures: Peak head linear acceleration (g) was measured to address impact severity, and categorized as mild, moderate, and severe based on the following criteria to address impact frequency: mild (10-20 g), moderate (20.01-40 g), and severe (>40 g). These dependent variables were employed in the statistical analyses previously described. Results: We observed significant interaction effects between sport and event ($\beta = 1.25$, t = 5.62, P < 0.001), and sex and event ($\beta = 1.12$, t = 3.34, P < 0.001) for peak head linear acceleration. Specifically, soccer athletes (competition $= 20.05 \pm 12.81$ g, practices $= 18.41 \pm$ 12.57 g, $\beta = 1.05$, t = -6.62, P < 0.001) and males (competition = 21.52 ± 14.15 g, practices = 20.89 ± 14.27 g, $\beta = 1.03$, t = 2.85, P = 0.004) sustained more severe impacts during competitions relative to practices. Lacrosse athletes (competition $= 19.37 \pm 13.77$ g, practices $= 21.66 \pm$ 14.75 g, $\beta = 1.18$, t = 5.93, P < 0.001) and females (competition = 18.68 ± 11.92 g, practices = 18.60 ± 12.84 g, $\beta = 1.05$, t = 4.24, P < 0.001) sustained more severe impacts during practices relative to competitions. Males (19.3%) sustained a significantly greater moderate or severe head impact frequency than females (11.32%, z = 3.16, P = 0.002). Conclusions: Our results provide foundational knowledge towards characterizing head impact biomechanics in understudied sport populations. Sex, sport, and event-type differences could be due to coaching styles or inherent rule differences. Critically, identifying populations that sustain more severe head impacts in controllable situations such as practice can better inform concussion prevention strategies. Future research should continue to investigate head impact biomechanics and the effects of these repetitive head impacts on short- and long-term neurological function.

A Preliminary Comparison of Perceived and Real Head Impacts in Tackle and Flag Youth Football

Johnson RS, Lempke LB, Anderson MN, Schmidt JD, Lynall RC: University of Georgia, Athens, GA

Context: Media scrutiny around concussion has increased substantially. This scrutiny may skew perceptions of the actual head impact burden in youth football. To date, head impact perceptions have not been compared to on-field measures of head impact frequency. **Objective:** To compare parent and player perceptions of head impact frequency with on-field head impact data in tackle and flag youth football. Design: Prospective cohort. Setting: On-field head impact biomechanics and paper-based survey. Patients or Other Participants: Fifty-six youth football players (Tackle = 27, age = 11.02 ± 0.44 y; Flag = 29, age = 8.73 ± 0.50 y) wore head impact sensors (Triax Sim-G) during one season. Twenty-one parents (Tackle = 13, Flag = 8) and sixteen athletes (Tackle = 10, Flag = 6) completed the survey. Interventions: Players wore head impact sensors during practices and games that recorded impact frequency. Parents and players completed a paper survey at the beginning of the season regarding their perception of average head impact frequencies during practices and games. Main Outcome Measures: Descriptive statistics were used to describe survey responses and were compared to impact rates (IR; number of impacts/athlete-exposures) captured using the head impact sensors. Athlete-exposure was defined as one player participating in one session. Impact rate ratios (IRR) compared practices to games (practice rate/game rate) within tackle and flag football separately. IRR 95% confidence intervals (CI) not containing 1.00 were considered statistically significant. A multistep data cleaning process was used to eliminate false impacts. Results: 1,295 total tackle football impacts (815 practice, 480 game) were recorded across 42 practice sessions (IR = 3.06), and 19

game sessions (IR = 2.32). Tackle survey respondents believed athletes sustained 0 (13.04%), 1-10 (78.26%), and more than 10 (8.70%) head impacts during practices; and 0 (13.64%), 1-10 (77.27%), and more than 10 (9.09%) head impacts during games. Tackle players experienced a significantly higher head impact rate in practices compared to games (IRR = 1.32, 95% CI: 1.18, 1.48), while 52.38% of survey respondents believed more impacts would occur during games. 105 total flag football impacts (39 practice, 66 game) were recorded across 13 practice sessions (IR = 0.58) and 18 game sessions (IR =0.66). Flag survey respondents believed athletes sustained 0 (57.14%), 1-10 (42.86%), and more than 10 (0.00%) head impacts during practices; and 0 (42.86%), 1-10 (57.14%), and more than 10 (0.00%) head impacts during games. Though flag IR did not differ between practices and games (IRR = 0.82, 95% CI: 0.55, 1.22), 92.30% of survey respondents believed more head impacts would occur in games. Conclusions: Youth football parent and player head impact frequency perceptions differed from measured head impact frequencies collected during practices and games. These perceptions may influence a parent's decision to allow their child to play football. Educating parents and children regarding the potential head impact burden of youth tackle and flag football is warranted.

Opponent Records Affect Head Impact Biomechanics in Collegiate Women's Soccer Athletes

Foster FO, Bradney DA, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA; University of Wisconsin, Eau Claire, WI

Context: The discussion surrounding head impacts has become increasingly controversial in all sports due to the potential for long term consequences of subconcussive impacts. The relationship between opponent records and head impact frequency and magnitude has not yet been studied and could lead to prevention initiatives. **Objective:** To determine the relationship between head impacts and win/loss records of opposing teams **Descriptive** epidemiology study Setting: Collegiate soccer competition sites. Patients or Other Participants: Participants included 15 intercollegiate female soccer players (age = 19.80 ± 1.47 years, height = 166.29 ± 4.39 cm, mass = 65.05 ± 7.57 kg). Interventions: Opponent record (above .500 and below .499) served as the independent variable. Main Outcome Measures: We measured the magnitude and frequency of head impacts with X2 Biosystem xPatch sensors. The xPatch collected linear (g) and rotational (deg/ sec2) accelerations over 10 g. Head impacts that were recorded by the xPatch sensors were then confirmed using video analysis of each game. We examined magnitude differences using ANOVA due to multicollinearity between the dependent variables. We then determined frequency differences by calculating incidence rates per 1000 exposures and incidence rate ratios with corresponding 95% confidence intervals (CI95). **Results:** Opponent record significantly altered rotational acceleration (F1,409 = 5.17, P = .02, $\eta 2 = 0.01$), but not linear acceleration (P0.09 = .08). Rotational accelerations when playing teams with a record above .500 (298257.13 \pm 231478.30 deg/sec2) were greater than that of team below .500 (233106.99 ± 234824.62 deg/

sec2). Players sustained a higher frequency of head impacts when opponents had records above .500 (IR = 1295.28, CI95 = 969.53-1435.24) compared to when opponents had records of .499 or below (IR = 326.77, CI95 = 256.47-397.07; IRR = 3.96, CI95 = 3.11-5.04). Conclusions: Findings suggest that rotational accelerations differed based on opponent record potentially due to the idea of competitiveness and athleticism being greater when the record of a team is higher. NCAA Division III women's soccer players are 3.96 times more likely to receive an impact to the head during a game against an opponent with a record of .500 or above compared to .499 and below. We speculate that opponents with better records may have a higher skill level resulting in a more competitive match.

Transient Perturbation of Neuro-Ophthalmologic Function Following Acute Subconcussive Head Impacts

Bevilacqua ZW, Wirsching A, Huibregtse ME, Kawata K: Indiana University, School of Public Health, Bloomington, IN

Context: Subconcussion is a burgeoning phenomenon that results from low level head impacts that has the potential to cause neurological dysfunction. Soccer heading provides a safe and unique human model to study controlled head impacts. Using the King Devick (KD) test to measure saccadic eye movements is an emerging quantifiable way to detect neuro-opthalmologic impairment common among sport concussion injuries. **Objective:** To investigate the effect of subconcussive soccer ball heading impacts on KD scores. We hypothesized that subconcussive impacts would result in higher KD scores versus controls **Design:** Repeated measures Setting: Clinical neurotrauma laboratory. Patients or Other Participants: Twenty seven healthy young adult soccer players with at least 5 years of soccer heading experience were assigned to either a soccer heading group (8 male; 9 female; age = 20 ± 2 yrs; BMI = $25.01 \pm$ 4.75) or soccer kicking control group (4 male; 6 female; age = 21 ± 2 yrs; BMI = 24.38 ± 3.97). They have signed an IRB approved consent form. Interventions: The independent variables were group (heading vs. kicking control) and assessment time points (pre-, 0hr post-, 2hr post-, and 24hr post-heading/kicking). Prior to the intervention, all participants recorded a baseline KD score. Heading subjects then performed 10 soccer headers over the course of 10 minutes, where the subjects stood 40ft across JUGS machine and the ball traveled at 25 mph, whereas the control subjects kicked the soccer ball 10 times over the same time period. Following the intervention, KD measurements were recorded at the appropriate time points. At each time point participants were given the test containing a different set of numbers. Data were analyzed using repeated measures ANOVA and warranted subsequent tests using SPSS Statistics X8 ($p \le .05$) Main Outcome Measures: The dependent variable was King Devick performance speed in second **Results:** There was a statistically significant interaction effect (assessment time point vs. group), F(3, 75) = 8.841; p < 0.001. Follow-up one-way ANOVAs within each group indicated significant effects for both groups, F(3, 48) = 7.052; p = 0.01; mean \pm SD: pre 40.582 \pm 6.27, 0hr-post 40.876 ± 6.84 , 2hr-post 40.49 ± 5.87 , 24hr-post 38.46 ± 5.95 heading group, and F(3, 27) = 76.206; p < 0.001; mean \pm SD; pre 38.02 \pm 3.61, 0hr-post 34.88 ± 4.06, 2hr-post 37.70, 24hr-post 32.20 \pm 3.02. Post-hoc Tukey tests for the heading group delineated a significant difference between the first three measurements and the forth (baseline, 0 and 2hr-post vs. 24hr-post, p = 0.017, 0.011,0.020 respectively). Similarly, pairwise comparisons for controls showed significant differences between all measurement time points (p's ≤ 0.003), with the exception of 0hr vs. 2hr-post (p = 0.862). Lastly, independent sample t-tests revealed significant differences between groups during all post-intervention measurements, (baseline: t(25) = 1.177; p = 0.250), (0hr-post: t(25) = 2.513; p = 0.019), (2hr-post: t(25) =2.777; p = 0.010), (24hr-post: t(25) =3.083; p = 0.005). <u>Conclusions:</u> Our findings corroborate our hypothesis in that soccer heading appears to attenuate the learning curve seen with the KD test, ultimately inferring transient neuronal dysfunction.

Repetitive Subconcussive High-Magnitude Head Impacts Affect Short-term Neurological Function in College Lacrosse and Soccer Student-Athletes Barczak NE, Ford CB, Teel EF, Amalfe SA, Putukian M, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC; McGill University, Montreal, Quebec, Canada; Princeton University, Princeton, NJ

Context: Concussion is a serious injury and has been best studied in American football and ice hockey. Both lacrosse and soccer are considered high-risk sports accounting for a significant head injury prevalence sustained at the college level. Data exist regarding the lacrosse and soccer concussion injury mechanism; however, there are limited head impact biomechanics data. No studies have explored the short-term neurological findings related to repetitive subconcussive head impacts in these populations. **Objective:** To determine the one- and two-season effect high-magnitude linear and rotational head impacts have on changes in neurocognition, balance, and symptoms. Design: Two-year (pre-/post-season) prospective cohort design. Setting: Two NCAA Division I universities. Patients or Other Participants: Our convenience sample of participants included 141 Division I NCAA soccer (age = $20.59 \pm$ 1.22 yrs, height = 68.98 ± 3.67 cm, mass $= 156.56 \pm 20.73$ kg) and 156 lacrosse $(age = 20.73 \pm 1.26 \text{ yrs}; height = 69.31$ \pm 3.57 cm; mass = 164.49 \pm 27.61 kg) student-athletes. Interventions: Studentathletes' head impact biomechanics were measured by X2 Biosystems xPatch head impact sensors during this two-year study. Impacts were determined to be 'high-magnitude' if the impact exceeded the study's 90th percentile for linear or rotational acceleration, respectively. We performed separate multiple regression models using head impact biomechanics to predict pre- to post-season changes for one- and two-season spans for each clinical measure, while controlling for sex (male/female) and

sport (lacrosse/soccer). Main Outcome Measures: Pre- to post-season change measures were determined from the following: 1) Neurocognition (Immediate Postconcussion Assessment and Cognitive Test-ImPACT; CNS Vital Signs), 2) Balance (Balance Error Scoring System-BESS), and 3) Symptoms (Graded Symptom Checklist). These dependent variables were employed in the statistical analyses previously described. Results: Approximately two-thirds of student-athletes sustained high-magnitude impacts [N_{rotational} = 203 (65.9%); \tilde{N}_{linear} = 194 (63.0%)]. Student-athletes sustaining more high-magnitude rotational head impacts had predicted declines in processing speed ($\Delta = -0.93 \pm 17.54$, F_{1.34} = 8.29, P = 0.007) and balance performance $(\Delta = 0.15 \pm 7.75, F_{1.88} = 4.32, P = 0.041).$ Changes in symptom frequency ($\Delta =$ -0.02 ± 2.58 , $F_{1,54} = 9.24$, P = 0.004) and severity ($\Delta = -0.10 \pm 4.31$, F₁₅₃ = 7.94, P = 0.007) were predicted by high-magnitude rotational head impact frequency, in addition to cumulative linear and rotational acceleration and overall impact frequency. An unexpected predicted increase in ImPACT verbal memory was also observed ($\Delta = 1.09 \pm 10.64$, F_{1.58} = 3.89, P = 0.05). <u>Conclusions:</u> Sustaining greater high-magnitude impacts (linear or rotational) may have demonstrable short-term negative effects on common concussion neurological measures, which include symptom frequency and severity, balance performance, and neurocognition. These effects were mostly found after controlling for sex/sport, suggesting complex relationships between factors warranting further study. Our observed statistical findings are driven by small mean clinical changes that are largely variable. These findings should be interpreted with caution, and support further studying long-term maladaptive balance, cognition, and symptom findings in college lacrosse and soccer players. We submit developing guidelines to protect lacrosse and soccer student-athletes from unnecessary high-magnitude head impacts may serve to deter negative short- and long-term neurological declines in this population.

Characterizing Head Impacts in Boys' Youth Lacrosse

Woodring S, Kelshaw P, Hepburn L, Lincoln A, Cortes N, Caswell SV: George Mason University, Manassas, VA; MedStar Sports Medicine, Baltimore, MD

Context: Participation in organized boys' youth lacrosse (BYL) continues to increase nationwide. Research indicates that player-to-player contact is most common among U13/U15 level BYL players. Previous research combined wearable sensor technology with video analysis to characterize head impacts in high school lacrosse players. To date no studies have investigated game related head impacts in BYL **Objective:** To characterize head impacts in BYL game play using wearable sensors and video analysis. Design: Prospective cohort. Setting: Metropolitan youth lacrosse league. Patients or Other Participants: Fifteen male youth lacrosse players (age = 12 ± 1 years) from a single team volunteered for this study during the 2016 season. Interventions: Each player was instrumented with a sensor (gForce Tracker; Markham, ON, Canada) affixed to the inner crown of their respective helmet. All game related impacts recorded by the sensors were verified using time synchronized game video. Main Outcome Measures: Frequency of verified impacts, peak linear acceleration (PLA) and peak rotational velocity (PRV) were reported. Descriptive statistics and impact rates were calculated. Results: A total of 6 games were captured during the season. Seventy-four verified impacts (PLA ≥ 15 g) were recorded by the sensor and confirmed on video over 68 player-games (Impact Rate = 1.1 impacts/player-game; 95% CI: 0.8, 1.3; median PLA = 22.1 g; PRV = 802.0 deg/s). Of these impacts, 62 (83.8%) were confirmed impacts to the head (Median PLA = 22.6 g; PRV = 817.5 deg/s). The impact rate for verified head impacts was 0.9 (CI: 0.7, 1.1) per player-game, equivalent to 10.3 head impacts per team game and < 6 head impacts ≥ 15 g per player-season. Midfielders accounted

for the greatest number of head impacts (n = 44, 59.5%) followed by defenders (n = 12, 16.2%) and attackers (n = 6, 16.2%)8.1%). Defenders had the highest median PLA and PRV of head impacts (27.3g, 1102.0 deg/s), followed by attackers (23.2g, 1037.5 deg/s) and midfielders (22.2g, 737.5 deg/s). The most common head impact mechanisms were contact with stick (n = 30, 48.3%), and player (n = 30, 48.3%), followed by ground (n = 2, 3.2%). Stick impacts to midfielders accounted for the most frequent and largest magnitudes of head impacts (n = 22, 35.5%; PLA = 22.9 g, PRV = 723.5 deg/s). The most common impacts by game play activities were defending (n = 15, 24.2%), settled play (n = 14, 22.6%), and loose balls (n = 12, 12)19%). No head impacts were observed for goalies. No concussions were diagnosed during this study. Conclusions: The rate of head impacts among U13 BYL players is comparable, but the magnitude of head impacts is considerably less, than reported among boys' high school lacrosse players. Future research should include a larger and more geographically diverse sample. In addition, the effects of small-sided games associated with the US Lacrosse Athlete Development Model on head impacts in BYL should be evaluated.

Characterizing Verified Head Impacts in Girls' Youth Lacrosse Kocik AD, Kelshaw P, Lincoln AE, Hepburn L, Cortes N, Caswell SV: George Mason University, Manassas, VA; MedStar Sports Medicine, Baltimore, MD

Context: Girls' youth lacrosse (GYL) is among the fastest growing team sports in the US. Research suggests that a large proportion of game related injuries in girl's lacrosse occur to the head. Previous research combined wearable sensor technology with video analysis to characterize head impacts in girls' high school lacrosse players. To date no studies have investigated game related head impacts in GYL. Objective: To characterize head impacts during a single season of girls' youth lacrosse game-play using wearable sensors and video analysis. **Design:** Prospective cohort. Setting: Metropolitan youth lacrosse league Patients or Other Participants: Eighteen female youth lacrosse players (age = 13 ± 1 years). from a single team volunteered for this study Interventions: All members of team wore sensors (X2 Biosystems; Seattle, WA) affixed to the right mastoid process. All game related impacts recorded by the sensors were verified using time synchronized game video. Main Outcome Measures: Frequency of verified impacts, peak linear acceleration (PLA) and peak rotational acceleration (PRA) were reported. Descriptive statistics and impact rates were calculated. Results: Nine games were captured during the season. Thirty-eight verified impacts (PLA ≥ 15 g) were recorded (Median PLA = 18.3 g; PRA = 3351.0 rad/s²) during 148 player-games (IR = 0.3/player-game, CI: 0.2, 0.3). Ofthese impacts, 11 (28.9%) were confirmed to impact the head (Median PLA $= 27.8 \text{ g}; \text{PRA} = 3992.4 \text{ rad/s}^2$). The IR for verified head impacts was 0.1 (CI: 0.0, 0.1) per player-game, equivalent to 1.2 head impacts per team game and <1 head impact \geq 15g per player-season. Overall, midfielders sustained the most head impacts (n = 6, 54%), followed by attackers (n = 3, 28%), and defenders (n = 2, 18%). Defenders demonstrated the highest median PLA and PRA (38.7 g, 7684.5 rad/s²), followed by midfielders (27.8 g, 3646.2 rad/s²) and attackers $(25.1 \text{ g}, 3808.6 \text{ rad/s}^2)$. The most common head impact mechanisms were contact with stick (n = 6, 54.5%) and player (n = 5, 45.5%), there were no ground or ball impacts. Head impacts were equally divided among types of game play activities. However, the activity of defending represented the highest median PLA and PRA (50.6 g, 7719.5 rad/s²). No head impacts were observed for goalies. No concussions were sustained during this study. **Conclusions:** The rate of head impacts among U13 GYL players is comparable, but the magnitude of head impacts is lower, than reported among girls' high school lacrosse players. Future research should include a larger and more geographically diverse sample. In addition, the effects of small-sided games associated with the US Lacrosse Athlete Development Model on head impacts in GYL should be evaluated.

The Effect of Protective Headgear on Impact Forces in Girls' High School Varsity Lacrosse

Caswell SV, Kelshaw PK, Lincoln AE, Hepburn L, Dunn R, Cortes N: George Mason University, Manassas, VA; MedStar Sports Medicine, Baltimore, MD

Context: Game-related head and facial injuries in women's and girls' lacrosse primarily result from stick and ball contacts. A women's lacrosse headgear performance standard was developed to reduce impact forces from these mechanisms. As of January 2017, all headgear worn during girls' lacrosse must meet the ASTM F3137 performance standard. Yet, the effectiveness of headgear meeting ASTM F3137 to reduce impact forces during girls' lacrosse game play is unknown. **Objective:** To evaluate changes in impact forces from stick and ball contacts during two seasons of girls' high school lacrosse game play. Design: Pre- (no headgear worn) and post- (headgear worn) comparison. Setting: Girls' high school varsity lacrosse games. Patients or Other Participants: 35 female participants $(16.2 \pm 1.2 \text{ years}, 1.66 \pm 0.05 \text{ m}, 61.2$ \pm 6.4 kg) volunteered for the study during 18 games in the 2016 and 15 in the 2017 lacrosse seasons, respectively. Interventions: Year 1 (2016): no-headgear worn. Year 2 (2017): headgear (Cascade LX Women's Lacrosse Headgear) worn. All participants were instrumented with wearable sensors (X2 Biosystems; Seattle, WA) affixed to the right mastoid process prior to each game. All game-related impacts recorded by the sensors were verified on video. Impacts were considered valid using the following criteria: a) linear acceleration \geq 20g, b) player was identified on the field, c) player was in camera view, and d) impact mechanism could be clearly identified as either stick or ball. Main Outcome Measures: Descriptive statistics (frequency, median and interquartile range (IQR)) of peak linear acceleration (PLA) and peak rotational velocity (PRV) were calculated for all verified stick and ball related impacts. Differences in PLA and PRV between no-headgear and headgear groups were evaluated using Wilcoxon rank sum tests. Results: 38 verified head impacts (2016 n = 22, 2017 n = 16) were recorded (median (IQR) PLA = 24.5 (22.4-41.2) g, PRV = 1391.7 (1073.1–1765.7) deg/s) during 700 (2016 n = 375, 2017 n = 325) player-games. An examination of stick (n = 34 (89.5%); PLA = 24.5 (22.9-41.2) g, PRV = 1391.7 (1085.4-1765.7) deg/s) and ball (n = 4 (10.5%); PLA=28.1 (21.5-44.8) g, PRV=1298.1 (864.6-1873.9) deg/s) impacts revealed no significant differences between headgear conditions (no-headgear, n =22; PLA = 24.0 (22.3–45.3) g, PRV = 1545.4 (1085.4-1867.8) deg/s vs. headgear, n = 16; PLA = 28.3 (22.9-39.2) g, PRV = 1324.9 (1029.3–1700.7) deg/s) were observed for PLA (p = 0.759) or PRV (p = 0.356). <u>Conclusions:</u> No meaningful difference in stick- and ball-related impact forces was detected between no-headgear and headgear seasons with a single girls' varsity high school lacrosse team. Further research should be conducted with a larger sample of teams and different levels of play to evaluate if ASTM F3137-approved headgear reduces impacts forces from stick and ball impacts. Additional research investigating potential changes in player behavior subsequent to the voluntary implementation of women's lacrosse headgear is warranted.

Head Impacts During Women's Lacrosse Conference and Nonconference Games

Truman AS, Bradney DA, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA; University of Wisconsin, Eau Claire, WI

Context: Head impacts are a growing concern in athletics due to the potential long and short term consequences associated with head trauma. Although contact to the head is illegal in women's lacrosse, impacts occur especially during games. The conference affiliation of opponents during NCAA Division III lacrosse competitions may have the potential to change the level of play during games and thus the number and magnitude of head impacts. Determining biomechanical differences depending on conference affiliation may provide insight for prevention initiatives. **Objective:** To compare head impacts of division III intercollegiate women's lacrosse players during conference and nonconference games. Descriptive epidemiology study. Setting: Collegiate women's lacrosse fields. Patients or Other Participants: 44 NCAA Division III women's lacrosse players (age = 20.26 \pm 1.03 years, height = 165.59 \pm 5.66 cm, mass = 63.22 ± 7.48 kg) volunteered to participate. Interventions: Game type (conference vs non-conference) served as the independent variable. Main **Outcome Measures:** Participants wore X2 Biosystems xPatch sensors for every lacrosse game played over a 3 year period (2015, 2016, and 2017 seasons). The sensors recorded angular (deg/sec2) and linear (g) accelerations and the frequency of head impacts. All games were video recorded for verification of head impacts. We determined frequency differences by calculating incidence rates (IRs) per 1000 exposures (participation in 1 game) and incidence rate ratios (IRRs) with 95% confidence intervals (CI95). We used ANOVA to determine magnitude results due to multicollinearity of the dependent variables. Results: There was a 4 fold higher likelihood of getting a head impact in conference games (IR = 804.88, CI 95 = 530.26-1079.50) compared to non-conference games (IR = 195.12, CI 95 = 59.91-330.33; IRR = 4.125, CI 95 = 1.90-8.93). Neither linear (F1,40 = .062, P = .80, $\eta 2 = <.01$, $1 - \beta = .01$) nor rotational $(F1,40 = .44, P = .51, \eta 2 = .01, 1 - \beta = .10).$ Conclusions: We speculate that an increase in level of play and competitiveness occurs during conference games due to the importance of positioning for post-season play and conference tournaments increasing the frequency, but not magnitude of head impacts in women's lacrosse athletes. Clinician attentiveness should be higher during conference games due to the increased frequency of head impacts observed during conference games. Head impact prevention initiatives and stricter officiating should be focused on conference games.

Magnitude and Frequency of Head Impacts in Men's Lacrosse Practice Drills

Kaiser EJ, Bradney DA, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA; University of Wisconsin, Eau Claire, WI

Context: The interest in studying head impacts has increased recently due to the potential long term effects of head trauma in sports. Head impact magnitude and frequency occurring during practice in men's lacrosse have yet to be studied. By examining magnitude and frequency in various practice drills, coaches can create practice plans to decrease the risk of head impacts. **Objective:** To evaluate head impact magnitude and frequency during various men's lacrosse practice drills. Design: Descriptive epidemiology study. Setting: Collegiate men's lacrosse practices. Patients or Other Participants: The participants included 11 Division III men's lacrosse athletes (age = $20.27 \pm$ 1.27 years, mass = 85.35 ± 6.82 kg, height $= 182.91 \pm 6.02$ cm). Interventions: Practice drill served as the independent variable. We obtained practice plans from the coaching staff to assist in coding impacts. Practice drills consisted of 6v6, Army 1v1 at X and man up and man down drills. The 6v6 drill consisted of 6 offense versus 6 defensive players and was used to put in new offensive and defensive schemes as well as simulate the opponent's offense and defense. Army 1v1 at X is a skeleton drill where defensive players would go 1 on 1 without a stick to help with positioning when an offensive player is driving towards the goal from behind. Man up/man down drills are used to simulate man up offense versus opponents' man down defense or vice versa. Main Outcome Measures: We measured the magnitude and frequency of head impacts using X2 Biosystems xPatch sensors. The xPatch collected linear (g) and rotational (deg/sec2) accelerations over 10 g. Each impact recorded by the xPatch was then confirmed through video analysis using film from each practice. Frequency differences were determined

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by calculating incidence rates (IRs) per 1000 exposures and incident rate ratios (IRRs) with corresponding 95% confidence intervals (CI 95). Magnitude differences were determined using ANOVA. **Results:** The type of practice drill did not significantly alter the combined dependent variables (multivariate F28,66 = .75, P = .80, $\eta 2 = .24$, $1-\beta = .57$). Players sustained a higher frequency of head impacts during 6v6 (IR = 34.48, CI 95 = 14.97-53.99) compared to man up/man down drills (IR = 2.60, CI 95 = -2.50-7.71; IRR = 13.24, CI 95 = 1.72-101.83). Conclusions: Findings suggest head impacts in various practice drills have similar magnitudes. Although 6v6 is an intricate part of practice, based on the results we should create practice plans that limit the amount time spent in 6v6. Further research regarding magnitude and frequency across various practice drills should be completed.

Characteristics of Head Impacts Sustained by Intercollegiate Soccer Athletes During Free Play and Set Pieces Witter RG, Bradney DA, Breedlove

KM, Bowman TG: Lynchburg College, Lynchburg, VA; University of Wisconsin, Eau Claire, WI

Context: Researching head impacts in sport has become more relevant due to potential long and short-term neurocognitive consequences of repetitive head trauma. Athletes are often in scenarios where head impacts are inevitable. Determining which scenarios are more likely to involve head impacts may allow initiatives to improve technique and mechanics to limit the risk of injury. **Objective:** To compare the frequency and magnitude of head impacts sustained by men's and women's intercollegiate Division III soccer players based on type of play during games (free play, set pieces). Descriptive epidemiology study. Setting: Soccer fields. Patients or Other Participants: 21 National Collegiate Athletic Association Division III soccer players (16 women: $age = 19.80 \pm 1.47$ years, height = 166.29 \pm 4.39 cm, mass = 65.05 \pm 7.57 kg; 5 men: age = 19.60 ± 1.06 years, height $= 180.34 \pm 6.22$ cm, mass $= 77.56 \pm$ 6.33 kg). Interventions: The independent variable of this study was game scenarios (free play where the play is continuous without the referee manipulating the flow of the game and set pieces composed of corner kicks, throw ins, free kicks, goal kicks, and kickoffs that are determined by the referee's call). Main Outcome Measures: X2 Biosystems (Seattle, WA) xPatch sensors collected linear acceleration (g), rotational acceleration (deg/sec2) and frequency of head impacts over 10 g. Video analysis confirmed xPatch recorded head impacts. Frequency differences were determined by calculating incidence rates (IRs) per 1000 exposures and incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CI 95). ANOVA calculations examined magnitude differences due to multicollinearity between the dependent variables. **Results:** Participants were more likely to sustain a head impact during free play (IR = 653.92, CI 95 = 582.83-725.02)compared to set pieces (IR = 346.08, CI 95 = 294.36-397.80; IRR = 1.89,CI 95 = 1.57-2.27). Game scenario did not significantly alter linear accelerations $(F2, 1 = 1, P = .35, \eta 2 = .002, 1 - \beta = .16)$ or rotational accelerations (F2,1 = 1.82, P = .18, $\eta 2 = .004$, $1-\beta = .27$). <u>Conclusions:</u> There were a significantly higher number of impacts during free play as compared to set pieces. This could be due to the larger opportunity for impact during free play or players motivation to regain possession whereas during set pieces, possession is given. Practicing proper mechanics outside of set plays can decrease the risk of sustaining head impacts. Education of spacial awareness during this portion of the game could be beneficial to improve reaction and anticipation of impacts. Clinically, knowing that there is a higher rate of head impacts during free play denotes that medical staff should be aware of the flow of the game.

Girls' Lacrosse Players Attitudes Towards Protective Headgear

Kelshaw P, Hepburn L, Lindsey B, Lincoln A, Cortes N, Caswell SV: George Mason University, Manassas, VA; MedStar Sports Medicine, Baltimore, MD

Context: US Lacrosse has implemented a rule requiring that all protective headgear worn during girls' and women's lacrosse must meet the ASTM F3137 performance standard. Although not required, headgear meeting ASTM F3137 became available for optional use during the spring 2017 lacrosse season. Headgear adoption remains controversial in girls' lacrosse due to concerns of risk compensation and more aggressive game-play behaviors. Prior research has yet to investigate girls' lacrosse players' attitudes about headgear use and difference in attitudes subsequent to headgear use. **Objective:** To evaluate high school girls' lacrosse players' attitudes toward headgear prior to and after a season of use. Design: Prospective Cohort. Setting: Metropolitan public high school in Virginia. Patients or Other Participants: Twenty-five girls' high school lacrosse players participated in this study, (age = 15.6 ± 1.3 years; playing experience = 4.8 ± 3.4 years). Interventions: Women's lacrosse headgear meeting ASTM F3137 were provided and voluntarily worn for all practices (n = 49) and games (n = 15) during a single season of play. A 35 item written survey instrument was administered during the first week of the season and again in final week of a lacrosse season. Survey constructs evaluated players' attitudes toward headgear use (23 items), with previously validated anger (6 items), and aggression (6 items) scales. The 23-item headgear attitudes instrument was anchored by a 5-point Likerttype scale ranging from strongly agree to strongly disagree. The anger and aggression instrument was also anchored by a 5-point Likert-type scale ranging from almost never to almost always. Main Outcome Measures: Descriptive statistics and three paired-samples t-tests were conducted to compare players' attitudes toward headgear, anger and aggression in pre-and post-headgear conditions. Results: Overall, no significant differences existed in the mean scores for players attitudes toward headgear (pre = 1.8 ± 0.3 vs. post = 1.8 ± 0.4 ; p = .37) anger (pre = 1.3 ± 0.5 vs. post = 1.3 ± 0.5 ; p = .88) and aggression (pre = 0.3 ± 0.4 vs. post = 0.3 \pm 0.3; p = .47) in the pre-and post-headgear conditions. At the item level, players demonstrated largely neutral responses in regards to how headgear use affected their attitudes toward safety and confidence in gameplay. However, players felt that opponents will play more aggressively towards them when wearing the headgear. Conclusions: The girls' lacrosse participants did not demonstrate a significant change in their attitudes of headgear following a season of use. Overall, the average scores demonstrated a neutral attitude toward the use of headgear. The results demonstrate that despite concerns, the use of headgear does not change the players' attitudes during gameplay; however, players are concerned that their opponents may become more aggressive. This suggests that the use of headgear will not significantly increase risk compensation leading to more physical play. Future research should investigate field-based measures for behavioral changes in girls' lacrosse subsequent to headgear use.

Free Communications, Poster Presentations: Head, Neck, and Spine

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM 11:15AM; Peer

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Airway Emergencies in Lacrosse: Impact of Exposure Procedure and Device on Time and Ventilation Quality

Boergers RJ, Bowman TG, Picinich LA, Bruno P, Forlenza CJ, Prata GM: Seton Hall University, South Orange, NJ; Lynchburg College, Lynchburg, VA

Context: Expedient airway management is a critical step in the management of catastrophic injuries. Facemask removal and helmet removal are both expedient airway exposure procedures, however helmet removal creates more cervical spine motion which may cause additional injury. Patient ventilation has been found to be compromised due to the inability to make a seal of a pocket mask over the chinstrap of lacrosse helmets, but the King airway produces quality ventilations. No study has evaluated the success rate and time of King airway placement by athletic trainers. Objective: To assess the impact of different airway exposure procedures and different airway management devices on time and ability to provide quality ventilations on high fidelity manikins. Design: Crossover trial. Setting: Simulation laboratory. Patients or **Other Participants:** Sixteen (8 males:

age = 33.3 ± 9.7 years; 8 females: age = 33.4 ± 9.8 years) athletic trainers participated. Interventions: Participants performed 1 minute of rescue breathing using 2015 American Heart Association (AHA) standards during 4 trial conditions on Resusci Anne Q-CPR manikin (Laerdal Medical Corporation, Wappingers Falls, NY). The two independent variables were: airway exposure technique (HR = helmet removal, FMR = facemask removal) and airway management device (PM = pocket)mask, KA = King airway). The manikin was properly fitted with Warrior Burn Hitman shoulder pads and Warrior Evo helmet for trials (Warrior Inc., Boston, MA). All data collection sessions were counterbalanced. Main Outcome Measures: The dependent variables were: ventilation success (%), ventilations in AHA range (%), time to airway exposure (s), time to first breath (s), ventilation volume (mL) and ventilation rate (ventilations/minute). A 2 x 2 ANOVA was used to evaluate the main and interactive effects of airway exposure technique and airway management device on the dependent variables. Results: Participants provided successful ventilation in all trials regardless of device (PM = 100%, KA = 100%). There was a significant main

effect for airway exposure technique on time to airway exposure (P < 0.001; HR = 19.2 ± 10.7 , FMR = 31.3 ± 11.6). There were significant main effects of airway access technique (P < 0.001; HR $= 47.0 \pm 18.4$, FMR $= 59.9 \pm 18.2$) and airway management device (P < 0.001; $PM = 43.0 \pm 14.7$, $KA = 63.9 \pm 17.7$) on time to first breath. Ventilations in AHA range varied by device in the FMR procedure (PM = 54.9 ± 48.03 , KA = 73.7 \pm 38.5), but not the HR procedure (PM $= 69.0 \pm 38.8$, KA $= 69.2 \pm 37.0$), which is clinically relevant. There were no significant main effect for airway exposure technique (P = 0.42) or ventilation device (P = 0.12) on ventilation volume. However, there was a clinically significant difference in ventilation volume between airway management devices in the FMR procedure (KA = 462.2 ± 71.8 , $PM = 386.4 \pm 142.1$). Conclusions: Athletic trainers can successfully insert and ventilate with a King airway. HR is the most time efficient airway exposure procedure regardless of device. All trials resulted in a time to first breathe around 1min. HR and ventilation with PM is preferred for most airway emergencies. With suspected cervical spine injuries, FMR and ventilation with KA may be preferred.

Ventilation volume by device after facemask removal. AHA recommends ventilation volume between 400 and 700mL (indicated by red box)



The Epidemiology of Sports-Related Mouth/Teeth Injuries Among Collegiate and High School Athletes

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Context: Although relatively uncommon, sports-related mouth/teeth injuries can be costly to treat and may have a long-term functional, social, and psychological impact. Objective: To describe mouth/teeth injuries sustained by collegiate and high school athletes. Descriptive epidemiology Setting: Data from the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) and National Athletic Treatment Injury and Outcomes Network (NATION). Patients or Other Participants: Collegiate athletes participating in 25 sports during the 2009/10-2015/16 academic years; High school athletes participating in 27 sports during the 2011/12-2013/14 academic years. Interventions: Athletic trainers (ATs) reported athlete-exposures (AEs) and injuries. Main Outcome Measures: Unweighted AEs, injury counts, and injury characteristics were summarized using frequencies and percentages. Injury rates per 10,000 AEs were reported with 95% confidence intervals (CIs). Results: In the 2009/10-2015/16 academic years, collegiate athletes sustained 231 mouth/teeth injuries for an overall injury rate of 0.38 injuries per 10,000 AEs (95% CI: 0.33-0.43). Men's basketball (1.35; 95% CI: 0.95-1.74), men's wrestling (1.11; 95% CI: 0.51-1.71), and women's basketball (0.92; 95% CI: 0.56-1.27) had the highest rate of mouth/teeth injuries in collegiate sports. In the 2011/12-2013/14 academic years, high school athletes sustained 108 mouth/teeth injuries for an overall injury rate of 0.21 injuries per 10,000 AEs (95% CI: 0.17-0.25). Boys' basketball (0.96; 95% CI: 0.64-1.28), boys' baseball (0.67; 95% CI: 0.32-1.02), and girls' field hockey (0.47; 95% CI: 0.12-0.82) had the highest rate of mouth/

teeth injuries in high school sports. The most common types of mouth/teeth injuries among collegiate athletes were tooth fracture/avulsion (29.4%), mouth laceration (19.1%), and jaw contusion (16.9%) while over half of the mouth/ teeth injuries among high school athletes were jaw contusions (55.6%). For both collegiate and high school sports, contact with another player (66.8% and 54.6%, respectively) and contact with an apparatus (19.5% and 19.4%, respectively) were the most common mechanisms of injury. The majority of collegiate (69.1%) and high school (75.9%) mouth/teeth injuries resulted in a time loss of less than 24 hours; however, 7 (3.0%) collegiate athletes were out for the remainder of the season, and 4 (1.7%) collegiate athletes and 4 (3.7%) high school athletes were out for 30 or more days. 13.0% (n = 30) of collegiate mouth/teeth injuries required surgery, and 4.6% (n = 5) of high school mouth/teeth injuries required surgery. Conclusions: Although not all, many mouth/teeth sports-related injuries may be prevented by wearing a mouthguard, an effective, inexpensive, and underutilized piece of protective equipment. The rate of mouth/teeth injuries was relatively low among collegiate and high school athletes; however, these injuries occurred in sports in which a mouthguard could be worn to potentially reduce the risk of mouth/teeth injury. More research is needed to better understand why collegiate athletes had a higher mouth/teeth injury rate than high school athletes.

Biomechanical Analysis of Cervical Spinal Nerves During Radial and Ulnar Biased Neurodynamic Testing Hixson KM, Lohman Bonfiglio CM, Gilbert KK, Brismee JM, Sobczak S, Sizer PS, Day M, James CR: Center for Rehabilitation Research, **Clinical Anatomy Research** Laboratory, Department of Rehabilitation Sciences, School of Health Professions, Texas Tech University Health Sciences Center, Lubbock, TX; Department of Interdisciplinary Health Sciences, Arizona School of Health Sciences, A.T. Still University, Mesa, AZ; Département d'anatomie, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada

Context: Neurodynamic testing(NT) via a median nerve bias has been shown to cause significant displacement and strain in spinal nerves C5-C8; however, it is unknown whether alternative NT strategies can similarly evaluate cervical spinal nerves. A thorough anatomical neurodynamic examination of the radial and ulnar nerve biases, to date, have not been performed. Additionally, it is unknown whether ulnar biased NT will cause significant displacement and strain in only the spinal nerves from which it receives contribution. **Objective:** To determine the displacement and strain of cervical spinal nerves C5-C8 during NT via radial(R) and ulnar(U) nerve biases. Design: Cross-sectional study. Setting: Clinical anatomy research laboratory. Patients or Other Participants: Eleven unembalmed cadavers (6 male, 5 female; mean age = 80 ± 13.2 years). Interventions: Radiolucent markers were placed into spinal nerves C5-C8 proximal and distal to the intervertebral foramen. Posteroanterior fluoroscopic images were taken while cadavers underwent neurodynamic testing with radial and ulnar biases. Main Outcome Measures: Images at rest and full tension were digitized and compared. Marker displacement and strain were calculated and differences between resting and full tension positions were compared using one sample t-tests. Differences between spinal nerve levels were assessed using one-way repeated measures analyses. Results: Radial biased NT resulted in significant parallel displacement (2.46-4.62 mm, P < 0.01) and strain (7.99-11.98%, P < 0.05) with no significant differences between spinal levels. Ulnar biased NT resulted in significant parallel displacement (2.16-4.41 mm, P < 0.05) and strain (7.12-12.95%, P < 0.05) with a significant difference in strain between spinal levels C5/C6 (t = 2.918, p = 0.026), and C5/C7 (t = 3.210, p = 0.015). Conclusions: Radial and ulnar biased neurodynamic testing causes significant displacement and strain in spinal nerves C5-C8. These results suggest that the brachial plexus plays a role in tensile force distribution, despite the varying spinal nerve contributions to each peripheral nerve. Clinically, the results of this cadaveric study suggest that radial and ulnar neurodynamic testing strategies may be useful in evaluating suspected cervical spinal nerve pathology, especially if a patient is unable to tolerate the end position of the median nerve biased neurodynamic test. Further comparative analyses should be conducted to examine and evaluate a combined clinical approach to neurodynamic testing. Additionally, as technology advances, in vivo studies should be conducted to examine the effects of various neurodynamic testing strategies.

Division III Collegiate Softball Athlete With Traumatic Blowout and Nasal Fracture: Level 3 CASE Study

Nicol E, Levine J, Matuseski N: Kean University, Union, NJ

Background: A blowout fracture occurs when there is impact to the periorbital area with such force, that the orbit ruptures at its weakest point, either the medial wall or floor. It usually includes fractures of the frontal, zygomatic, and maxillary bones. The athlete also had involvement of the nasal bones, the most commonly fractured midface bone. Patient: A 21 year-old female Division III softball player was diagnosed with an orbital blowout and nasal fracture. During off-season practice, she foul tipped an inside pitch to the face. She was wearing a helmet without a cage. There was a laceration above her right eyebrow and epistaxis. Cervical spine involvement was cleared, and first aid was administered until EMS arrived. Right eye was swollen shut, therefore teardrop sign was not observed. Intervention or Treatment: Upon hospital arrival, the laceration was repaired with stitches. CT scans of the head, orbit, and maxillofacial was performed. Results showed a comminuted depressed fracture of the right orbital floor which reached the inferior orbital foramen. She also fractured the frontal process of her right maxilla, bilateral nasal bones, anterior wall of the right maxillary sinus, and the junction of the left nasal and frontal process of the maxilla. She was instructed to ice and prescribed Percocet and Medrol. An ophthalmologist indicated surgery was required to fix the orbital fracture and the nasal bones, but risky if performed simultaneously. Closed reduction set the nose, and orbital floor repair surgery was performed. The incision was done at the inferior fornix transconjunctival and titanium mesh coated with porous polyethylene was used. Through this approach no visible scar presented. She began light activities and returned to play 3 months after the injury,

successfully completing the season. The nasal bones were not reconstructed until 9 months post injury. Outcomes or Other Comparisons: The majority of blowout floor fractures do not require surgery, if no complications are present. Usually fractures are monitored for 1-2 weeks to allow both swelling and hemorrhaging to subside. Indications of surgical repair include entrapment of the inferior rectus, enophthalmos, and fractures of at least half of the orbital floor. There are different surgeries when required. A variety of biomaterials can be used in repairing the orbital floor such as bone grafts, composite polymers, etc. Conclusions: The final diagnosis was fractures to floor of the right orbit, frontal process of the right maxilla, anterior wall of the right maxillary sinus, and bilateral nasal bones. She returned to play in time for the season, without reconstructive nasal surgery. The entire softball team now wears a helmet with a cage. Clinical Bottom Line: Facial protective equipment should be mandated at all levels for softball participation to reduce instance of traumatic facial fractures.

Cervical Spine Injury in High School Basketball Player: Level 4 Clinical CASE Study

Werner JL, Foster T, Worley R, Gubanich PJ: Cincinnati Children's Hospital Medical Center Division of Sports Medicine, Cincinnati, OH

Background: An 18 year-old male, high school basketball player, with no previous spinal cord injuries or known congenital abnormalities sustained an axial load to the crown of head when he struck the shoulder of an opposing player. A Certified Athletic Trainer assessed the athlete in the prone position. The athlete was unable to move his lower extremities and complained of bilateral hand tingling and pain. There was no loss of consciousness. He denied headache, vision changes, difficulty breathing, or chest pain. The athlete was stabilized and EMS was activated. A backboard and c-collar were employed and he was transported to the emergency department. Differential Diagnosis: Cervical fracture, cervical strain, cervical disc herniation, spinal cord injury. Treatment: Physician assessment in the emergency department revealed no spinal tenderness or step-off deformity. Mental status: alert, oriented, and anxious. Glascow Coma Scale: 15. Cranial nerves: normal. The athlete showed diminished motor strength below the level of the biceps bilaterally with preserved sensation to light touch. Hoffman's test was negative bilaterally. CT of head and spine were negative. Due to the presence of paralysis without evidence of fracture, a spinal cord injury was suspected. An MRI showed a contusion of the spinal cord with spinal stenosis at C3-C4. The patient was diagnosed with congenital spinal stenosis, measuring 9mm in AP-diameter, with an acute spinal cord contusion and quadriparesis. A posterior C3-C5 decompressive laminectomy was performed two-days post-injury with immediate improvement. Post-operatively, he was placed in a Miami J collar and bilateral LE splints for foot-drop. Motor strength two-days post-op: right upper extremity 4/5, left upper extremity 4/5, right lower extremity 2/5, left lower extremity 3/5. He exhibited decreased sensation at C6-C8, otherwise fully intact to light touch. Occupational and physical therapy were initiated at three-days post-op. He was discharged at eight-days post-op to a rehabilitation center to continue therapy. Motor strength on discharge: deltoid and biceps bilaterally 5/5, triceps bilaterally 4/5, grip strength right 0/5 and left 2/5, hip flexion bilaterally 4/5, knee flexion right 2/5 and left 3/5, knee extension bilaterally 4/5, ankle dorsiflexion right 1/5 and left 3/5, ankle plantar flexion bilaterally 4/5. Sensation was fully intact to light touch. The athlete returned to school full-time at two-months post-injury. At four-months, he walked with normal arm swing and no signs of spasticity. Impairments with tandem and reverse tandem walk, fine motor skills, and reduced rapid alternating movements continued. Sit-to-stand (without the use of arms), reflexes, neck ROM, and upper extremity strength were normal. The athlete was advised against returning to high-impact sports with his history of cervical myelopathy and spinal cord injury. Uniqueness: Cervical spine injuries are life-threatening and fairly uncommon in sports. To our knowledge, this is the first documented case of a cervical spinal cord contusion with tetraplegia in a high school basketball player. While the mechanism of an axial load to the spine causing trauma is well described, it is rare for this to occur during basketball. Approximately 11,000 cervical spine injuries present to the emergency department annually due to football; whereas the prevalence in basketball is currently unknown. An axial load in conjunction with congenital spinal stenosis posed a potential catastrophic risk to this athlete, although his overall outcome is fairly good. Conclusions: Although rare, catastrophic injuries may occur during any athletic event. Emergency Action Plans are imperative for each sporting venue and practiced regularly with those involved to ensure proper care for all athletes. Certified Athletic Trainers need to have a high index of suspicion for these injuries and practice per established guidelines and protocols to prevent further injury and optimize outcomes.

Non-Displaced Sternoclavicular Physeal Fracture of a 21-Year-Old Female Collegiate Club Rugby Athlete

Shafer C, Sinclair Elder AJ, Pak J: University of Colorado, Colorado Springs, CO; Centura Orthopedics, Colorado Springs, CO

Background: This case study follows an apparently healthy 21-year-old female collegiate club rugby athlete, who reported to the athletic training room with a chief complaint of pain and anterior protrusion of her right clavicle at the SC joint. The mechanism of injury was unknown. The athlete reported mild to moderate pain described as nagging and sharp at both rest and with shoulder motion. Pain was reported at 3/10 at rest and as well as any active range of motion of the right arm and 5/10 upon palpation of the SC joint. There was no previous history of shoulder injury or pain; however, the athlete reported previous history of pain to the left clavicle, but not to the right clavicle. Evaluation by the athletic trainer revealed no obvious edema or ecchymosis, but a mild potential deformity and slight anterior protrusion of the right medial clavicle was noted. Active range of motion and manual muscle tests were within normal limits and a positive horizontal adduction compression test was found. Differential Diagnosis: Assessment was possible dislocated clavicle or possible clavicular fracture. Treatment: Physician examination resulted in the same findings as the athletic trainer's evaluation and orders for radiologic imaging were executed. The athlete was subsequently diagnosed with a non-displaced grade 1 Salter-Harris fracture of the right medial SC joint physis. The fracture was successfully treated with conservative management of rest and observation of signs and symptoms. She remained asymptomatic for the first 4 weeks post-injury and was cleared by the physician to return to athletic activity. Uniqueness: This case is unique due to the lack of the dislocation and displacement accompanying the medial

physeal fracture. Physeal fracture literature is limited yet indicates that physeal fractures of the medial clavicle occur primarily with clavicular dislocations; there is no literature regarding the occurrence of medial physeal fracture without dislocation, nor is common age specified other than age through closure of the physis (< 25 years old). Additionally, the athlete was 21-yearsold with a medial clavicle physeal fracture. Athletic trainers may overlook the fact that the medial clavicle physis is one of the last to close at approximately age 25, and not realize, particularly without dislocation, that a physeal fracture is a possibility especially after a case with an unknown mechanism. Conclusions: The athlete had successful return to play at 4 weeks following conservative care of the non-displaced fracture. Athletic trainers in the collegiate setting should be aware that the SC physis is likely open in their athletes and could have a physeal fracture present in the medial clavicle, even if dislocation is not present. Referral for imaging is essential, even in a case that presents as a potentially minor case.

College Athletic Trainers' Use of Recommendations for Acute Care of Spine Injured Patients Snyder Valier AR, Welch Bacon CE, Kucera KL, Williams RM: A.T. Still University, Mesa, AZ; University of North Carolina, Chapel Hill, NC

Context: The severity of spine injuries necessitates immediate, high quality care essential for promoting positive patient outcomes. Care aligning with best practices, such as the National Athletic Trainers' Association **Executive Summary Recommendations** for Appropriate Care of Spine Injured Athletes (ES-Spine), should be provided. However, implementation of recommendations can be challenging. Knowledge of end-user influential factors for use and barriers to use can drive strategies to support implementation of recommendations. **Objective:** To describe the implementation patterns and influential factors for use and barriers to use of college athletic trainers (ATs) who do and do not implement the ES-Spine. Design: Cross-sectional. Setting: Qualtrics survey. Patients or **Other Participants:** 2,630 participants from a sample of 27,528 ATs accessed the survey (access rate = 9.6%). 853 college ATs (433 males, 413 females, 5 prefer not to answer, 2 missing, age = 34.83 ± 11.54 years) completed at least one survey component and were included. Interventions: Participants were invited through email to complete the Athletic Trainers' Beliefs, Attitudes, and Implementation Strategies on Appropriate Care of Spine Injured Athletes (BAISAC-Spine) survey. The BAISAC-Spine consisted of several multipart questions that evaluate ATs' knowledge, comfort, ease, and success with implementing the ES-Spine. ATs who implemented a recommendation were asked about influential factors for implementing that recommendation. ATs who did not implement a recommendation were asked about barriers to implementing that recommendation. Main Outcome Measures: Survey

responses are reported (frequencies and percentages). Results: Most college ATs partially (46.4%, n = 143/308) or fully (40.6%: n = 125/308) implemented ES-Spine. Over half of college ATs reported they activate emergency action plans (EAP) according to injury severity (97.0%, n = 610/629), use immobilization devices for transport (89.6%, n = 491/548), apply rigid immobilization devices prior to transport (85.3%, n = 482/565), develop EAPs with EMS (76.1%, n = 499/656), develop transport plans for emergency situations (67.2%, n = 355/528), remove protective equipment before transport (60.8%, n = 365/600), and remove equipment with three trained rescuers (56.4%, n = 327/580). Over half of college ATs reported they do not use the 8-person lift technique to move suspected spine injured patients (59.0%: 317/537) or conduct a time out to review the EAP before all events (54.7%: 352/643). College ATs who implement recommendations were most influenced to do so by priority in care, professional responsibility and/or best practice, and EMS relationship. Commonly endorsed barriers for ATs who do not implement recommendations included insufficient personnel and not enough trained staff. Conclusions: Most college ATs implement current spine care recommendations to some extent, with the fewest number following recommendations for regular review of EAPs and performance of the 8-person lifting technique. Effective implementation requires strategies to overcome end-user barriers, which for college ATs include limited staff and trained personnel. Implementation strategies are needed to assist ATs who are not currently using available best practice recommendation or are facing implementation barriers.

Football Helmet Facemask Removal Skill Development in Novice Athletic Training Students

Wright CJ, Silva NG, Swartz EE, Arnold BL: Whitworth University, Spokane, WA; University of New Hampshire, Durham, NH; Indiana University, Indianapolis, IN

Context: To secure airway access in a football athlete with a suspected cervical injury, facemask removal is preferred to helmet removal to minimize cervical motion. Facemask removal requires proficiency in equipment removal procedures, including the use of specialized tools (e.g. FMxtractor®) to cut loopstraps which attach the facemask to the helmet, if necessary. While facemask removal performance has been reported in experienced athletic trainers under a variety of conditions, skill acquisition is largely undocumented. **Objective:** To document skill development for facemask removal in novice athletic training students. Design: Single-cohort intervention. Setting: Laboratory. Patients or Other Participants: Eighteen college students (7 males, 11 females, age = 20.1 ± 1.5 years) without experience removing a football facemask. Interventions: In a single session, students participated in a standardized 20min facemask removal instructional module followed by 6 consecutive recorded facemask removal trials. Trials consisted of completely removing a facemask from a helmet worn by a live model by removing the 4 loop-strap attachments. In each trial, 1 of the 4 attachments required the use of a backup cutting tool (FMxtractor®) rather than the standard tool (screwdriver or quick release mechanism), adding difficulty to the task. Trial time was documented using a digital stopwatch, confidence was rated using a 5-point Likert scale, and rating of perceived exertion (RPE) was rated using the modified Borg category ratio-10 scale. Motion of the model's head was tracked using a marker on a wand attached to a mouth piece, and recorded by MaxTRAQ 2D

software. Main Outcome Measures: Dependent variables included: time to task completion (s), confidence, RPE, total head movement (summed motion in cm), maximum medial-lateral excursion (cm), and maximum superior-inferior excursion (cm). For all variables except head motion, separate 3 (trial) by 2 (strap location) RMANOVAs investigated differences. Motion variables were analyzed with mixed-model RMANOVAs with effects for strap location and trial. Failure rate (trial time >3 minutes) was documented. Results: Participants failed 11.1% of trials (0.67 \pm 0.8 per participant). There were significant improvements from the first to last trials in: time to task completion $(118.48 \pm 9.01 \text{ s to } 90.52 \pm 7.68 \text{ s}, \text{F}_{2.36} =$ 4.582, P = 0.017), confidence (3.2 ± 0.1) to 4.0 \pm 0.2, F_{2,36} = 12.690, P < 0.001) and RPE (3.0 \pm 0.2 to 1.9 \pm 0.3, F_{2,36} = 14.249, P < 0.001). Head motion did not improve after practice (all P > 0.05). Compared to trials where a forehead loop-strap was cut, cutting cheek loopstraps took significantly longer (F₁₁₇ = 36.483, P < 0.001, mean difference [MD] = 65.67 s, with higher RPE (F_{1.17} = 17.611, P = 0.001, MD = 1.18), lower confidence ($F_{117} = 13.319$, P = 0.002, MD = 0.60), more total head movement $(F_{1.60} = 15.920, P < 0.001, MD = 39.45)$ cm), and more medial-lateral excursion $(F_{1.69} = 4.353, P = 0.041, MD = 0.78$ cm). Conclusions: Following standardized instruction and practice, students demonstrated improvements in time, confidence and RPE. While overall skill performance began to approximate reported norms, improvements in success rate, consistency, and motion are needed.

Free Communications, Poster Presentations: High School Football Case Studies

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Beer Paview Authors – Last Names A through M: 10:20AM 11:15AM; Beer

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Unique Presentation of Brachial Plexus Neuropathy in a High School Football Player

Grimsley EE, Timlin JJ, Wilkenfeld DA, Scifers JR, Nnaeto CA, Gibson BW: Freedom High School, Bethlehem, PA; Moravian College, Bethlehem, PA; St. Luke's University Health Network, Bethlehem, PA

Background: Brachial plexus neuropathies, often referred to as "stingers," are highly prevalent in football players who have sustained one of the following mechanisms: cervical traction, shoulder depression combined with ipsilateral neck flexion, or cervical compression.¹ Generally, "stingers" present with minimal clinical findings.² However, this case revealed marked decreased muscle tone and swelling that is not characteristic of an acute brachial plexopathy. Furthermore, while brachial plexopathies are common, patient presentation and course of recovery can vary.³ Patient: Patient is a 5' 10", 164-pound, 16-year-old, male football linebacker with a chief complaint of pain and weakness in his right shoulder secondary to an external rotation (ER) and horizontal abduction (ABD) traction mechanism of injury. Initial evaluation was unremarkable and the patient was treated using cryotherapy and a shoulder spica wrap for pain. The patient was allowed to return to play for a second session the same date of injury. During the second practice session, the patient reported no secondary trauma to the involved shoulder. Following the second practice, visual inspection revealed swelling, redness, and warmth of the right upper extremity, severe scapula dyskinesia, as well as decreased muscle tone of the right pectoralis major, upper trapezius, and deltoid. The patient complained of mild paresthesia in the distal right upper extremity (UE). Bilateral UE range of motion (ROM) was grossly within normal limits (WNL). Strength testing revealed pain and decreased strength of the infraspinatus, teres minor, pectoralis major, latissimus dorsi, anterior deltoid, and triceps. Neurologic examination demonstrated decreased sensation from C5-C7 dermatomes. The patient was referred to the team orthopedic surgeon for further assessment and diagnostic imaging. The physician's exam revealed (+) empty can test, (+) Speed's test, (+) jerk test. In addition, the patient reported pain upon palpation of C5 spinous process. ROM presented WNL bilaterally. Plain radiographs were negative for bony abnormalities of the shoulder and cervical spine. MRI results revealed a right infraspinatus and teres minor strain. The patient's final diagnosis was a brachial plexopathy, coupled with infraspinatus and teres minor strains, which consequentially resulted in scapular dyskinesis. Intervention or Treatment: Treatment for the brachial plexus neuropathy and resulting loss of strength included resistive exercise focused on the upper trapezius and pectoralis muscles. Additionally, a rotator cuff strengthening plan was implemented, coupled with strengthening of the deltoids, biceps, and triceps to address shoulder weakness, and scapular stabilizer strengthening to address the patient's scapula dyskinesia. **Outcomes or Other Comparisons:** Following two weeks of rehabilitation, the patient was allowed to return to minor-contact and he was medically cleared for full contact one week later. The patient returned to unrestricted activity without further complication. Conclusions: This case is unique due to the confounding presentation involving both anterior and posterior aspects of the right shoulder girdle; specifically, the significant decreased muscle tone in the upper trapezius and pectoralis major that presented within hours of the patient's mechanism of injury. In addition, the presence of swelling, redness, and warmth in the distal right upper extremity that resolved the next day was suspected to be transient acute thoracic

outlet syndrome. Therefore, this case is unique for its presentation and multiple comorbidities that occurred within one day of the onset of injury. Clinical Bottom Line: Brachial plexopathies are common injuries among athletes engaged in collision sports. However, due to the close proximity of neurovascular structures in this anatomical region, clinicians must consider damage to not only the nervous tissue, but also the vascular structures. It is essential to conduct a thorough evaluation, including diagnostic imaging, in order to determine the severity and the nature of the neuropathy and any comorbidities.

Type 2 Scheuermann's Disease in a High School Football Athlete: A Level 4 Case Report Cieszko E, Powers ME, Gildard M: Marist College, Poughkeepsie, NY

Background: During preseason, a 17year old interscholastic football athlete presented to his athletic trainer with non-descript, chronic low back pain. He was above average height and weight but was not obese. His past history was negative. He reported that the pain worsened during exercise or after prolonged sitting. Upon examination it was noted that the patient had full range of motion in his neck, upper extremities, and lower extremities. He had a normal gait and was not tender to palpation on his vertebrae, however a lack of a lordotic curve in the lumbar region was observed. Lower and upper extremity manual muscles tests were 5/5 bilaterally. Sensation was intact and reflexes at the patella tendon, achilles tendon, biceps brachii, triceps brachii and brachioradialis were a 2. Balance and coordination were normal and there was no family history of back problems such as scoliosis. Differential Diagnosis: Scoliosis, idiopathic kyphosis, congenital kyphosis, spondylitis, spondylolysthesis, and disc herniation. Treatment: The patient was referred to his primary physician for nonspecific low back pain, and was later referred to a pediatric orthopedist. The patient underwent a standing posteroanterior and lateral radiograph of the spine and magnetic resonance imaging (MRI). These images were used to measure angles of the spinal curvature. Excessive anterior wedging of the lumbar vertebral bodies was apparent on observation and the patient was diagnosed with Type 2 Sheuermann's disease. The treatment plan included a rest period, bracing protocol, and a core and back strengthening program. The patient was instructed to wear a lumbar back brace for two months for roughly 20 hours a day. Cardiovascular exercises such as biking and walking were permitted. After two months the patient began a strengthening protocol without a brace under supervision of the athletic trainer. Early stages of rehab consisted of core and lumbar strengthening exercises. Aqua therapy was also introduced to the patient early to promote relaxation, increase range of motion, and incorporate cardiovascular endurance. As time progressed the exercises became more challenging and functional. Uniqueness: This case was unique because type 2 Scheuermann's disease is very rarely diagnosed, as it makes up only 0.4-2% of all diagnosed cases. Scheuermann's disease has been defined as a rigid thoracic and thoracolumbar kyphosis associated with vertebral body wedging in late childhood. However, more recent definitions note specific criteria of three or more adjacent apical vertebrae each wedged at a minimum of 5° and a thoracic curve of 45°. Type 2 Scheuermann's disease does not have a distinct and clear cause but several are theorized including aseptic necrosis of the ring vertebral apophyses, abnormal vertebral endplate cartilage, irregular mineralization, disorders in vertebral ossification, alternations in collagen aggregation, and genetics. Intense postural therapy is usually encouraged followed by a bracing or casting program. Surgical protocols are reserved for patients who have a progressive curve angle though conservative treatment is often most beneficial. Conclusions: Scheuermann's disease is a rare condition of unknown etiology that affects the spinal column. Patients are best diagnosed with a combination of observation and diagnostic imaging to identify thoracolumbar kyphosis. Our case was challenging as the patient's only complaint was non-descript low back pain. The patient has discontinued physical therapy as imaging revealed a reduction of the thoracolumbar deformities associated with Scheuermann's Disease.

Avulsion Fracture of the Iliac Crest at the Apophysis in an Adolescent Football Player Landrum M, Bartz-Smith S: Grand Valley State University, Allendale, MI

Background: A 16 year old, 6'4", 195lb male football player presented with right hip pain following a tackle in which he landed directly on his right hip. The athlete has a history of genetic true leg length discrepancy in his left leg which he uses a heel lift to accommodate. During the third game of the season, the athlete presented to the athletic trainer with repeated falls on the anterior superior portion of his right hip causing discomfort restricting his running, jumping, and walking. He described sharp stabbing pain in his right hip extending into his low lateral abdomen. Range of motion, Ober test, Thomas test, and manual muscle testing resulted in 8.5/10 pain on the visual analog scale. Pain restricted ability to continue play. Athlete was referred to the orthopedic physician three days later with an iliopsoas strain with the possibility of iliac fracture. Differential Diagnosis: Iliopsoas strain, iliac fracture, hip pointer. Treatment: Initial treatment prior to seeing the physician was rest and ice. The physician ordered an x-ray which revealed an avulsion fracture of the iliac crest at the apophysis. The patient was told to rest until normal motion was pain free. Patient remained weight-bearing for the duration of this stage of treatment. Upon reaching a pain-free range of motion milestone, the patient was allowed to begin non-specific cardio and core exercises. Three weeks post-injury, the patient began practicing with the team at 80%. The following week, the athlete returned to full participation. Uniqueness: A fracture of the apophysis of the iliac crest is rare and not well documented in the literature. Apophyseal avulsions of the pelvis, specifically at the anterior superior iliac spine, ischial tuberosity, and anterior inferior iliac spine, are common in adolescents 11-17 due to developing enchondral ossification. Common fractures are divided into two types. Type I is a sartorius avulsion usually caused during the starting phase of sprinting. Type II is a tensor fascia lata avulsion typically occuring during the initial phase of swinging a baseball bat. This case does not match either type. The contribution of the leg length discrepancy to the injury is inconclusive. Conclusions: Due to the uniqueness of the injury, there is little literature about treatment options. Literature supports a surgical approach when the fracture measures greater than 1.5 centimeters and has been displaced. A conservative approach was chosen due to the small size of the fracture and lack of displacement. It is important as an athletic trainer to ensure that more serious pathologies are ruled out before assuming a diagnosis, especially when abnormalities exist in the examination results. In this instance where a conservative treatment was chosen, the athletic trainer must exercise caution with the speed of rehabilitation and return to play decisions due to the slow healing of the bone and cartilage. Fracture to the iliac crest at the apophysis should be considered in adolescent athletes due to the underdeveloped cartilage when symptoms include the inability to activate multiple muscles at the attachment site of the iliac crest. Due to the lack of literature about this specific injury, clinicians must be aware of the possibility.

Displaced Closed Tibial and Fibular Shaft Fractures in a High School Athlete

Begley C, Wilson B: University of Kentucky, Lexington, KY; Paul Laurence Dunbar High School, Lexington, KY

Background: The athlete is a 17 year old male participating in football as a middle linebacker. His height is 72" and weight is 230 pounds. He has no significant past medical history. He was initially evaluated on field by Certified Athletic Trainer complaining of pain and deformity in his left lower leg secondary to an opposing athlete collapsing on him. Differential Diagnosis: Fracture or dislocation of the knee or leg. Treatment: The athlete was assessed on field following the play. Visual inspection showed signs of obvious deformity of lower leg with immediate swelling and no open wounds. The athlete exhibited tenderness to palpation globally in the left lower leg. Range of motion and manual muscle testing were deferred due to pain. The team physician was called onto field and EAP was activated by school law enforcement. Posterior tibial and dorsalis pedis pulses were within normal limits, sensation was intact in all nerve distributions of the foot, and motor strength was intact but decreased secondary to pain. ATCs and team physician splinted the left lower extremity in position of function with use of vacuum splint. His pulse, sensory, and motor function were reassessed and were again found to be within normal limits.athlete was transferred to emergency department by EMS for evaluation. Radiographs were obtained and showed displaced fractures of the tibia and fibula. The patient was provisionally stabilized in a long-leg splint and admitted for observation and surgical planning. The following day, he underwent reamed, locked intramedullary nailing of the tibia through a suprapatellar approach. The postoperative plan consisted of touch down weight bearing with physical and occupational therapy

for assistance with mobilization. He was monitored for compartment syndrome for twenty-four hours post-operatively and was discharged home in stable condition. He will be seen for routine follow up with advancement of weight bearing and return to physical activity as indicated by fracture healing. Uniqueness: Displaced tibial and fibular shaft fractures are most commonly seen in high energy trauma such as motor vehicle accidents or falls from great heights. More unusually, this injury is seen in the high school athletic population. Conclusions: The athlete was diagnosed with displaced closed fractures of the tibial and fibular shafts. An EAP was executed by ATC and team physician. The patient was treated operatively and expected returned to ADL in the spring of 2018. Athletic Trainers need to recognize and understand the need for emergency management training as well as proper planning, execution of EAP, and management of emergency situations in the athletic setting.



Thoracic Compression Fractures in a High School Football Player Williams AR, Horan MP, Goins JM, Torres-McGehee TM, Weber SR: University of South Carolina, Columbia, SC; Palmetto Health USC Medical Group, Columbia, SC

Background: The patient is a 5'4", 118lbs, 15-year-old male high school football wide receiver/defensive back. While attempting to make a tackle, he made contact with an opposing player with his head down. The patient landed face down and was unable to push himself up due to pain and weakness. He was able to roll himself over and remove his helmet prior to the arrival of the athletic trainer. He had immediate complaints of bilateral tingling along his upper back and weakness across his shoulders and upper back, in which the athletic trainer began maintaining C-spine stabilization. Palpation revealed pain over C5-T1 and a possible step-off deformity, therefore the EAP was activated and EMS was called onto the field to assist with spine-boarding. The athlete was placed on a spineboard, his shoulder pads were removed, and he was transported to the local emergency room. Differential Diagnosis: Cervical spine fracture, Cervical vertebra dislocation, Cervical strain, Thoracic compression fracture. Treatment: X-rays and CT scans were performed the night of the injury, and no fractures were noted. During ER physician evaluation the bilateral tingling had resolved, pain had decreased, and strength was improving. Upon physician review of x-rays and CT scans in the ER the patient was released with a cervical strain diagnosis. The following morning a radiologist reviewed the scans and found them to be unsatisfactory, after which the patient was called back for a MRI. MRI findings lead to the diagnosis of compression fractures to T1-T7 vertebra. The following morning the patient was fitted and placed in a Aspen vista 464 thoracolumbosacral orthosis brace at an orthopedic clinic for an estimated 6 weeks. 4 weeks after the initial injury

new x-rays were performed to assess his healing and check for complications. After review the physician decided to leave him in the brace for 2 more weeks. The patient was removed from the brace and is currently participating in a 6 week physical therapy program to increase strength. Uniqueness: This case is unique as head down contact causing an axial load most often results in cervical spine fractures and ligamentous injuries of C5-C6.1 Thoracic fractures caused by high-impact injuries are often associated with chest injuries and/ or life threatening injures which can lead to subtle thoracic fractures being missed 20-22% of the time during initial evaluation and imaging reports.^{2,3} The rib cage provides protection and stability to the upper thoracic spine T1-T9, due to this it requires higher forces to generate compression fractures than it would in the cervical or lumbar spine.3 Thoracic compression fractures are most commonly seen in elderly osteoporotic patients with a flexion mechanism of injury.2 Another interesting factor for this case is the compression fractures happened in the upper thoracic spine and most thoracic compression fractures occur in the lower vertebrae.4,5 Conclusions: This case shows an interesting outcome of head down contact and a compression fracture in a unusual location for this type of injury and age group. This injury shows that with head down contact the thoracic spine is also at risk for fracture and should be assessed during the initial trauma evaluation along with the cervical spine.

Free Communications, Poster Presentations: Hip Cases

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Reattachment of A Dual Avulsion Fracture of the Proximal Hamstring

Chicarella M, Nissen C, White D, Wallace D, Botto T: CCMC, Mount Laurel, NJ; Quinnipiac University, Hamden, CT

Background: According to the current literature available, there is little to no evidence regarding acute "two-tendon injuries." Single avulsion injuries are much more common in the acute setting. The mechanism of injury, a forceful eccentric loading of the hamstring, supports the eventual diagnosis of the athlete. Patient: 19-year-old Female D1 Volleyball athlete. Prior to injury, the athlete was removed from participation related to a weight loss of approximately thirty pounds between her 2015-16 PPE's. The athlete successfully underwent treatment with a registered dietician from August 2016 to October 2016 to address her weight loss. The athlete was cleared to return to activity on October 16, 2016, approximately three weeks prior to injuring her hamstring on November 12, 2016. Athlete had no prior history of hamstring injuries to the involved leg. On February 2, 2017, the athlete reinjured her left hamstring during practice. Athlete was referred back to the team physician who ordered a MRI. Intervention or Treatment: Initial diagnosis by the team physician on November 17, 2016, was a Grade II left hamstring strain. The athlete began rehabilitation immediately. The athlete was compliant and participated in rehabilitation until she left school for winter break on December 19, 2016. The athlete continued rehabilitation for the entirety of winter break at home without complication and was cleared to progress back into full activity by the certified athletic trainer on January 30, 2017. The athlete reinjured the same hamstring on February 2, 2017, three days after returning to activity. After re-injury to the hamstring and lack of progression with rehabilitation, the athlete was scheduled to visit the team physician. Visit with the physician on February 23, 2017, confirmed initial findings of a grade II hamstring strain. MRI was further ordered to confirm findings. MRI revealed a portion of the semitendinosus that had avulsed off the ischial tuberosity and retracted approximately 5.5 cm from its insertion point. The athlete underwent successful surgery to reattach the muscle on March 8, 2017. During the surgery to repair the complete avulsion fracture of the semitendinosus the surgeon found an additional partial avulsion fracture of the semimembranosus. The avulsion fracture of the semimembranosus did not require any surgical intervention. To date, the athlete has made a complete recovery without any further complication. Outcomes or Other Comparisons: According to various research found regarding timelines of single hamstring avulsion recoveries, rehabilitation is approximately 4-5 months. This athlete recovered in approximately 7 months from the date of surgery to return to play. Conclusions: This athlete suffered from significant weight loss prior to her injury that may have played a role in the athlete's dual avulsion fracture injuries. Nutrition plays a significant role in the overall health of an individual and should be emphasized throughout the entirety of their life. Clinical Bottom Line: Lack of significant nutrition not only can, and often lead to injury, but also contribute to factors that will often make the recovery process both more complicated and difficult.

Low Back Pain as a Complication of Slipped Capital Femoral Epiphysis in a Collegiate Volleyball Player

Fiesler T, Warner BJ, Berry VA, Mesman DL, Cage SA: University of Texas, Tyler, TX; Christus Trinity Mother Frances, Tyler, TX; Grand Canyon University, Phoenix, AZ; The University of North Carolina, Greensboro, NC

Background: An 18-year-old collegiate volleyball player reported to the athletic training clinic complaining of diffuse low back pain. The patient stated a two year history of back spasms. Previous treatments had included moist hot pack, motor TENS, and stretching, with limited success in reducing pain. Initial evaluation revealed bilateral spasm of the erector spinae and quadratus lumborum. Decreased active trunk flexion, lateral flexion and rotation were noted due to pain. Patient reported no neurological symptoms, and could not recall a specific incident causing the initial presentation of symptoms. The patient began a regimen of dynamic warm up, soft tissue mobilization through cupping therapy and myofascial release, and a core strengthening therapeutic exercise program. Following two weeks of treatment, patient reported no significant improvement, and was removed from participation with referral to the team physician. Differential Diagnosis: Back spasms, low back strain, low back sprain, lumbar disc pathology, sacroiliac joint dysfunction. Treatment: Day 15, upon reporting to team physician, patient underwent a comprehensive evaluation. Lumbar spine and pelvis x-rays revealed a surgically repaired slipped capital femoral epiphysis on the patient's right hip. Patient stated that she did not mention the surgery during the athletic training staff evaluation, as she did not realize it might be pertinent to the low back pain. Further evaluation revealed significant weakness with hip adduction and decreased right hip internal rotation. Following diagnosis, a new plan was made to address strength and range of motion deficits. Patient was instructed to begin

taking 400 mg of ibuprofen three times a day for two weeks. Day 17, patient reported that pain had begun to decrease, noting she was able to perform activities of daily living with considerably less pain. Patient continued to perform therapeutic exercise for core stability and groin strength, while soft tissue mobilizations were targeted toward improving internal range of motion in the involved hip. Day 18, patient passed functional testing and returned to position related drills during practice. Following practice, patient stated she was sore along her erector spinae and quadratus lumborum muscles, and was instructed to report if symptoms worsened. Day 20, patient participated fully in competitions throughout the weekend, and reported soreness but no return of the symptoms that led to seeking out medical care. Day 35, patient completed the remainder of her competitive season. At the conclusion of the season, patient was provided a rehabilitation program for winter break and was instructed to report any recurrence of symptoms. Upon returning to school the following semester, the athletic training staff was informed that the patient had chosen to forego further participation in organized athletics. The patient reported the decision as a desire to focus on academics, and not a measure taken due to back pain. Uniqueness: Slipped capital femoral epiphysis afflicts only 1 to 7 in 100,000 Americans, with increased prevalence in males to females at a 2:1 ratio. Commonly reported complications of surgical intervention include hip pain, limp and limited hip range of motion. In this case, the patient was a female who presented with diffuse low back pain as a primary complication. A scholarly search of the terms "slipped capital femoral epiphysis" and "volleyball" yielded no results. Conclusions: When performing a medical evaluation, medical history and injury history are often times the crucial aspects of the examination. Following initial evaluation, clinicians must evaluate and re-evaluate patient outcomes to determine efficacy of the current treatment protocol. Should initial treatment fail, it is of the utmost importance that the clinician seek out all diagnostic means of determining the underlying pathology.

Chronic Hip Pain in a Collegiate Soccer Player

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Background: Student-athlete is a 21-year-old, female, soccer player who plays midfield/forward and is right leg dominant. In November 2016, the athlete complained of lateral right hip pain during sport-specific activity. Athlete has a history of low-back-pain and pubic symphysitis. During examination by the athletic trainer, athlete had pain over the greater trochanter and no obvious deformity, swelling, or ecchymosis at the hip. Examination of ROM revealed: full hip AROM and PROM, pain with hip flexion, adduction, and abduction for AROM, and pain with hip extension, adduction, and abduction for PROM. Manual Muscle Testing for hip flexors, extensors, adductors, and abductors were graded 4 out of 5 and painful except for the hip flexors. Thomas test was positive for hip flexor tightness. Differential Diagnosis: Hip flexor and abductor strain, pubic symphysitis, athletic pubalgia Treatment: Following winter break, athlete was revaluated by athletic trainer and reported increased pain after returning to activity. Athlete was given hip flexor spica to help with pain during practice. Athlete saw team physician and had an MRI with contrast ordered for the right hip. Athlete had a follow-up with physician and he suspected a slight tear in anterior labrum of the right hip or iliopsoas tendinitis. Athlete was given a cortisone injection in the hip to decrease pain and if the injection was successful would get another before Fall season. Athlete began a return-to-play progression and had decreased pain and increased hip ROM. One week later after a 20-minute shooting drill where athlete was striking the ball multiple times, hip pain returned to level prior to injection. Athlete was shut down from soccer-related activity for four weeks. After summer break, athlete received a Platelet Rich Plasma injection in the right hip and was cleared

for activity two weeks later. Athlete was able to begin low-impact conditioning and progress to full sport-specific activity. Uniqueness: Hip labral pathologies are usually treated with surgical interventions, but in this case conservative treatment has been successful managing her pain levels as well as allowing her to continue playing soccer. Conclusions: Conservative treatment and strengthening of the flexors, extensors, and abductors of the hip, helped athlete return-to-play at a functional level. Athlete tolerated pain while playing during Fall season and upon follow-up with physician, was prescribed a dose pack to decrease inflammation and has been managing pain with medication and daily rehabilitation. In the case of a hip injury like this it is important to distinguish between a muscle strain, labral tear, or injury to the joint capsule. If the pain is deeper it is important to rule out a labral tear. Specifically, with a soccer player that needs to be able to strike a soccer ball and sprint full speed without pain, these activities will aggravate the damaged tissue because of the forceful flexion and extension needed for those movements.

Hip Pain in a College Lacrosse Player

Connolly DS, Felton SD, Craddock JC, Knight AR: Florida Gulf Coast University, Fort Myers, FL; The University of the South, Sewanee, TN

Background: This Level 4 Case report presents an athlete who was a 22 year-old (177.8 cm and 80.74 kg) male NCAA division III lacrosse athlete. The athlete had no prior medical issues. Athlete reported to the athletic trainer room for the first time requesting a second opinion related to the undefined hip pain. The believed mechanism of injury was when the athlete "jammed" his foot into a curb when running to catch a bus. He had previously seen an orthopedic physician prior to returning to school for fall semester. The physician prescribed anti-inflammatories and advised rest, providing no true diagnosis. The physician also ordered X-Rays. Results demonstrated what appeared to be arthritis of the hip, similar to that of an elderly individual. The physician then ordered an MRI and a CT scan. Between the images it was determined that surgical intervention was needed to complete a total hip replacement. The cause was still unknown, and further tests were ordered to try and determine it. A needle was inserted into the hip and fluid was extracted from the joint space. This fluid was observed for two weeks. Differential Diagnosis: Staphylococcus aureus infection from an abrasion over the hip, Torn labrum, Avascular necrosis. Treatment: Athlete began treatment to relieve as much pain as possible. Per physician recommendations the athlete is to remain NWB. The fluid retrieved from hip joint was found to be Staphylococcus aureus, and the athlete was placed on antibiotics for infection immediately. The athlete continued treatment for pain relief, until surgical interventions could be scheduled and performed. Uniqueness: While hip pain can be a common complaint among many athletes, the cause is always much less severe. While there has been much success found when doing hip replacements in patients over 80, the results have not been as successful when the athlete is under the age of 35. When the patient is over the age of 80 is has been found that the replacement has lasted from between 8 to 10 years. With athletes that were under the age of 35 it was found that 57% of the time after 5 years either actual or potential loosening occurred. This could set the athlete up for potentially needing more than 5 total hip replacements throughout his life. Conclusions: This case report highlighted the diagnosis of an infection of the hip joint that will result in a total hip replacement in a young otherwise healthy athlete. This infection was the result of a wound that the athlete neglected to attend to. Wound care is a vital part of athlete care, and should be stressed to all of our athletes. This case provided evidence and best practice protocols for rehabilitation for athletes with this unique injury, along with the return of the athlete to as normal of a life as possible outside of athletics.

Non-Contact Anterior Hip Dislocation in a Male Collegiate Lacrosse Athlete: Level 4 CASE Study

Overhiser AO, Hoch JM: University of Kentucky, Lexington, KY

Background: A 21-year-old (182.22 cms, 79.37kg) senior collegiate lacrosse player was participating in a game when he pivoted to pass the ball, slipped on the wet turf, and fell to the ground with his hip in hyperflexion and abducted. He reported the absence of an audible or perceptible "pop" or "crack". Patient reported pain in his left hip and visual inspection revealed the hip was in forced external rotation. The patient had no past pertinent history of hip injury or congenital deformities. Differential Diagnosis: Hip dislocation caused by a) hip dysplasia b) Ehlers-Danlos syndrome, and c) acute mechanism with accompanied soft tissue pathology, femur or pelvis fracture. Treatment: The patient was immobilized and EMS was called. The patient was taken to the local emergency department and x-rays were taken of the patient's hip and low back. Results of the x-ray confirmed an anterior hip dislocation. Two-hours post dislocation, his femur was relocated by a general practitioner in the emergency department with the guidance of an on-call orthopedic surgeon. He was released later that evening, non-weight bearing on crutches, and prescribed oral analgesics. The patient followed up with a local orthopedic surgeon the next day who referred him to a trauma specialist. The hip specialist ordered follow-up x-rays to rule out a fracture and recommended that the patient maintain a non-weight bearing status for 6-weeks. After the period of nonweight bearing, the patient was cleared to begin rehabilitation. Initial rehabilitation consisted if general hip strengthening in all directions, paying attention to external rotation and extension. Uniqueness: Hip dislocations are rare, and anterior dislocations make up few of these occurrences. Of all hip dislocations, athletic-related hip dislocations only account for 2-5% of reported injuries. Contrary to common mechanisms of injury which most often include trauma or a car accident; this
patient sustained his injury by slipping on wet turf. It is important to know if there is an underlying causation of a hip dislocation, i.e. hip dysplasia or Ehlers-Danlos syndrome, so any further complications and a proper treatment plan can be identified. Conclusions: Although the incidence of anterior hip dislocation is rare, it is an important differential diagnosis to include. The probability of avascular necrosis of the femoral head greatly increases if the time to reduction is longer than 6-hours. The patient was relocated within two hours and has had positive outcomes in participating in recreational activities such as jogging and golfing. A six-month follow-up shows the patient is negative for signs of avascular necrosis.

Free Communications, Poster Presentations: Infectious Disease and Allergy

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Community Associated Methicillin Resistant Staphylococcus Aureus (CA-MRSA) Infection Incidence and Management of Suspicious Bacterial Lesions in High Schools and Intercollegiate Athletic Programs

Braun T, Kahanov L: Idaho State University, Pocatello, ID; Misericordia University, Dallas, PA

Context: Despite reductions of Community Associated Methicillin Resistant Staphylococcus Aureus (CA-MRSA) infections in inpatient populations, athletes remain a higher risk population with variable incidence rates. Therefore continually assessing best practices for infectious skin diseases is warranted. The majority of CA-MRSA research among athletes is retrospective indicating an accurate assessment of CA-MRSA infections in athletics is lacking. Although current standards exist for diagnosis, treatment and prevention of skin infections, limited CA-MRSA research on athlete treatment protocols mitigates the ability of clinicians to address allocation of resources and the standard of care. Further identifying the extent and standard of care of CA-MRSA infections, researchers and clinicians may better address adherence to best practices. **Objective:** To prospectively assess CA-MRSA infection incidence, sport risk, referral practices and physician management protocols for suspicious bacterial lesions over the 2016-2017 academic year among athletes. Descriptive epidemiology study. Setting: Intercollegiate and high school athletic programs across the United States. Patients or Other Participants: Two hundred and seventeen Certified Athletic Trainers (ATs) responded to survey request. The ATs provided care for 92,253 student athletes. Interventions: Bimonthly questionnaires consisted of 16 questions within four content areas: (1) demographic sport

information, (2) CA-MRSA infection rate, (3) suspicious bacterial skin lesion infection rate, (4) management of CA-MRSA infections and suspicious bacterial skin lesions. Two experts in the field assessed the questionnaire for content validity. The internal consistency of the selected items is considered acceptable (Cronbach's alpha = .827). Main Outcome Measures: Frequencies, ANOVA, incidence rates and relative risk were calculated to determine differences between settings and sports for CA-MRSA infections. Results: The overall CA-MRSA infection incidence was 20.3 per 10,000 athletes (95% CI, 18 to 23). The incidence and relative risk were significantly higher in wrestling (100.0 per 10,000, 95% CI, 66, 151: RR = 5.46, 95% CI 3.50, 8.49, P < .05) and football (81.8 per 10,000, 95% CI, 68, 99, RR = 8.28, 95% CI, 6.19, 11.06, P < .05) compared to remaining queried athletic population. The majority of the suspicious bacterial lesions requiring referrals (65.1%, n = 262) were to either primary care or general physicians. Athletes received prophylactic antibiotic treatment for CA-MRSA regardless of diagnostic confirmation in 37.4% (n = 72) of the 193 athletes prescription antibiotics. Of the 187 athletes suffering CA-MRSA infections, 27% (n = 51) incurred susceptibility testing, 40% (n = 74) cultures and 21%(n = 39) incision and drainage procedures. Conclusions: Regardless of preventative and best practice recommendations, the incidence of CA-MRSA infections among athletes remains high. Upon referral, many cases of suspicious bacterial lesions are issued prophylactic antibiotics, vet diagnostic and treatment protocols vary from established recommendations. Likewise, the high incidence and variance in referrals necessitate that ATs continue to assess the current standard of care to advocate and ensure optimal outcomes for athletes.

A Case Study Evaluating the Efficacy and Cost-Effectiveness of Two Acute Wound Management Strategies McCann ST, Smith JJ, Baer DJ: West Chester University of Pennsylvania, West Chester, PA

Background: Acute skin trauma is common among athletes participating in all sports. Proper management of acute skin trauma creates an optimal healing environment and reduces complication risk. Clinical decisions and intervention protocols for acute wounds vary among athletic trainers and are often based on ritualistic practices. The National Athletic Trainer's Association Position Statement: Management of Acute Skin Trauma provides recommendations on the proper steps of providing appropriate acute wound management. While the position statement lays out recommendations for the appropriate timeline to change dressings, the physical demands of sport may alter the frequency of applications to maintain proper healing conditions. Because frequent dressing changes can be expensive, best practice wound care strategies may not be feasible for athletic trainers with budgetary restrictions. While research and practice guidelines support using occlusive dressings, some clinicians may benefit from more cost-effective strategies. This Level 1 validation CASE study explores the differences in cost and effectiveness between occlusive and non-occlusive dressings in an athletic population. Patient: Two NCAA Division-II collegiate football athletes at the same institution who suffered superficial skin abrasions on the anterior surface of their knees. Intervention or Treatment: We compared the efficacy and cost-effectiveness of two wound care strategies recommended by the National Athletic Trainer's Association Position Statement: Management of Acute Skin Trauma. Athletic trainers thoroughly cleansed and debrided both

wounds according to the recommended guidelines. We managed one wound using recommended occlusive dressings, and managed the other with acceptable non-occlusive dressings. We managed and monitored athletes daily for wound healing. After healing occurred, we conducted a cost analysis of each method. For the patient managed with the occlusive dressing, healing occurred after 11 days; For the patient managed with the non-occlusive dressing, healing occurred after 7 days. Outcomes or Other Comparisons: No complications occurred during the healing process of either wound. We calculated and compared the cost of one dressing application, day-to-day cost, and total cost for each management strategy. Healing time between the two athletes was comparable. The total cost for occlusive management (\$16.73/dressing) over 11 days was \$100.38 (\$9.13/day). The total cost for non-occlusive management (\$0.91/dressing) over 7 days was \$12.74 (\$1.82/day). Conclusions: We observed no differences in healing between the two athletes in this case study, suggesting that the efficacy of appropriate non-occlusive wound management is comparable to the recommended occlusive wound management. Comparing these two cases, the cost of an occlusive dressing was 5 times greater than the non-occlusive dressing with minimal visible differences in their ability to produce a wound healing environment. Using non-occlusive dressings is a cost-effective method for athletic trainers to properly manage acute skin trauma, especially in settings with a limited budget. Although occlusive dressings are the recommended best practice, our findings suggest that non-occlusive dressings are an effective alternative. Clinical Bottom Line: Non-occlusive dressings are appropriate and cost effective to achieve wound healing in settings where expensive occlusive dressings are not affordable.

Mycobacterium Avium Complex After OATS Procedure of Patella: Level 3 CASE Study Padilla D, Carpentieri S, Matuseski

N: Kean University, Union, NJ

Background: Myobacterium Avium Complex (MAC) is a type of bacterial infection that affects people who have compromised immune systems; MAC can cause life-threatening symptoms such as persistent or cyclic fever, weight loss, sweats/chills, chronic diarrhea, cramping, abdominal pain, unexpected tiredness, lymph node enlargement, and anemia. People who have healthy immune systems may also be infected with MAC; however, the symptoms they experience are not usually life threatening. Patient: A 19-year-old, female Division 3 Volleyball player had an OATS (osteoarticular transfer system, replaces damage cartilage in the knee with healthy cartilage from another area of the joint) preformed on her right patella. Athlete has a history of Ectodermal Dysplasia with T-cell immunodeficiency, a genetic disorder which causes immune system dysregulations and leaves athlete in a chronic immunosuppressive state. Following the procedure, patient had minimal pain and swelling; on day 6 post-op symptoms had worsened, with increased pain and swelling on her knee, low grade fever and general feeling of malaise. On day 21 post-op patient developed coagulase-negative staphylococcus which was treated with antibiotics. Athlete persisted with pain and swelling on her knee, limited motion, and difficulty being compliant with the CPM machine. Intervention or Treatment: Athlete was prescribed antibiotics for MAC. Athlete had three postop washouts (flushing the joint with fluid to expel any loose debris); resulting in less pain and discomfort allowing her to begin formal physical therapy. Six weeks post-op, culture have been negative to date after third washout. Four months post-op athlete had minimal pain over her knee. Five months post-op athlete started to feel pain over her left SI joint. An MRI of her pelvis demonstrated edema within the inferior cartilaginous portion of her left SI joint and multiple small erosions of the joint space. Diagnosis was unilateral sacroiliitis on her left side due to the previous infection on her knee. Athlete was cleared to return to play after a year of her OATS procedure; however, one week after pre-season started athlete started to complain of pain on her SI joint and on her right knee. Physician advised to not use heat at all and take off a week of practice. Throughout the season, pain was managed with ice and stim IFC for the hip and pre-mod in the knee. Outcomes or Other Comparisons: Athlete now is able to practice normal, however, ice and stim for pain management will be utilized for the entire season. Special considerations for some lower body exercise are used due to increased pain. If pain worsened, the athlete would take a week off from activity as well as continue rehab for pain management. In this case, rehab from OATS is very different than on healthy athletes; there's not any use of heat modalities, slowly increase of intensity on exercises, and longer time to return to play (regular rehab time 12-14 weeks) Conclusions: Myobacterium Avium Complex is a very rare type of bacterial infection and with the athlete medical history make the chances of getting it very high. However, since her condition is understood the Athletic Trainers and the coach can take extra precautions on the prevention of injuries and the management of them to prevent the need of surgical intervention to decrease the risk of infection after surgery. Clinical Bottom Line: Many complications could come after a surgical procedure, especially on athletes with immune system deficit. However, as Athletic Trainers we have to be extra cautious on injury prevention and be as conservative as possible on the treatment of injuries to prevent these athletes to go under a surgical procedure.

Return to Play Following Typhoid Fever in a Collegiate Tennis Player: A Case Report

Mesman D, Warner BJ, Wade M, Stonestreet C, Cage SA: Grand Canyon University, Phoenix, AZ; The University of North Carolina, Greensboro, NC; Christus Trinity Mother Frances, Tyler, TX; The University of Texas, Tyler, TX

Background: A 20-year-old female collegiate tennis player underwent pre-participation physical examinations and reported that she had contracted typhoid fever the previous month. The patient contracted the illness while in Peru on a mission trip, and was diagnosed upon return to her home country at which point she was treated with intravenous antibiotics. At the time of pre-participation physical examinations, the patient still reported symptoms including: fatigue, difficulty sleeping, and loss of appetite. Furthermore, the patient had lost 15 pounds since contracting typhoid fever. Differential Diagnosis: Previously diagnosed and treated typhoid fever. Treatment: Upon consultation with the team physician and the team strength and conditioning coach, plans were put in place to begin a gradual return to play protocol once the patient's symptoms had fully subsided. During this time, it was determined that the One Mile Step Test would be used to assess the patient's fitness levels throughout her return to play progression. Two weeks following pre-participation physical examination, the patient was sleeping through the night and tolerating food well, leading to clearance for her to begin her return to play protocol. In the first phase of return to activity, the patient began with prolonged periods of walking with progression based off of patient tolerance. By the end of the first week, the patient was able to stationary bike and perform light weight lifting. As the patient began to progress, light sport specific activities were incorporated along with light jogging. At this time, the patient's time on the One Mile Step Test was used once a week to assess cardiovascular activity. The patient's first One Mile Step Test was time at 15:27, which fell into the "fair" category of the test. After six weeks, the patient's time on the One Mile Step Test reached the "good" category with a time of 14:00, allowing the athletic training staff to increase the intensity of the patient's training. Two weeks after increasing exercise intensity, patient was cleared by the team physician to resume team conditioning and practices. Following clearance, the patient had no further issues related to typhoid fever and was able to participate fully in her team's competitive season. While the patient did not reach her pre-illness weight until the following fall, she reported no adverse effects from the loss in body mass. Uniqueness: Typhoid fever is a condition typically found in developing countries, but is a very uncommon diagnosis in developed countries. In this case, the patient's travel to a foreign country and working in an underdeveloped community placed her in an environment where she was at risk for contracting typhoid fever. To the best of the author's knowledge, there are no other cases that describe a patient's return to competitive activity following recovery from typhoid fever. Conclusions: It is important that health care practitioners have a reliable referral system in place. Although aspects of this system may be rarely used, their availability may prove critical in the recovery of a patient suffering from an uncommon condition. When treating a patient with an uncommon condition, evaluation and re-evaluation of return to play protocols and progressions is paramount.

Alpha-Gal Allergy After Chigger Bite

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Background: A chigger or a trombiculid mite, bit a 31-year-old male strength and conditioning coach in April when the patient was clearing his yard of tall grass. The site of the bite developed into itchy, reddish bumps with a dark center. The patient then began to develop continual topical allergic reactions. This occurred 19 times and the symptoms included: hives, an intense itching and burning sensation thought-out the body, as well as swollen hands and feet. In addition to the hives, the patient would immediately get an upset stomach to the point of vomiting and/or loose stool. As the reactions continued, the patient's blood pressure dropped and the patient felt extremely fatigued, dizzy and anxious. These allergic and anaphylactic reactions continued throughout the summer. Differential Diagnosis: Anaphylaxis, Chronic Urticaria, Angioedema Treatment: After being referred to an allergist, a panel of bloodwork was performed which included the alpha-gal antibody test. Based on his IgE anti-alpha-gal antibodies levels found in his blood, he was diagnosed with Alpha-Gal. Galactose-alpha-1 and 3-galactose is not normally found in humans, so when greater than 0.35 kU/L it is considered a positive test. Alpha Gal is treated by avoiding foods that contain mammalian meat. The patient remains on a strict vegetarian diet for life. On two separate occasions following diagnosis the patient inadvertently ate a vegetarian burrito prepared on the same grill as bacon. An anaphylaxis reaction consisting of shortness of breath and facial swelling took place exactly 6 hours after ingestion. When the patient underwent anaphylaxis an EpiPen was administered in order to combat the allergic reaction before being transported to the hospital. Uniqueness: Alpha Gal is an allergy to the alpha galactose 3,6 enzyme contained in most mammals. The allergic reaction occurs after ingesting mammalian food products. This disorder is more common in the southeast region of the United States because of the volume of ticks. The Centers for Disease Control does not log cases of alpha gal allergy syndrome therefore the number of diagnosed patients is unknown; however, the number of reported cases is rapidly growing since first reported in 2006. Most cases of Alpha Gal have been linked to being bitten by the lone star tick however in this patient a chigger caused the allergy. Another unique characteristic to this disorder is the delayed onset of symptoms. The anaphylaxis and allergic reaction does not occur until six hours after ingesting meat, which is why it is so hard to diagnose this disorder. Most anaphylaxis occurs immediately after the ingestion of the allergen, but Alpha-Gal is considered a carbohydrate that is not normally found in humans therefore the time required to break this enzyme down is lengthier. Conclusions: While this case is unique, it's important for athletic trainers to recognize the signs and symptoms of alpha-gal allergy. This is a life-threatening allergy with severe reactions that will not be avoided unless the ingestion of meat is avoided. Ticks and chiggers are seen in in tall grass areas such as near athletic fields or throughout a cross country race course. It is important to educate the patients about the severity of this disorder because of how minimal the mammalian product ingested has to be to cause a reaction. Athletic trainers must be aware of possible cross contamination during food preparation and athletic trainers must be able to refer when their condition is not improving or the exact cause of reaction is unknown.

Hand, Foot, and Mouth Disease: A Case Series

Haddad G, Johnson P, Phillips K, Williams J, Granito D: University of Michigan, Ann Arbor, MI

Background: 13 members of an intercollegiate football program (ages 18-22 years old) presented with cases of hand, foot, and mouth disease (HFMD) within a 24-day period. All 13 athletes initially reported symptoms within the two day contagious incubation period that included fever, pharyngitis, malaise, and lack of appetite. Distinctive erythematous papulovesicular lesions developed on the hands, feet, and/or intraoral surfaces 24 to 48 hours following fever onset. In more severe cases the lesions spread to cover the torso, buttocks, and genitals. Oral lesions are reportedly painful and itchy. Cutaneous lesions are itchy and carry a pus-like fluid, eventually bursting and crusting during maturation of the infection. Differential Diagnosis: The initial onset of non-specific symptoms are commonly reported amongst college athletes during most general illnesses. Initial evaluation lead to considerations of strep throat, cold, mononucleosis, and influenza. The presentation of the distinct erythematous papulovesciular lesions 2 days following initial evaluation made the diagnosis of hand foot and mouth definitive. Treatment: No lab tests were conducted for coxsackievirus or enterovirus. The development and specific location of lesions led to a confident diagnosis in all cases. All 13 athletes were educated on the progression of the disease and were isolated. Athletes were instructed to send daily pictures of lesions for the purpose of monitoring progression. Intravenous fluids were administered in select cases to maintain adequate hydration levels and reduce initial symptoms. Sport participation resumed once no new lesions developed, athlete was afebrile, and the existing lesions had crusted. The crusted lesions were covered during sport activity. Uniqueness: HFMD in immunocompetent adults is rare based on

the high incidence rate of the infection during childhood. The high volume of diagnosed cases in a short time frame makes this case unique in considering the rate of transmission, methods of transmission, and preventative measures carried out to inhibit further transmission of the virus. Conclusions: HFMD is a highly infectious, communicable, viral disease commonly observed in infants and children younger than five years old. The Enterovirus 71 and/or Coxsackievirus A6 are the common vectors in the spread of HFMD. 10.8 percent of an intercollegiate football roster contracted HFMD within a 24 day period. Average time away from sport participation and team activities was 5.38 days. The close quarters and high prevalence of human contact that exist in the sport of football, its facilities, and on a college campus may have led to increased levels of transmission. Appreciating the disease's potential and recognizing its definitive characteristics will assist athletic trainers in minimizing transmission within their facilities and teams.

Free Communications, Poster Presentations: Knee and Hip

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Measurement Reliability of Anterior Translation of the Knee Using a Digitally Instrumented Arthrometer

Kovaleski JE, Gurchiek LR, Barnard BJ, Schwarz NA: University of South Alabama, Mobile, AL

Context: Measurement reliability is important when new sports-medicine devices or techniques are developed. To assess anteroposterior knee joint motion and laxity, the Blue Bay Knee Arthrometer, equipped with an electronic interface, reproduces the measurement capability of the KT-1000 and KT-2000 devices. Objective and reliable assessment data of normal anterior knee translation is critical before comparison with an injured ACL knee can be made. **Objective:** To determine the reliability of anterior translation measurements obtained from an instrumented knee arthrometer. Design: Intratester reliability was examined using a test-retest design Setting: Research laboratory. Patients or Other Participants: Both knees of 20 participants (22.5 \pm 2.6 years; 81.6 ± 24.3 kg; 173.1 ± 12.4 cm) with no history of ACL injury. Interventions: Testing was conducted using the Blue Bay Knee Arthrometer (Blue Bay Medical, Inc., Navarre FL) that detects motion between two sensor pads, one in contact with the patella and the other in contact with the tibia. With the subject lying supine, the examiner used a thigh support to position both knees in 25 degrees of flexion with feet secured in a support. The examiner applied an anterior load and an audible "beep" sounded when a 67-N (15-lb.) and 89-N (20-lb.) force was produced. A manual maximum test was also performed and measured total anterior displacement. The touchscreen electronic interface allowed the examiner to visualize and record the applied loads and resultant translations. The test-retest procedure involved the examiner positioning the arthrometer, measuring and recording anterior translation, removing the instrument, and repeating the measurements. Three measurements were recorded for each trial and the greatest amount of translation achieved was used in the statistical analysis. Main Outcome Measures: Intraclass correlation coefficients (ICC 2,1) determined intratester reliability for the instrumented measurement of anterior translation (millimeters) at 67-N, 89-N, and manual maximum. The standard error of measurement (SEM) was calculated as an estimate of measurement precision. Results: Excellent ICCs for intratester reliability were found: 67-N load: ICC = .933 (95% CI, .877-.964); Trial $1 = 4.88 \pm 2.0$ mm, Trial $2 = 4.87 \pm$ 1.9 mm (95% CI, 4.43-5.31 mm); 89-N load: ICC = .935 (95% CI, .880-.965); Trial $1 = 6.16 \pm 2.2$ mm, Trial 2 = 6.20± 2.2 mm (95% CI, 5.69-6.67 mm); Manual Maximum: ICC = .922 (95% CI. .858-.958). Trial $1 = 8.04 \pm 2.0$ mm. Trial $2 = 8.13 \pm 1.77$ mm (95% CI, 7.77-8.50 mm). The SEMs indicated high precision of anterior knee translation measurement (range: .369 to.407 mm). Conclusions: The results are clinically useful in providing information about reliability and objective measures at different force loads for reproducible anterior knee translation measurement using the Blue Bay Knee Arthrometer.

Biomechanical Characteristics of the Ankle and Knee in Females With and Without Patellofemoral Pain During a Drop Vertical Jump Duffy R, Baellow A, Hertel J, Saliba S: University of Virginia, Charlottesville, VA

Context: Patellofemoral pain (PFP) is one of the most prevalent knee pathologies among active people. Those suffering from PFP typically present with pain during various daily activities such as running, stair ambulation, squatting, jumping, and sitting. Recent literature has suggested that those with PFP may display altered distal biomechanics at the foot and ankle while completing functional tasks. Although many studies have been conducted to examine the hip and knee joint biomechanics in a PFP pathological population during functional tasks, few studies have examined biomechanics at the ankle between a PFP pathological and healthy sample during a jumping task. **Objective:** To determine how ankle and knee strength, range of motion (ROM), kinematics and kinetics differ between females suffering from PFP and healthy controls during a drop vertical jump (DVJ). Design: Cross-Sectional. Setting: Laboratory. Patients or Other Participants: 26 physically active college-aged females, 13 healthy (69.1 ± 4.7 kg, 170.3 ± 9.5 cm, 20.2 ± 1.4 yrs) and 13 PFP (66.5 \pm 6.4 kg, 166.7 \pm 14.3 cm, 21.2 ± 2.0 yrs) participated in this study. Interventions: Ankle and knee strength and ROM. 3 trials of a DVJ assessed with a three-dimensional motion analysis system, interfaced with a 12-camera Vicon Nexus system. Ground reaction forces were measured with force plates that were embedded into a treadmill. Main Outcome Measures: Subjective worst pain in the past 24-hours measured by the 10-point Visual Analog Scale (VAS) and the Anterior Knee Pain Scale (AKPS), subjective function measured by the Activities of Daily Living

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Scale (ADLS), active knee and ankle ROM and maximum voluntary isometric contractions as a measure of strength (knee flexion and extension, ankle dorsiflexion, plantarflexion, eversion, and inversion) and kinematics and kinetics during a DVJ. Kinematics were measures in all three planes as the difference between peak kinematics at quiet standing and during the DVJ. Internal joint moments normalized to participant's body mass (kg) were used to calculate kinetics. **Results:** The PFP group had significantly more pain on the VAS (Healthy: 0 ± 0 , PFP: 2.2 ± 2 , p = 0.001) and AKPS (Healthy: 100 ± 0 , PFP: 75.8 \pm 6.5, p < 0.001) and less function on the ADLS (Healthy: 99.8 ± 0.8 , PFP: 78.9 ± 9.5 , p < 0.001) than the healthy control group. The PFP group had significantly more active ankle dorsiflexion (Healthy: $12.5 \pm 5.0^{\circ}$, PFP: $18.2 \pm$ 7.1°, p = 0.027). There were no significant findings between the two groups in strength or kinematics and kinetics during the DVJ. Conclusions: Subjects with PFP displayed significantly more ankle dorsiflexion than healthy controls. No differences were found between the two groups in strength, kinematics, or kinetics. Further research is needed to determine an association between ankle ROM during functional tasks in those with PFP to open new treatment avenues and improve outcomes for those suffering from PFP.

Comparison of Clinician Assisted Versus Unassisted PNF Stretching on Hamstring Flexibility, Isometric Force Output, and Maximum Vertical Jump Height Lockhart JT, Begalle RL, Selkow NM, Williams S: Illinois State

NM, Williams S: Illinois State University, Normal, IL; Daemen College, Amherst, NY

Context: Proprioceptive neuromuscular facilitation (PNF) is an effective tool to improve hamstring flexibility, but requires a trained partner or clinician to perform. It is unknown if PNF stretching without a clinician's assistance would have the same effects on flexibility and athletic performance. **Objective:** To determine the effects of clinician assisted versus unassisted contract-relax PNF stretching on hamstring flexibility, hamstring maximum voluntary isometric contraction (MVIC), and maximum vertical jump height. We hypothesized the unassisted protocol would induce similar changes as the assisted protocol, but greater changes in comparison to control group. Design: Randomized controlled trial. Setting: Athletic training clinic. Patients or Other Participants: Twenty-six physically active male and female college students $(age = 20.12 \pm 2.91 \text{ yrs}, height = 172.69)$ ± 6.72 cm, mass = 70.50 ± 14.05 kg) with restricted hamstring flexibility (<90° passive straight leg raise) participated in this study. All participants were free of injury at the time of testing. Interventions: Subjects were randomly allocated to one of three groups; clinician assisted, unassisted, or control group. The control group completed pre- and post- test measures only. The intervention groups completed a 6-week stretching intervention (12-total sessions) either with clinician assistance or utilizing a stretching strap (unassisted). Pre- and post- intervention measurements were recorded for all outcome measures. The dominant kicking limb was used for unilateral assessments. Main Outcome Measures: Hamstring flexibility was assessed via hip flexion angle during a passive straight leg raise. Peak hamstring MVIC's were assessed during knee

flexion using a handheld dynamometer and normalized to each subject's body mass. Maximum vertical jump height was measured using a Vertec. Three trials were recorded for each outcome measure and the arithmetic mean was used to calculate change scores (Post – Pre). Change scores were utilized for data analysis. Separate one-way ANOVA's were performed to identify differences between groups followed by post-hoc testing when appropriate. Results: Groups were similar on all pre-test measures. We observed a significant group difference in hip flexion ROM change ($F_{(2, 25)} = 9.853$, p = 0.001). Post-hoc comparisons found both the Unassisted (+10.26° \pm 6.03, p = 0.002) and Assisted (+10.27° \pm 3.81, p = 0.004) PNF intervention groups had a greater improvement in ROM compared to the Control group (-0.41° \pm 7.00). No significant changes were observed for hamstring MVIC ($F_{(2, 25)} = 2.542$, p = 0.101) and vertical jump height ($F_{(2, 25)}$ = 0.133, p = 0.877). <u>Conclusions:</u> The Assisted and Unassisted PNF stretching techniques successfully improved hamstring flexibility. Performance measures were not impacted by the stretching intervention. Teaching a patient to perform the contract-relax PNF stretching technique to target hamstring flexibility can be as effective as clinician assistance. These results may provide time saving benefits to clinicians while promoting improved flexibility and independence in patients.

Estimating Eccentric Knee-Flexor Strength From Body Mass Among Female Athletes

Sanfilippo JL, Heiderscheit BC: University of Wisconsin, Madison, WI

Context: Decreased eccentric knee-flexor strength (ECC-KF) has been shown to increase the risk for hamstring injury. An estimate of ECC-KF strength has been defined for males based on body mass (BM); however, the sample did not included female athletes. As such, no estimate of ECC-KF exists for females despite having a similar risk of incurring a hamstring strain injury when participating in a sport that involves high-speed running. **Objective:** Determine the relationship between BM, height, and ECC-KF in NCAA Division 1 collegiate female athletes from various sports. Design: Cross-Sectional Setting: Division 1 Collegiate Athletics Patients or Other Participants: The study included 41 healthy female Division 1 collegiate athletes [average BM 67.7kg ± 8.0 (range, 57.0-86.6); average height 172.0cm ± 6.6 (range 156.2– 188.0)] across 3 sports (basketball, soccer, and sprinters). Interventions: Three maximal repetitions of bilateral Nordic hamstring curls were performed, with the repetition of greatest force used in subsequent analyses. Predicted ECC-KF was calculated using a previously published male-specific model (ECC-KF (N) =4 * BM (kg) + 26.1). Main Outcome Measures: Measured and predicted ECC-KF were compared using a paired t-test. A female-specific estimate of ECC-KF was then defined using a backwards stepwise linear regression considering BM and height. Results: Using the previously reported model derived from males, no difference was detected in strength between the predicted (297.3 \pm 32.1N) and measured ECC-KF (289.1 \pm 60.6N; P = .334). The female-specific model for estimated ECC-KF strength included BM only as height was not a significant factor. The resulting female-specific model was ECC-KF (N) = 3.6*BM (kg) + 47.4, and explained 20.3% of the variance in measured ECC-KF. Conclusions: A model to

estimate ECC-KF derived from male soccer athletes appears to be generalizable to female athletes from a variety of sports. Nearly 60% of the female athletes from the current study played collegiate soccer which may partially explain the model similarity. Further research should be conducted to assess the need for gender specific models; however, in this dataset the models produced fairly similar results.

Estimating Eccentric Knee-Flexor Strength From Body Mass and Height in a Varied Athletic Population

Gibson KM, Sanfilippo JL, Thomas GM, Heiderscheit BC: University of Wisconsin, Madison, WI

Context: Hamstring strain injuries are prevalent across running sports as the hamstring muscles perform considerable negative work during terminal swing phase of high speed running. While decreased eccentric knee-flexor strength (ECC-KF) has been shown to increase the risk for hamstring injury, it is not clear what an individual's expected ECC-KF level should be. An estimate of ECC-KF strength has been defined based on body mass (BM); however, the sample included athletes from a single sport with a limited range of body sizes. Objective: Determine if a previously suggested relationship between BM and ECC-KF extends to NCAA Division 1 collegiate male athletes from various sports, and if the addition of height improves the relationship. Design: Cross-sectional Setting: Division 1 Collegiate Athletics Patients or Other Participants: This study included 94 healthy male athletes [average BM 97.7 kg \pm 21.6 (range, 60.7-157.9); average height 186.1 cm \pm 7.8 (range 167.6-210.8)] across 4 sports (basketball, American football, soccer, and sprinters). Interventions: Three maximal repetitions of bilateral Nordic hamstring curls were performed with the repetition of greatest force used in subsequent analyses. Predicted ECC-KF was calculated using a previously published model (ECC-KF (N) =4 * BM (kg) + 26.1). Main Outcome Measures: Measured and predicted ECC-KF were compared using a paired t-test. A backward stepwise linear regression was performed to determine if ECC-KF can be better predicted using BM and height. Results: No difference was detected in the measured $(415.3 \pm 104.0 \text{ N})$ and predicted (417.0 \pm 86.5 N) mean ECC-KF across sports (p = 0.868). When including only BM in the regression 23.7% of the variance

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in ECC-KF was explained, whereas the combination of BM and height explained 29.5% of the variance, resulting in a final model of ECC-KF (N) = 3.5*BM (kg) – 4.6 * Height (cm) + 935.4. Conclusions: Previous estimation of ECC-KF from a single sport sample can be generalized to athletes from other sports. The athletes from the current study had considerably larger BM than those used in the previously reported analysis and included 4 sports. Estimating ECC-KF in a diverse athletic population can be improved by combining BM and height, thereby better identifying those at risk for hamstring strain injury.

Impairment-Based Rehabilitation With Patterned Electrical Neuromuscular Stimulation Improves Lower Extremity Function in Individuals With Patellofemoral Pain Glaviano NR, Marshall AN, Mangum LC, Hart JM, Hertel J, Russel S, Saliba SA: University of Virginia, Charlottesville, VA; University of Toledo, Toledo, OH; A.T. Still University, Mesa, AZ

Context: Patellofemoral pain (PFP) is a chronic condition that presents with subjective functional limitations, lower extremity muscle weakness, and decreased physical activity. Patterned electrical neuromuscular stimulation (PENS) has been shown to affect muscle activation and pain following a single treatment, but its use has not been studied in a rehabilitation trial. Objective: Determine immediate and long-term influence of a 4-week impairment based rehabilitation program with PENS or without PENS on subjective function, lower extremity strength, and physical activity in individuals with PFP. Design: Double-blinded randomized controlled trial. Setting: Laboratory. Patients or Other Participants: Twenty-one patients with PFP (Sex: M = 5, F = 16, Age: 23.4 \pm 7.6 years, Mass: 69.0 ± 19.5 kg, Height: 168.0 ± 7.5 cm). Interventions: Participants completed a 4-week supervised rehabilitation program in conjunction with random assignment to PENS or sham treatments. Main Outcome Measures: Subjective function was assessed using the Anterior Knee Pain Scale (AKPS), Activities of Daily Living Scale (ADLS) and Visual Analog Scale for current pain (C-VAS). Knee extension, hip abduction, and hip external rotation was assessed using a hand-held dynamometer during maximal voluntary isometric contractions. Physical activity was assessed with steps per day, recorded by FitBit HR. Subjective function, strength, and physical activity were assessed pre- and post-intervention. Subjective function was assessed

6-months and 1-year post-intervention via the AKPS and C-VAS. Repeated measures ANOVA with Tukey's post hoc testing was conducted with a significance level of $p \le 0.05$. Cohen's d effect sizes with 95% confidence intervals were calculated. Results: There were no significant group by time interactions for any dependent variables between pre- and post-intervention. There were significant time main effects for all measures when combining group data, suggesting that the use of an impairment based interventions was effective at improving subjective function (AKPS (Pre: 76.3 \pm 7.5, Post: 87.1 \pm 7.7, p < 0.001), ADLS (Pre: 79.3 ± 10.0 , Post: 88.0 ± 5.5 , p = 0.001), and C-VAS (Pre: 1.3 ± 1.5 , Post: 0.62 ± 0.64 , p = (0.03)), lower extremity strength (knee extension (Pre: 3.9 ± 1.5 N/kg, Post: 4.9 ± 2.9 N/kg, p = 0.06), hip abduction (Pre: 2.9 ± 0.8 N/kg, Post: 4.5 ± 2.5 N/ kg, p = 0.006), and hip external rotation (Pre: 1.5 ± 0.4 N/kg, Post: 3.2 ± 3.5 N/ kg, p = 0.03), and physical activity (Pre: $8,815.5 \pm 1,905.3$, Post: 9,861.1 \pm 2,987.8, p = 0.04). Clinically important improvements in C-VAS were seen in the PENS group (Baseline: 1.35 ± 0.69, Post: 0.53 ± 0.66 , p = .018, d = 1.21 [0.26, 2.17]), at 6-months (0.49 \pm 0.47, p = 0.005, d = 1.46 [0.47, 2.44])and 12-months $(0.59 \pm 0.66, p = .017, d)$ = 1.13 [0.18, 2.07]). Those in the sham group did not have statistical improvements in C-VAS at either 6-months or 1-year. Conclusions: The use of an impairment-based intervention was effective at improving subjective function, strength, and physical activity levels in individuals with PFP. Those who received PENS had improved C-VAS at 6- and 12-month following the conclusion of the rehabilitation program compared to their baseline scores. The addition of PENS with an impairment based rehabilitation program may provide long-term benefits for patients with PFP.

Relationships Between Triple Extensor Explosive Strength and Horizontal Jump Performance Huang YL, Johnson ST, Norcross

MF: Oregon State University, Corvallis, OR

Context: While significant relationships between knee (KE) and ankle (AE) extensor rate of torque development (RTD) and vertical jump height have been identified, hip extensor (HE) RTD has not been associated with vertical jump performance. Though it was proposed that this might be due to the HE having a greater influence on horizontal versus vertical movements, this notion has not been evaluated. **Objective:** To assess the relationships between triple extensor RTD and maximal horizontal jump (HJ) distance. Design: Crosssectional. Setting: Research laboratory. Patients or Other Participants: Forty healthy, physically active volunteers (20 Males, 20 Females, Age: 22.7 ± 3.3 years, Height: 1.72 ± 0.10 m, Mass: 73.7 ± 16.9 kg). Interventions:

Isometric HE, KE, and AE torque-time curves of the dominant limb were recorded using a Biodex System3 dynamometer. Participants contracted as hard and fast as possible for 3-5 seconds against the dynamometer arm following a light stimulus. Three valid trials with 60 seconds rest between trials were collected. Participants also completed three HJ with arms akimbo for maximal distance. Main Outcome Measures: RTD was calculated as the slope of the line of best fit of the torquetime curve from torque onset (2.5% of peak torque) to 50 (RTD50) and 200 (RTD200) ms, respectively, following onset. For each participant, RTD outcome measures were taken from the trial for each joint that exhibited the greatest RTD as determined using a 10 ms sliding window and normalized using an allometric function (x Body Mass^(0.67)). Maximal HJ distance was measured in cm. Relationships between RTD of the triple extensors during each time interval and HJ were assessed using separate, Pearson correlation coefficients ($\alpha \le 0.05$). **Results:** Mean values

for RTD (Nm·s⁻¹[kg^{0.67}]⁻¹) were: HE50 $= 28.3 \pm 15.5$, HE200 $= 35.3 \pm 13.8$, $KE50 = 26.0 \pm 15.3$, $KE200 = 27.9 \pm$ 10.8, AE50 = 15.0 ± 7.5 , and AE200 = 17.6 ± 7.3 . Results of the correlational analyses are presented in the Table. KE and AE RTD during both time intervals, but only HE RTD from 0-200 ms were significantly correlated with HJ. Conclusions: HE, KE, and AE RTD200 explained 16-20% of the variance in HJ. However, while slightly more variance in HJ was explained by AE50 (22%) and KE50 (26%), HE50 was not significantly related to HJ distance. These results suggest that unlike a maximal vertical jump, greater explosive strength of the HE as well as the KE and AE is important for improved HJ performance. However, the lack of relationship between early-phase HE explosive strength (e.g., RTD50) and jump performance suggests differences in the underlying explosive strength capacity of the HE muscle group- perhaps due to the gluteus maximus' dual role as a hip extensor and trunk stabilizer.

Table. Pearson Correlation (r) coefficients between horizontal jump distance and hip, knee, and ankle extensor rate of torque development during the initial 50 (RTD50) and 200 (RTD200) milliseconds after torque onset.

	RTD50	RTD200
Hip Extensor	0.283 (p=0.077)	0.406 (p=0.009)
Knee Extensor	0.512 (p=0.001)	0.442 (p=.004)
Ankle Extensor	0.473 (p=0.002)	0.422 (p=0.007)

Protein-S Deficiency Diagnosed Post-ACL Injury in a Collegiate Track and Field Athlete

Lewis MD, Weaver TA, King ST: Messiah College, Mechanicsburg, PA; OSS Health, York, PA

19-year Chinese-**Background:** old American track and field athlete presented to certified athletic trainer (AT) in March 2016 with antalgic gait related to pain and edema in left calf two weeks post-injury to the ACL. Initial injury occurred during pole vault. Evaluation of knee by AT occurred on the day of injury and referral to team physician took place within three days. MRI confirmed complete tear of ACL. Two weeks post-injury, he was tender to palpation and Homan's sign was positive in left calf. Athlete reported onset of symptoms within past three days and complained of intermittent shortness of breath with ADL. Prior to start of season athlete received clearance for full physical activity and was not aware of personal or family history related to clotting conditions or venous disorders. No previous surgeries reported. Differential Diagnosis: DVT, superficial thrombophlebitis, gastrocnemius strain, or ruptured popliteal cyst. Primary injury to ACL due to awkward landing during pole vault. This was likely mechanism of injury responsible for symptoms in left calf. Initial exam of calf revealed pain, edema, antalgic gait and reduced function of the knee and ankle. Homan's sign was positive and athlete reported tenderness with palpation of the gastrocnemius when conducted in isolation and conjunction with Homan's sign. That same day, team physician referred athlete for diagnostic ultrasound (US) of the calf to rule out a DVT. Treatment: Initial US was negative. Persistent symptoms led to second US one week later. This test was positive for a DVT and athlete received a Lovenox injection and Warfarin prescription. Symptoms persisted and athlete returned to emergency department three days later due to onset of increased shortness of breath with ADL. Additional US confirmed DVT and chest CT with contrast revealed multiple pulmonary emboli. Results led to hospital admission. Athlete remained five days for treatment. Warfarin administered for two weeks prior to course of Pradaxa for six months. ACL repair delayed until December 2016. Over this period, three follow-up US of the calf indicated continued clot reduction. Pradaxa discontinued prior to surgery and ACL repaired December 2016. Athlete began course of Xarelto post-operatively as clot preventative. Swelling and tenderness in calf returned one week after surgery. Athlete underwent immediate diagnostic US and was diagnosed with multiple DVT and subsequently hospitalized one week. On-giong pharmacological treatment has included both Lovenox injections and oral Xarelto. At January 2017 hematology apointment, low levels of protein-S in blood sample resulted in diagnosis of protein-S deficiency. Presence of this condition obscured by high levels of blood thinners in previous tests. Against physician's prescription, athlete had been taking medication only intermittently leading up to final test. Uniqueness: Protein-S acts to regulate chemical reactions in blood to prevent disproportionate clotting. Limited data suggest deficiency occurs in roughly 0.03-0.13% of Caucasian population, 1-2% of Japanese population, and similarly increased occurrence rates in Chinese population. The ACL injury and subsequent repair served as two traumatic events, triggering the DVT and PE. Presence of blood thinners may have initially prevented correct diagnosis. Conclusions: Asian, male, collegiate athlete had undiagnosed protein-S deficiency which resulted in clot formation secondary to ACL injury. Condition continued undiagnosed until second DVT occurred post-ACL repair. This is often hereditary, but may occur secondary to vitamin K deficiency or liver disease. Athlete continues rehabilitation with AT status-post ACL repair. No activity restrictions at this time. Athletic trainers should be aware of signs and symptoms of DVT and PE and advocate for additional diagnostics in the best interest of their patient if situation warrants. Clearance for athletic participation does not guarantee absence of medical conditions that may result in life-threatening situations.

Subjective Mental and Physical Health and Physical Activity Level is Lower in Individuals With Patellofemoral Pain Baellow A, Glaviano NR, Jaffri A, Saliba S: University of Virginia, Charlottesville, VA

Context: Patellofemoral pain (PFP) is a common source of knee pain in active individuals, accounting for 25-40% of all knee injuries examined in a sports medicine clinic. Less than 30% of those with PFP are pain-free following intervention, and only 6% are symptom-free at the 16-year follow up. PFP is a chronic condition, which results in not only long-term physical impairments, but subjective impairments as well. It is unknown the extent of the relationship between physical activity level impairment and subjective global health impairment in individuals with and without PFP. Objective: To determine how subjective physical and mental health and physical activity levels differ between individuals suffering from PFP and healthy females. Design: Casecontrol. Setting: Laboratory. Patients or Other Participants: 20 healthy - 15 females, 5 males $(69.91 \pm 10.91 \text{ kg}, 171.76 \text{ kg})$ \pm 8.15 cm, 20.65 \pm 1.79 yrs) and 20 PFP pathological - 15 females, 5 males (69.39 \pm 15.41 kg, 168.19 \pm 7.65 m, 23.55 \pm 4.71 yrs) physically active individuals volunteered for this study. Interventions: Physical activity was assessed by steps per day over 14 consecutive days with a FitBit Charge HR. A 12-Item Short-Form Health Survey (SF-12) was also collected. 8 subscales from the SF-12 are weighted and calculated; physical function (PF), role physical (RP), bodily function (BF), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (ME). PF, RP, BF, and GH combine to assess subjective physical health (PCS), and VT, SF, RE, and ME combine to assess subjective mental health (MCS). Main Outcome Measures: Independent t-tests were used to compare variables between groups. A simple linear regression analysis was run

to estimate the amount of variance in physical activity described by PCS and MCS. Results: Individuals with PFP took significantly fewer steps per day (Healthy: $13,169 \pm 1,000$; PFP: $8,636 \pm$ 2,027, p < 0.001) than healthy individuals. PFP individuals scored significantly higher on PF (Healthy: 100 ± 0 , PFP: 80 \pm 20.83, p < 0.001), RP (Healthy: 100.0 \pm 0.0, PFP: 90.63 \pm 9.83, p < 0.001), BP (Healthy: 100.0 ± 0.0 , PFP: 78.75 \pm 18.63, p < 0.001), GH (Healthy: 91.0 \pm 7.54, PFP: 82.5 \pm 14.74, p = 0.029), SF (100.0 ± 0.0, PFP: 90.0 ± 7.53, *p* < 0.017) and RE (Healthy: $100.0 \pm .00$, PFP: 96.88 \pm 5.55, p < 0.021). 68% of the variability was explained by both PCS and MCS in the number of steps taken by the participants. Conclusions: Individuals with PFP are less physically active than their healthy counterparts in average steps per day and are less subjectively physically and mentally healthy than their healthy counterparts. A strong relationship between subjective physical and mental health and physical activity exists in individuals with PFP. Mental and physical health statuses are strong determinants of physical activity of the PFP participants. Clinicians should assess SF-12 results in PFP pathological individuals as a quick and simple measure of subjective physical and mental health, and a strong indicator for true physical health.

Lower Extremity Landing Kinematics Differ Across Maturation Stages in Youth Soccer Athletes

Sullivan BS, Trigsted SM, Crisafulli GA, Zuk EF, Boling MC, Ford KR, Taylor JB, DiStefano LJ, Nguyen A: High Point University, High Point, NC; University of Connecticut, Storrs, CT; University of North Florida, Jacksonville, FL

Context: Knee injuries in youth athletes continue to rise in conjunction with increased participation in organized sports at early ages. While evidence supports changes in lower extremity neuromuscular control throughout puberty, limited research has examined the movement patterns of youth athletes prior to the onset of puberty. Prevention programs have been shown to reduce the risk of knee injuries, however, understanding the differences in movement strategies in youth athletes as they progress through stages of maturation is needed to identify the most appropriate time to implement prevention programs. **Objective:** To examine differences in lower extremity landing kinematics between maturation groups during a double-leg landing in youth soccer athletes. Design: Descriptive study. Setting: Field setting. Patients or Other Participants: One hundred and two youth soccer athletes (50M, 52F: 11.3 ± 1.7 yrs, $40.4 \pm$ $10.8 \text{ kg}, 146.3 \pm 16.0 \text{ cm}$) participated. Interventions: Three-dimensional kinematics of the left limb were assessed using an electromagnetic motion analysis system during a bilateral jump landing (JL) task from a 30cm box, set 50% of the participants' height from a force plate. The Pubertal Maturational Observational Scale (PMOS) was used to classify participants into pre-pubertal (PRE), pubertal (PUB), and post-pubertal (POST) maturation groups. Main **Outcome Measures:** The average sagittal, frontal, and transverse plane hip and knee angles at initial contact (IC = vGRF > 10N) and peak angles during the deceleration phase (IC to max knee flexion) of the JL task were

used for analyses. Participants were categorized into PRE (N = 48, PMOS < 2), PUB (N = 36, PMOS = 2-5), and POST (N = 18, PMOS > 5) maturation groups. One-way ANOVAs, with three between-subject factors (maturation group: PRE, PUB, POST) were used to determine differences in lower extremity kinematics during the JL task. Post-hoc LSD comparisons were performed when appropriate. Results: Significant differences were observed between maturation groups for knee flexion (P = 0.045) and knee valgus at IC (P = 0.016), and peak knee flexion (P = 0.012) and peak hip flexion (P = 0.018) during the deceleration phase. Specifically, PRE landed with less knee flexion (mean difference = 4.6°, P = 0.018) and greater knee valgus (mean difference = 5.0° , P = 0.005) at IC, and less peak knee flexion (mean difference = 13.1° , P = 0.003) and hip flexion (mean difference = 10.8° , P = 0.023) during the deceleration phase compared to POST. No other landing kinematics differed between maturation groups (P > 0.05). <u>Conclusions</u>: Prepubertal soccer players demonstrate a landing pattern at the hip and knee that may increase their risk of knee injuries compared to post-pubertal athletes. This may be a result of poor neuromuscular control during this stage of maturation. Prevention programs should be implemented early, prior to the onset of puberty, in an effort to develop effective neuromuscular strategies and reduce the risk of knee injuries in youth athletes. Future work is needed to identify contributions to this at risk landing pattern and examine the effectiveness targeted interventions in youth athletes.

Free Communications, Poster Presentations: Knee Cases

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Uncharacteristic Schwannoma Identified in Tibiofemoral Joint: A Case Report

Garrett WZ, Gwinn G: Marshall University, Huntington, WV

Background: The purpose of the Level 3 case study is to explore alternative diagnoses for patients with posterior knee pain during activity and to introduce the possibility of a schwannoma as a diagnosis. Schwannomas are benign tumors that stem from the nerve sheath in peripheral nerves. Approximately 25-45% of schwannomas are found in the head and neck region, while less than 1% are located in the lower extremity. Alternate diagnoses for the patient were a meniscal pathology, Baker's cyst, abnormal lymph node, or ganglion. The case was abnormal due to the patient reporting no neurological symptoms for the exception of centralized posterior knee pain. Patient: The Patient was a healthy 29-year-old white male who participated in an adult kickball league. The chief complaint was posterior knee pain with squatting or walking up stairs. During the Athletic Trainer's and Orthopedic Surgeons evaluation, the patient had no signs of swelling, had a palpable knot on the posterior lateral part of the tibiofemoral joint, no neurological deficits, negative ligamentous testing, and a positive McMurray's test on the lateral portion of the knee and he was scheduled for an MRI to confirm the diagnosis. Intervention or Treatment: After recieving the MRI results, the test revealed inconclusive findings and a follow-up MRI was scheduled with contrast for the following week. The MRI with contrast revealed the possibility of an Ovoid mass, Baker's Cyst, Abnormal Lymph node, or Myxoid Lesion. The patient was referred to an Orthopedic Oncologist for further testing. The patient was examined by the Orthopedic Oncologist and he believed the mass to be an abnormal lymph node. The patient was given three treatment options: monitor and re-evaluate after six months, biopsy the tissue, or surgical removal of the ovoid mass. The patient elected to have surgery and the ovoid mass removed. Surgery was schedule one month after the evaluation. During surgery the ovoid mass was located on the peroneal nerve and removed. The mass was sent to pathology for further examinaton. Outcomes or Other Comparisons: The histology revealed a benign schwannoma measuring 1.5cm. The patient was released from the hospital the same day as surgery on crutches and weight bearing as tolerated. The night of surgery the patient suffered from drop foot in the

right leg but regained lower leg control the following morning. Two days post-op the patient started lower extremity range of motion exercises and re-established full ROM and weight-bearing status within one week. The patient had no abnormal complications post-surgical intervention and has been able to return to full activity with no limitations. Conclusions: Challenges to the case were the location of the ovoid mass in the lateral portion of the posterior knee resulted in false positive special tests for Meniscal injury and Baker's Cyst. Additional challenges to the case were the patient presented no neurological deficits with a tumor on the peroneal nerve, which in comparison to other schwannomas all subjects had neurological symptoms. Clinicians should consider the possibility of a schwannoma when evaluating patients with posterior-lateral knee pain with a palpable abnormatlity. Clinical Bottom Line: Schwannomas are benign tumors that stem from the nerve sheath in peripheral nerves. Approximately 25-45% of schwannomas are found in the head and neck region, while less than 1% are located in the lower extremity. The clinician should be sure to check for neurological signs and symptoms when evaluating patients with pain in the posterior tibiofemoral joint.



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Bilateral Plica/Fat Pad Removal in a Collegiate Swimmer: A Level 3 Case Study

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Background: Plica/fat pad removal is a potential procedure to address chronic pain resulting from plica tissue inflammation that cannot be controlled with conservative treatment. This surgery is a common procedure among the athletic population, but is not often seen in swimmers or other non-weight bearing athletes, let alone bilaterally. This clinical case study is a level 3 exploration case that introduces a common surgical procedure for weight bearing athletes, to a non-weight bearing athlete. Patient: A 21 year-old collegiate breaststroke swimmer presented with bilateral chronic knee pain towards the end of her third year. She complained of pain since her first year of collegiate swimming, but the pain has become increasingly worse over the past three years. Pain worsened with breaststroke kick, squats, running, and ascending stairs, localized to the medial border of the patella and near pes anserine, bilaterally. Full range of motion was noted bilaterally, but pain with bilateral knee flexion over pressure and with full quadriceps contraction. Pain would decrease with rest, but would always return when doing breaststroke. The athlete presented with noticeable weakness with gluteus medius, gluteus maximus, quadriceps, and core strength. Intervention or Treatment: Rehabilitation focusing on gluteus medius, gluteus maximus, and core strengthening. Cryotherapy, NSAIDs, cortisone injections, and iontophoresis attempted to control pain, but were unsuccessful. Athlete initially stopped all swimming activity in the water for the first two weeks after the season, doing only rehabilitation exercises. She returned to the water doing limited breaststroke sets, but pain was still present bilaterally. Following four months of conservative treatment, the team physician recommended surgery to address the athlete's synovial plica syndrome. This surgery consisted of removing the inflamed plica and Hoffa's fat pad tissue, bilaterally. Right knee surgery was first and then 3 weeks later the same procedure was done on the left knee. Outcomes or Other Comparisons: A plica/fat pad removal is most commonly seen with weight bearing athletes. There are very few cases reporting a swimmer undergoing this procedure, let alone to both knees. The decision for performing this procedure on both knees would be most appropriate after the physician looked at the MRI images. MRI images showed a considerable amount of inflammation surrounding the medial aspect of the patella, bilaterally, stemming from the plica and fat pad. Two days after each surgery this athlete had full knee flexion and extension range of motion, without pain. The athlete had significant improvements in post-operative isometric hip abduction and flexion strength bilaterally, when compared to pre-operative strength. The athlete returned to the water 4 weeks after the latter knee surgery to start a swimming progression for the upcoming season. She had no pain when returning to the water, and no pain when starting short and easy breaststroke sets. Conclusions: The findings of this case may suggest that this procedure is not only valid for the weight bearing athlete, but also nonweight bearing athletes. Plica and fat pad removal resulted in immediate resolution of symptoms and allowed the athlete a quick, pain free return to swimming. Clinicians should be aware of the potential benefit of plica and fat pad removal for challenging patellofemoral pathologies that are not resolving with conservative treatment. For post-operational rehabilitation, it is necessary to strengthen gluteus medius, gluteus maximus, core, and quadriceps muscles, while maintaining bilateral ROM throughout all knee and hip planes. Clinical Bottom Line: Synovial plica syndrome is a pathology most commonly found in weight-bearing athletes that should not be neglected from the non-weight bearing athletic population. Presentation and severity of this pathology can be the same for both kinds of athletes.

BMC Subcondroplasty for Knee Chondral Defects in a Triathlete: 1 Year Follow Up

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Background: Knee injuries account for a large amount of musculoskeletal diseases in the general population. The annual incidence of such injuries has been reported to be 2.3 injuries per 1,000 people, and these injuries are a combination of acute and degenerative diseases. There has been an increased interest in the use of biologic/non-operative treatment options for chondral lesions; including bone marrow concentrate. This concentration of mesenchymal and hematopoietic stem cells has recently gained interest and is generally injected into the joint space to promote healing. In association with chondral defects, lesions that appear in T2-weighted MRI are indicative of damage to the subchondral bone. Subchondral bone is essential to the health of cartilage due to its metabolic and shock absorptive properties. A subchondroplasty procedure typically involves injecting calcium phosphate within the subchondral aspect of bone to support the healing of compromised subchondral bone. This level 3 case study combined the two methods of treatment. Patient: A 39 year old female recreational triathlete was diagnosed with femoral chondral defects of the left knee. She complained of left knee pain inhibiting her ability to train and compete. Pain was described as constant, severe, sharp and stabbing with a mechanical component, and only relieved with rest and ice. MRI revealed bone-bruise edema on the lateral femoral condyle in the trochlear margin plus a full thickness chondral defect in the femoral articular cartilage. Intervention or Treatment: A bilateral PSIS bone marrow aspiration under fluoroscopic guidance with a left knee intraarticular bone marrow concentrate injection and left lateral femoral condyle subchondroplasty with bone marrow concentrate under fluoroscopic guidance was performed. Sixty ml of blood was aspirated and processed by Greyledge Technologies, Vail, CO. Five ml of bone marrow concentrate was injected into the intraarticular space and 5 ml of bone marrow concentrate was injected into the subchondral lesion. Outcomes or Other Comparisons: Although an IDKC was not completed prior to the injection, one year after the injection the patient's score was 79.1 where her pre-injection function was negligible according to self-reports. At one month post-injection the patient reported being able to walk one mile and was beginning to kick in the pool. At 2 months the patient was able to perform running intervals and riding her bike with some resistance. At 6 months post-injection, the patient was able to run/walk a half and full marathon and was very satisfied with her results. She has continued to improve and compete with little to no difficulty. One-year follow up imaging showed a stable chondral defect and resolved bone edema of the lateral femoral condyle. Conclusions: Performing subchondroplasty with bone marrow concentrate is a novel approach to sports medicine that was utilized for treatment of a recreational triathlon athlete with chondral defects and bone marrow edema. Bone marrow grafting has been shown in the literature to effectively repair osteonecrosis in the hip. The subchondral plate is an essential aspect of the joint where it provides support for the articulating cartilage. Often times, the subchondral bone is greatly involved in the pathogenesis of articular cartilage disease due to its function not only as a shock absorber, but as an element in the metabolism of articular cartilage. Therefore, the athletic trainer should be aware that not only does the cartilage itself need treatment, but the subchondral bone should be considered as well. Clinical Bottom Line: In adult recreational athletes with chondral defects of the knee, subchondroplasty and intraarticular injection with bone marrow concentrate may be an appropriate treatment that allows the cartilage to remodel and lengthen the lifetime of the joint.

Diagnosis and Management of a Medial Patellar Subluxation in a Collegiate Baseball Player: A Case Study

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Background: A 22-year-old collegiate baseball catcher reported to the athletic training staff following a game reporting severe pain along the medial aspect of the patellofemoral and tibiofemoral joints. Pain began immediately after the patient came out of his catching stance to make a throw to second base, and was accompanied by a popping sensation. The patient was able to complete the competition, but was in significant pain and reported feelings of instability along his medial knee. Patient presented with mild swelling at the medial joint line, palpable tenderness along the medial border of the patella, recreation of symptoms when patella was mobilized medially and relief of symptoms when patella was mobilized laterally. A plan was set in place to re-evaluate the patient the following day with referral to team physician if symptoms had not significantly resolved. Differential Diagnosis: Medial meniscus tear, Patellar tracking issues, Medial plica irritation. Treatment: The patient reported to the athletic training clinic the following day with persistent symptoms. Patient stated that feelings of instability had not subsided, and the team physician was contacted to arrange an appointment for that morning. AP, lateral and sunrise view x-rays were negative for fractures, however the sunrise view revealed an abnormally low medial condyle. This was believed to be the cause of medial instability, and likely allowed the patella to sublux medially and irritate a medial plica. Patient was consulted on the potential risks of continuing to attempt participation in team activities, and consented to attempting conservative treatment before considering surgical intervention. The patient began a rehabilitation protocol designed to improve patellar tracking and maintain range of motion. During this time patient was removed from weightbearing conditioning and any practice activities that would exacerbate symptoms. Utilizing these measures along with taping for patellar tracking, the patient was able to participate in competition without incident for the remainder of the season. Following completion of the competitive season, the patient consulted with a team orthopedic surgeon and consented to excision of the medial plica that had remained irritated throughout the season. Upon excision of the plica, the patient re-initiated patellar tracking and range of motion rehabilitation and was cleared to return to full participation for the following non-traditional season. Uniqueness: Nearly all patellar subluxations reported in current literature have been lateral. While medial patellar subluxations are documented, as many as 94% of subluxations occur after a lateral retinacular release. In additional literature, as little as 3% of medial patella subluxations are reported as spontaneous. In this case, the patient had received no such surgical intervention that would have resulted in complications, and presented with a congenital abnormality that resulted in a predisposition to medial subluxation. Furthermore, the irritation of a medial plica confounded initial diagnosis by mimicking the symptoms of a possible medial meniscus tear. Conclusions: When evaluating a musculoskeletal injury, thorough examination and history are crucial. Following initial evaluation, re-evaluation is important to insure that the inciting pathology is identified. Once a pathology is identified, a deliberate, specified course of treatment and rehabilitation can be prescribed.

Rare Traumatic Physeal Fracture in a Competitive Youth Soccer Athlete

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Background: A 15 year old male soccer player sustained a right knee injury after a fall while participating in a high-level soccer showcase. On-field examination yielded generalized knee pain, edema to the anterior aspect of the right knee inferior to the joint line, obvious deformity to the proximal aspect of the right tibia, and inability to bear weight on the right lower extremity. The athlete was transferred to the main medical tent where further evaluation was completed, including lower extremity neurovascular status. The athlete was placed in a knee immobilizer and the decision was made to transfer the patient to the Emergency Room for injury management. The athlete had radiographs taken and was stabilized at the local Emergency Department (ED), then transferred to the closest Pediatric Specialty Hospital for further evaluation via ambulance for proper monitoring during transit. Differential Diagnosis: Contusion, knee/patellar dislocation, fibular/patellar/ tibial fracture, ACL/LCL/MCL/PCL/ Patellar tendon sprain, ACL/LCL/MCL/ PCL/Patellar tendon injury, vascular injury. Treatment: : In advance of the hospital transfer, the Athletic Trainer (AT) advised the on-call Orthopaedic Surgeon of the patient's status, including past medical history and mechanism of injury. Upon arrival to the Pediatric Specialty Hospital's ED the athlete was evaluated by the on-site Emergency Medicine Physician and the official Orthopaedics Consultation was made. Review of x-rays taken at the original ED demonstrated a displaced angulated tibial tubercle avulsion fracture without any other fractures or dislocations noted. After discussion with the parent and athlete, it was determined that surgical intervention was the best treatment option. Indications for surgical intervention consisting of an open reduction and internal fixation were to allow union, prevent malunion, maintain range of motion, to prevent compartment syndrome, and to preserve the leg. Intraoperative evaluation determined the athlete had sustained a Salter-Harris Type 4 fracture that occurred through tibial apophysis and then up through and into the growth plate. There was also injury to the anterior recurrent tibial artery with extracapsular bleeding, which can increase the risk for compartment syndrome. The fracture was able to be successfully reduced without further neurovascular compromise or injury, and was secured utilizing two cannulated screws, which have subsequently been removed following successful healing of said fracture. The injury to the vascular structure was also repaired and extracapsular hematoma evacuated to decrease the risk of compartment syndrome Uniqueness: Salter-Harris fractures are unique to the pediatric population and should be considered as part of the diagnosis when evaluating pediatric orthopaedic injuries, especially those occurring during sports participation. Additionally, injury to the vascular structures should be assessed and considered as part of the differential diagnosis as compromise of such structures, regardless of the orthopaedic injury, can potentially lead to the loss of a limb, further medical complications, and possible inability to return to sports and leisure activities appropriate to the pediatric population. Conclusions: When performing injury evaluation of the pediatric population, it is important to consider diagnoses unique to this demographic such as those affecting the physes, including Salter-Harris fractures. Additionally, it is imperative that neurovascular structures not be forgotten, but thoroughly evaluated and included as part of the athlete's injury and prognosis.

Post-Surgical Management of Bilateral Tendinosis in a Division I Women's Basketball Player Rudolph AJ, Crawford SK, Rosen AB: University of Nebraska at Lincoln, Lincoln, NE; University of Nebraska at Omaha, Omaha, NE

Background: A division I women's basketball player (20 yrs, 190.5cm, 87kg) complained of bilateral knee pain during the preseason of 2016. She participated in basketball since age 7 and began competing in Amateur Athletic Union (AAU) at age 10. She reported experiencing her first knee pain at 13 and was diagnosed with Osgood-Schlatter Disease. During her freshman year of high school, she was formally diagnosed with bilateral patellar tendonitis. During her sophomore and junior years of high school, she received acupuncture and prolotherapy treatments but the bilateral knee pain persisted. During her freshman year in college, MRI reports on both knees showed flattening and sclerosis of the femoral condyle and focal lesions in the proximal-central third of the patellar tendon. In April 2016, Platelet-Rich Plasma (PRP) therapy and Tenex Health TX[™] procedures were provided. Other treatments included, eccentric loading with physical therapy. For her most recent complaint, she was diagnosed with bilateral chronic patellar tendinopathy and moderate patellar chondromalacia. Differential Diagnosis: Osgood-Schlatter Disease, Patellofemoral Pain Syndrome, Chondromalacia, Sinding-Larsen-Johansson Disease. Treatment: A bilateral open patellar debridement surgery, followed by PRP therapy and Tenex Health TXTM procedure was performed in October 2016. She was immobilized at 0° for four weeks. To control the pain, she received narcotics and Game Ready® treatments. Initial strengthening and ROM exercises included, isometric quadriceps contractions, gastrocnemius and anterior tibilais strengthening, supine abdominal exercises, and upper body strengthening. In November 2016, the patient was cleared for brace removal by the team physician and progressed to straight leg raises, proprioceptive neuromuscular facilitation (PNF) exercises, and balancing. In February 2017, she had no pain with walking and began closed-chained exercises, including box squats, double and single-leg calf raises, and AlterG® Anti-Gravity Treadmill at 30% BW. In April 2017, she was running 60% BW. In May 2017, biofeedback for the quadriceps and gluteal muscles were introduced with exercises, including step ups/downs, leg press, and BW squats. By the end of May, she was able to walk up and down stairs pain free. During summer workouts of 2017, running and jumping caused her the most pain and was limited in participation. She moved into the weight room with upper body, core, and eccentric calf and hamstring exercises. In addition, she progressed into functional and position drills in individual workouts. In August 2017, she experienced significant joint effusion in her right knee and was withheld from participation. She was regressed back to steps ups/downs, box squats, and short-arc quadriceps exercises for rehabilitation. She was cleared by the team physician in August 2017 and despite the pain it was determined that she would not do any more damage to her knees. Pain management treatments included, IcyHot wireless TENS, FLECTOR® patches, and APR Wave therapy. She returned to participation in September 2017. A progression was created, starting at 15 minutes of participation and at the start of the basketball season in October 2017, she was participating in one hour of practice daily. Her participation in practice continues to be limited daily. Uniqueness: This case is unique due to several reasons including, the longevity and severity of knee pain, the number of treatments and type of surgery performed. Bilateral open patellar debridement surgeries are rare, invasive and only considered when conservative treatment fails to facilitate patellar tendon healing. Conclusions: Patellar tendinosis is relatively common in highly-competitive basketball athletes often marked by degenerative changes of the tendon causing significant pain and dysfunction in patients. Surgical management is typically reserved for the most severe and unrelenting cases. High-level athletes who require a bilateral debridement can expect a lengthy rehabilitation and difficult pathway returning to play.

Knee Injury in a High School Wrestler

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Background: A 17 year old wrestler was practicing a live wrestling drill. His teammate grabbed his foot and forced him in to knee hyperextension with hip flexion. He immediately felt a pop on the medial side of his knee. He came to see his athletic trainer in the athletic training room. He was able to demonstrate a visible snapping of tissue over the anteromedial aspect of his knee and tibia. This snap was made more obvious when he externally rotated his leg and flexed and extended his knee with a valgus force. He had no history of knee injuries. He has full range of motion of the involved leg and full strength. He does not feel limited by this aside from the mechanical snapping and associated pain. On palpation, he has a 2cm soft tissue mass that is palpable along the proximal tibia and distal medial hamstring tendon, underneath the area of snapping. Knee special tests were all negative. Differential Diagnosis: Pes Anserine Tendon strain, Snapping Hamstring tendon, Hamstring tendon avulsion, tibial osteochondroma with pain secondary to hamstring abutment. Treatment: The athlete was referred to the primary care sports medicine team physician. Initial x-rays were ordered and a small bony tumor was noted on his proximal tibia. An ultrasound was performed at the clinic and it appeared that the tumor was soft tissue or cystic in nature. A subsequent MRI with and without contrast of the proximal tibia was ordered. MRI revealed an isolated proximal medial tibial plateau osteochondroma. No other intra-articular or ligamentous abnormalities noted. The patient was consulted to the team orthopaedic surgeon because he requested removal of the osteochondroma. The tumor was excised one week later as an outpatient procedure. There were no complications. The patient was able to weight bear with crutches for 3 days after surgery. He attended physical therapy three times a week for four weeks. He worked on leg, hip and core strengthening. He was able to return to normal activities four weeks after surgery. Uniqueness: Osteochondromas are the most common benign tumors of the bones. The tumors form cartilage-capped bony projections or outgrowth on the surface of bones. It occurs in any bone where cartilage forms bone. Tumors most commonly affect long bones in the leg, pelvis, or scapula. Development of osteochondromas take place during skeletal growth between the ages of 13 and 15 and ceases when the growth plate fuses at puberty. Osteochondromas occur in 3% of the general population and represent 35% of all benign tumors and 8% of all bone tumors. Most osteochondromas do not have any associated symptoms, they are normally discoveredby an unrelated injury. Conclusions: A 17 year old wrestler sustained a knee injury that caused his hamstring to become unattached to an underlying osteochondroma. After having successful surgery to remove the tumor, he was able to return to normal activities in one month. He ran track and cross country and returned to the current wrestling season with no problems.

Complications After a Patella Dislocation in a High School Athlete

Jacobs DC, Lattermann C: University of Kentucky, Lexington, KY

Background: A 15-yearold African-American male (height: 175cm, weight: 93kg) was playing recreational basketball when he twisted his knee and dislocated his patella. He was transported to the ED where his patella was reduced, he was given a knee immobilizer, placed on crutches, instructed to weight bear as tolerated, and was referred to a Sports Medicine clinic for further evaluation. Three-weeks later he reported to the Sports Medicine clinic where he presented with mild effusion, pain with palpation over the lateral and medial patellar retinaculum and lateral femoral condyle, painful patella apprehension test, equivocal J-sign test, limited/painful flexion and extension, and quadriceps atrophy. He had no other ligament laxity, normal reflexes, normal distal pulse, and no other significant injury history. The ED X-rays showed a slightly lateralized patella with no loose bodies or avulsions. He was placed in a lateral J-brace, given a physical therapy (PT) order for ROM and quadriceps strengthening, and an MRI was ordered for further evaluation. Two-days prior to the scheduled MRI, he collapsed, hit his head, and convulsed while at home. Emergency-managementservices transported the patient to the ED. At the ED the patient was responsive to his name by opening his eyes. Subsequently, he had another seizure and went into cardiac arrest and CPR was performed, he was intubated, and an emergent central arterial line was placed. After regaining a pulse, he remained unresponsive, and a CT scan was ordered. Differential Diagnosis: Differential Diagnosis: cardiomyopathy, neuro-cardio-genic syncope, a toxin cause, pulmonary embolism (PE) Treatment: The CT scan revealed a massive PE with heart strain. He was then sent to the cardiac catheterization lab for PE management. Once stabilized, the patient underwent multiple tests to determine if other blockages were present and also examine brain activity. During this time the patient was given anticoagulation medications. The results confirmed the initial PE diagnosis, he was admitted to pediatric intensive care unit, and remained in a coma for 4-days. Day 5 the patient regained consciousness and on day 6 he began in-patient. On day 14 he was discharged with instructions to follow-up with his doctors and given a PT home protocol. With rest and PT his knee was pain free. A cardiac MRI was performed and was normal. All of the patients physicians cleared him to return to activity within 6-months, and the patient returned to play football the following year. Uniqueness: Blood clots are uncommon in young healthy athletes. However, athletes may be at greater risk for developing a blood clot and subsequent PE as the symptoms could be misinterpreted as a less serious injury. Blood clots usually form and start in the lower extremities, and have been purported to be caused by traumatic injury, prolonged immobilization, post-surgery complications, genetic clotting disorders, protein deficiencies, use of oral contraceptives. Other causes such as diabetes, and history of stroke, cancer, and blood clots are also common. This patient did not present with a significant medical history. Additionally, he did not present with common signs of a DVT (sudden swelling or pain in the leg, rapid heart rate, trouble breathing or chest pain). However, he was immobilized for an extended period of time after his initial knee injury; which may have been the cause of his PE Conclusion: Conclusion: Pulmonary embolism diagnoses are less common in an athletic population. This case highlights an injury presentation common to ATs that most likely led to a blood clot. It is important to educate and instruct a patient immobilized about the risks of a blood clot and the importance of motion in order to reduce the risk of such an injury.

Cartilage "Blister" of the Lateral Femoral Condyle With a Proximal Tibiofibular Sprain in a College Basketball Athlete Gentry JA, Felton SD, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: Level 4 CASE report presents an athlete that was an 18 yearold male collegiate basketball athlete. Athlete's prior medical history included a bone contusion of the lateral femoral epicondyle of the left knee. Approximately one year ago, the athlete landed from a dunk awkwardly on his left leg. He had MRIs and X-rays taken. He was then diagnosed with a bone contusion on the lateral epicondyle of the left knee. Six-months following initial injury, athlete reported to the athletic trainer complaining of lateral left knee pain. Athlete stated he previously had a bone bruise and was in a controlled ankle motion walking boot and NWB for 6 weeks. He had completed rehabilitation but continued to have pain which worsened with the participation in basketball practices. Initial evaluation revealed no obvious deformities or signs of trauma. Athlete had pain with jumping, squatting, jogging, cutting, pivoting and completing some military tasks. Athlete was point tender over and around the fibular head. Full Active ROM and strength with knee flexion and extension. Athlete's proximal fibular glide demonstrated instability. Differential Diagnosis: Proximal tibiofibular joint sprain of the left knee. After rehab for this injury failed to reduce his pain he was seen by two physicians who ordered more X-rays and MRIs. He was then diagnosed with cartilage damage on the lateral epicondyle of the left femur. Treatment: After an initial two months of rehabilitation, the athlete continued to have knee pain. The team physician recommended a steroid injection. The athlete stated that the injection helped decrease his pain the rest of that same day and that night. However, when he woke up the next morning his pain had returned to normal. The doctor was hopeful that addressing the cartilage damage with surgery would remove the athlete's pain. Athlete was then scheduled for surgery to assess cartilage damage. During the surgery, it was found that the cartilage on the athlete's femur had "blistered" or "bubbled" away from the bone. There were no lesions in the cartilage, but it was no longer in contact with the underlying bone. The surgery performed will hopefully allow the cartilage to remain in contact with the underlying bone. Athlete is currently 7 weeks out and has begun a rehabilitation plan. Uniqueness: While osteochondral lesions in the knee are not uncommon, this athlete's case was. When the surgeon assessed the cartilage damage, he discovered that the athlete's cartilage had no lesions. However, an 8x18 mm chunk was blistered away from the bone with fluid between the cartilage and the femur. Another unique aspect of this case is the surgery that the doctor performed. He cut a chunk out of the blistered cartilage, drained the fluid and injected platelet-rich plasma to help improve healing. He then performed a microfracture surgery with the hope that it would be enough to fix the cartilage as well as remove the athlete's pain. Conclusions: This case highlighted the diagnosis and treatment of an athlete suffering from blistered cartilage of the lateral femoral condyle with a proximal tibiofibular sprain of the left knee. This case further highlighted an attempted surgery on an extremely rare and unique case. As the athlete's treatment, care, and rehabilitation continue we will discover if the initial surgery was enough or if he will need to undergo another surgery.

Free Communications, Poster Presentations: Lower Extremity Cases

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Non-Contact Comminuted Femoral Fracture in a Male High School Soccer Player: A Level 4 CASE Study

McTernan KH, Hoch JM: University of Kentucky, Lexington, KY

Background: A 17-year-old male high school soccer player (1.78m; 65.77kg) was participating in a game when he sustained a non-contact twisting injury to his lower extremity, resulting in a deformity to his distal thigh. The patient reported an audible pop followed by immediate pain and spasms of the musculature in his distal thigh. He was unable to weight bear and reported increased pain with any movement of his leg. The patient had lower extremity sensation intact to light touch throughout. His foot had 2+ dorsalis pedis and posterior tibial pulses, and his foot was warm and well perfused. He was oriented and alert, in no apparent distress, and his breathing was non-labored. The patient denied personal or family history of bone disorders as well as previous injury to the extremity. The patient was transported to a local emergency department for further evaluation. Differential Diagnosis: Quadriceps contusion, quadriceps strain, dislocated patella, anterior cruciate ligament tear, distal femur fracture. Treatment: X-rays were obtained and presented with a distal comminuted femoral shaft fracture. The patient underwent an antegrade intramedullary nailing of the distal third femur with trochanteric starting Smith and Nephew nail. The patient remained in the hospital two-days post-surgery for pain control. Upon discharge, the patient was prescribed an anticoagulant for two-weeks, NSAID for one-month, opioid pain medication prn, and anti-nausea medication prn. During the first week post-surgery, the patient was eased off the opioid, was touch-toe weight bearing with crutches, and began knee ROM and lower extremity strengthening through physical therapy (PT). One-month post-surgery the patient was ambulating with one crutch with minimal pain, and had hip and knee ROM within normal limits. By the second month of PT, the patient was cleared for full weight bearing, non-ballistic strengthening, and completing Alter-G workouts at 60% intensity. Four weeks later, he began sport specific exercise in his rehabilitation. At four-months post-surgery, the patient was able to complete all weight bearing aerobic activity and practice with non-contact play. By the fifth month of rehabilitation a follow-up x-ray presented with significant periosteal healing through fracture lines, and he was cleared for full participation. The patient currently plays soccer at the collegiate level without persistent complications from the surgery. Uniqueness: The femur is the largest, most dense bone in the body, thus it requires tremendous force to overcome the mechanical strength and cause a fracture. Femoral fractures are often the result of direct contact or torsion. Femoral fractures are most often the result of falling from a height, a car accident, or a high-speed sports collision. Other atypical causes include metabolic bone diseases, metastatic disease, or primary bone tumors. This case is unique in that the patient's mechanism of injury did not involve a high-energy force, nor did he present with biomechanical factors or previous medically history which would predispose him to this traumatic injury. Conclusions: Femoral fractures are serious pathologies that require immediate medical treatment due to the potential to damage vascularity surrounding the limb. Athletic trainers should be educated on atypical mechanisms of femoral fractures and the appropriate treatment protocols. A specific return to participation program should include gradual weight-bearing exercises, strengthening of surrounding musculature, and sport specific functional movements to increase confidence in each patient with this pathology.

Congenital Femoral Deficiency in an NCAA Division II Paralympic Male Swimmer

Gruber D, Vanata D, Scarpone Z, Zeitz J: Ashland University, Ashland, OH

Background: A 19-year-old National Collegiate Athletic Association and Paralympic male swimmer was diagnosed with congenital femoral deficiency (CFD) in the left limb by means of prenatal diagnosis. CFD is a rare birth defect characterized by a short femur, associated with hip and knee deformity, deficiency, or instability. Upon initial evaluation, the limb length discrepancy measured 19 centimeters and the patient was categorized as a Paley Type 2-B, which consists of a mobile pseudoarthrosis and either the absence of the femoral head or the fusion of the head to the acetabulum. Commencing at the age of 9 and concluding at the age of 18, the patient underwent 9 surgeries at the Paley Orthopedic and Spine Institute to reduce the limb length discrepancy. Differential Diagnosis: Proximal Focal Femoral Deficiency (PFFD), Tibial Hemimelia, Leg Length Discrepancy Treatment: On June 22, 2007, the patient underwent a Systematic Utilitarian Procedure for Extremity Reconstruction (SUPER) hip 2 surgery in which the proximal femur is reconstructed into a femoral neck. A SUPERhip 2 procedure is completed by applying an external fixator to the pelvis, femur, and tibia in order to stabilize the new alignment. The external fixator was removed on September 23, 2007 and the patient was given a brace to protect the femur and a prosthesis to avoid equinus of the foot. On June 17, 2008, the patient had the first lengthening surgery in which an osteoplasty was performed and an external fixator was applied. The external fixator distracts the bone which allows the bone to grow into the new space. The standard length achieved by each lengthening surgery is between 5 and

8 cm. The patient underwent a second SUPERhip 2 procedure in 2009 in an attempt to increase the range of motion of the hip. However, after the second SUPERhip 2, the patient still presented with severe coxa vara and significant ankylosis of the hip joint. The last attempt to increase hip mobility was through a surgical dislocation in November of 2010. During that surgery, the physician decided to apply an external fixator for stabilization due to the subsequent subluxations. During a swim meet in 2010, the patient suffered a fracture of the left distal femur. Surgery was performed to reduce and internally fix the fracture. In 2011, the physician impeded the growth in the patient's normal leg in order to decrease the amount of lengthening needed. In 2012, 2014, and 2016 the patient underwent 3 additional lengthening surgeries. Uniqueness: CFD occurs in approximately 1 in 50,000 births. Research regarding CFD in the athletic population is limited and the likelihood of athletes competing at the collegiate and Paralympic level with this condition are rare. Studies revealed that limb lengthening is an effective way to restore a patient with CFD to a normal life. Athletic trainers will benefit from the knowledge of management and treatment protocols presented in this case study for an athlete with CFD or other limb length discrepancies. Conclusions: The current discrepancy is 1 centimeter and the patient reports an enhanced quality of life and improved function due to the treatment received. The patient continues to perform rehabilitation with the University's swimming and diving athletic trainer in order to maintain maximum mobility of the knee and hip joints as well as strengthen the quadriceps, hamstrings, and gluteal muscles. Currently, the patient reports no symptoms during swimming, weight training, or rehabilitation exercises. For the future, the patient has aspirations to compete in the 2020 Paralympic Games in Tokyo, Japan.

Bilateral Popliteal Artery Entrapment Syndrome in a College Women's Lacrosse Player

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Background: A twenty-year-old female collegiate lacrosse player presented with recurring, intermittent symptoms of bilateral lower leg pain with activity over five years. Pain with numbness and tingling extending into feet and toes, as well as feeling an increased pressure in her calves, bilaterally, increased approximately eight weeks into current competitive season. Upon physical exam, there was mild swelling around the mid-shaft of her tibia. Differential Diagnosis: Medial Tibial Stress Syndrome, Compartment Syndrome, Popliteal Artery Entrapment Syndrome. Treatment: Gait analysis was negative; the patient was cleared by the head team physician to participate in activity, as tolerated. The patient was able to compete throughout the remainder of the season and therefore intramuscular compartment pressure measurement did not occur until the end of the season. At the time of measurement, the intramuscular compartment pressure was indicative of compartment syndrome. Patient was referred to another physician to be evaluated for any indication that bilateral fasciotomy release surgery was the best solution. Upon patient history and exam, that physician-ordered a magnetic resonance image (MRI); subsequently, the patient was diagnosed with bilateral Popliteal Artery Entrapment Syndrome. A corrective, bilateral surgical procedure was performed to release the artery from the medial gastrocnemius muscle head within the popliteal fossa. The patient was able to weight-bear and walk immediately but was not allowed to run for four weeks. She was instructed to gradually increase the amount and intensity of walking based on her tolerance of pain symptoms during the initial four weeks post-surgery. She was also instructed to work towards achieving full range of motion during this initial time frame. At four weeks post-surgery, she was allowed to begin a return to run progression. Anticipated return to full function will occur ten weeks post-surgery. Uniqueness: Popliteal artery entrapment syndrome can be seen in up to 3.5% of the population; most typically in active males under 30 years old. This diagnosis can be difficult as it can present very similar to other chronic injuries. The patient had recurring bilateral lower leg pain for several years and was treated for chronic medial tibial stress syndrome by multiple providers. Compartment syndrome testing was only initiated during her initial year of intercollegiate athletics participation. Correct diagnosis was only achieved through MRI. Conservative treatment of symptoms had previously proven unsuccessful, and surgical intervention resulted in symptom resolution. Conclusions: Initial testing was indicative of compartment syndrome. Conservative treatment did not result in symptom reduction. Referral to a physician for further testing produced a diagnosis of bilateral popliteal artery entrapment syndrome. Practitioners treating medial tibial stress syndrome or compartment syndrome conservatively without improvement in symptoms should refer for diagnostic imaging to rule out this serious, albeit rare, condition.

Simultaneous Combined Lower Extremity Injuries in a Collegiate Football Player

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Background: A 22 year-old male NCAA division III defensive back with uncomplicated medical history suffered an injury to his left foot and lower leg while attempting to make a play during an away football game. Initial on field complaint was of left foot pain with inability to bear weight. Sideline examination revealed left 1st metatarsophalangeal (MTP) joint dorsal dislocation. Differential Diagnosis: Differential diagnosis consisted of uncomplicated 1st MTP joint dislocation, 1st MTP joint dislocation with associated fracture, and 1st MTP joint dislocation with associated soft tissue injury. Treatment: 1st MTP joint was reduced on the sideline by the team physician applying axial distraction and extension to the joint. Following reduction, the athlete was found to be neurovascularly intact. Athlete then placed into a removable walking boot and issued crutches for weight bearing and transportation back to home site with the team after the game. Following the two and half hour return trip athlete noted left lateral shin pain in the distal one third of his fibula. Initial x-ray revealed mildly displaced transverse fracture of the distal shaft of the left fibula, as well as a fibular sided sesamoid fracture. During physician evaluation 2 days post injury the athlete was found to have full ankle plantarflexion and dorsiflexion with noted pain at fibular fracture site, full flexion and extension of 1st MTP, intact sensation, and 2+ dorsalis pedis pulse. Exam also revealed edema and ecchymosis at the 1st MTP joint with intact flexor and extensor tendons. The athlete was permitted to bear weight as tolerated. Three days post injury the athlete was placed into a long leg stirrup brace with a cast shoe due to increased pressure and discomfort at fibular fracture site while in the walking boot. Additional treatment consisted of daily cryotherapy and gentle toe and ankle active ROM. Follow up x-ray 18 days post injury did not show any increase in fracture displacement and was without significant radiological interval healing. The athlete self-transitioned from cast shoe to rigid work-type boots, without an increase in pain, while continuing to utilize the long leg stirrup. Physician evaluation 5 weeks post injury revealed no tenderness to palpation over the fibular shaft, mild tenderness to palpation along plantar surface of 1st MTP with intact motion. Increased soreness was noted while wearing less rigid footwear which was managed with a custom foot orthosis. Uniqueness: This case is unique in that the initial presentation and complaint of just toe pain by the athlete delayed the recognition of the associated fibular injury. The occurrence of 1st MTP dislocation itself is rare with only a few reported cases in sport. To our knowledge, a combined fibular fracture with 1st MTP dislocation in sport has not previously been reported. Review of the game film allowed for recognition of the injury mechanism. The athlete was struck by a teammate at the fibular fracture site, the impact of the initial contact forced his foot and already dorsiflexed toe to into the turf resulting in 1st MTP dorsal dislocation. Conclusions: The athlete was unable to return to the football season given the mid-season timing of the injury. However, he is progressing well and expected to make a full return to competitive play prior to the spring football practice season utilizing foot orthosis for additional support. This case highlights the need for continued monitoring and follow up after initial injury evaluation and treatment as well as the added value of reviewing game or practice film following injury for improved appreciation of injury mechanism.

Free Communications, Poster Presentations: Outcomes in Chronic Ankle Instability

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Intracortical Excitability of the Peroneus Longus Muscle in Patients With Chronic Ankle Instability

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Context: Reduced peroneus longus muscle activity during functional tasks is a commonly reported neuromuscular impairment in patients with CAI. However, the neurological origin of peroneus longus deficits remains unknown. Identifying the specific pathways involved may lead to development of therapeutic interventions to enhance neuromuscular outcomes for patients with CAI. **Objective:** Quantify corticospinal and intracortical excitability of the peroneus longus in patients with CAI compared to healthy people. Design: Cross-sectional, case-control study. Setting: Research laboratory. Patients or Other Participants: A total of 11 patients with CAI (age: 21.36 ± 2.80 years; body mass index [BMI]: $24.72 \pm 5.25 \text{ kg/m}^2$) and 7 healthy participants CAI (age: 22.0 \pm 2.16 years; BMI: 23.7 \pm 2.69 kg/m²) participated in the study. Interventions: The independent variable for analysis was group: CAI or healthy. CAI was defined in accordance with the guidelines of the International Ankle Consortium. Healthy controls were matched to participants with CAI on sex, age, and BMI. Main Outcome Measures: Transcranial magnetic stimulation (TMS) was used to quantify corticospinal and intracortical excitability. Electromyography electrodes were placed over the belly of the peroneus longus and a ground electrode placed over the patella of the involved limb. A matched limb was used in healthy controls. Corticospinal excitability was determined via active motor threshold (AMT) as the lowest stimulator output possible to elicit 4/8 motor evoked potentials (MEPs; amplitude>100mV). Intracortical excitability

was assessed via two separate paradigms to quantify the magnitude of inhibition present in the peroneus longus. Eight recordings of each measurement were completed and averaged for each participant. Long interval intracortical inhibition (LICI) was measured from the MEP obtained by delivering two TMS pulses both at 120% of AMT and separated by 100ms. LICI data were normalized to the MEP amplitude of a single TMS pulse delivered at 120% of AMT. Cortical silent period (CSP) was determined by delivering a single TMS pulse at 120% of AMT and measuring the period of cortical inactivity that followed (ms). Separate one-way ANOVAs tested differences in intracortical excitability (AMT, LICI, CSP) between groups (CAI, healthy). Alpha was set a priori at P < 0.05. Results: The AMT was not different between participants with CAI and healthy controls (CAI: 45.91 ± 13.79 ; healthy: 55.33 ± 9.35 ; P = 0.158). There was no significant difference in LICI (CAI: 0.87 ± 0.52 ; healthy: 0.95 ± 0.40 ; P = 0.774) CSP (CAI: 58.82 ± 32.87 ms; healthy: 73.27 ± 33.24 ; P = 0.448) between participants with CAI and healthy adults. Conclusions: Neither corticospinal excitability (AMT) nor intracortical excitability (LICI, CSP) differed between participants with CAI and healthy adults. Although previous research has identified reduced peroneus longus muscle activity, our data suggest this muscle is not inhibited in persons with CAI. Instead, it is likely that the peroneus longus is not being facilitated and interventions to increase peroneus longus excitability should be developed and implemented in rehabilitation for individuals with CAI.

Role of the Functional Movement Screen in the Identification of Neuromuscular Deficits Associated With Chronic Ankle Instability

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Context: Lateral ankle sprains account for an annual healthcare cost in the USA that has been estimated at \$3.8 billion. Chronic ankle instability (CAI) has been operationally defined as having a medical history of at least 1 ankle sprain within the past 12 months, and a history of the previously-injured ankle "giving way" and/or recurrent sprains and/or "feelings of instability". Previous research has suggested that decreased functional ability, diminished postural control, decreased active range of motion (AROM), increased ligament laxity, muscle weakness, delayed neuromuscular reaction as CAI risk factors. **Objective:** To determine the extent to which the Functional Movement Screen (FMS) was effective in differentiating apparently-healthy individuals from persons with neuromuscular deficits associated with CAI. A secondary aim was to identify specific risk factors that predispose individuals to CAI. Design: Case-Control Setting: Laboratory Setting Patients or Other Participants: 60 physically-active individuals (27 men and 33 women; age, 21.9 + 3.1 yrs). Of our 60 participants, 20 met our operational definition of having CAI. Interventions: We employed a 2:1 ratio of persons without a previous history of ankle injury to those with CAI, and triple matched them on sex, age (+5 yrs) and BMI category (underweight, normal, overweight, obese). Main Outcome Measures: Overall FMS Score (FMS); FMS Lower Extremity (FMS-LE) subscore; FMS Core Stability (FMS-CS) subscore; Foot and Ankle Disability Index-Sport (FADI-S); plantar flexion, dorsiflexion, eversion and inversion AROM; Y-Balance Test; and Athlete

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Single Leg Stability Test (ASLST). To investigate the extent to which postulated risk factors played a role in increasing risk for CAI, we calculated odds ratios using conditional logistic regression. Order of input of the 5 variables chosen was hypothesis-driven, specifically, FMS-LE, FADI-S, Dorsiflexion AROM, Y-Balance-Anterior, and ASLST. Group (2) x Limb (2) ANOVAs were used to identify differences between the Case (n = 20) and Control (n = 40) groups, and the involved/ uninvolved limbs of the participants with CAI (a < 0.05). Results: The FADI-S scores were significantly lower in the Case (CAI) group (78.3 + 17.9)than the Control group (97.8 + 4.3) [p = 0.001]. The overall conditional logistic regression was statistically significant (p = 0.001), with the FADI-S the only significant predictor (p = 0.012, Exp(B) = 0.816) of the 5 independent variables in the model. This finding indicated that for every 1 point a participant does not score on the FADI-S, she or he was 18.4% more likely to have CAI. Conclusions: The overall FMS scores and FMS subcomponent scores that we analyzed did not identify specific risks for CAI. Our lone patient-reported outcome measure, the FADI-S, emerged as a significant factor in determining those with, or at risk for developing CAI.

Altered Spinal Reflex Excitability of the Fibularils Longus Following Acute Lateral Ankle Sprain: Prospective Case Series Taniyama D, Terada M, Senoo K, Isaka T: Ritsumeikan University, Kusatsu, Shiga-ken, Japan

Context: It has been suggested that altered spinal reflex excitability of the lower leg muscles following an initial lateral ankle sprain (LAS) is one of contributing factors to CAI. Although the retrospective case-control studies have previously reported altered spinal reflex excitability of the lower leg muscles in patients with acute LAS and CAI, these authors relied on data without a pre-injury assessment. Prospective examination of the longitudinal changes in neuromuscular function from pre-injury characteristics would provide clinicians and researchers with a more comprehensive view of the underlying neuromuscular impairments in this population. **Objective:** Prospectively examine the consequences of athletic patients who sustained an acute LAS on spinal reflex excitability of the fibularis longus (FL). Design: Case Series. Setting: Research Laboratory. Patients or Other Participants: Four collegiate athletes cleared for Men's basketball competition $(18.46 \pm 2.95 \text{ yrs}; 176.69 \pm$ 10.21 cm; 78.42 ± 19.60 kg) were participating in a university IRB-approved research study. During a competitive season, these athletes sustained an acute grade 2 LAS. Interventions: All athletic patients were tested to bilaterally assess spinal reflex excitability of the FL prior to the beginning of the competitive season (pre-injury), as well as at 24-hour, one-week, and one-month post-injury. Spinal reflex excitability of the FL was assessed by eliciting Hoffman reflex (H-reflex) and muscle responses. Main Outcome Measures: The H:M ratio was calculated from the peak-to-peak amplitudes for the maximal H-reflexes and muscle responses. One-way repeated measures ANOVAs and Cohen's d effect sizes were used to assess changes in the H:M ratio from

baseline to post-injury time points. Significance was set a *priori* at P < 0.05. Furthermore, data were examined using the established minimum detectable change (MDC). Results: While there were not significantly differences in the H:M ratio of the FL for the injured and non-injured sides between time points (P > 0.05), the H:M ratio of the FL for the injured side was found to be decreased by 0.17 at 24-hour post-injury (0.26 ± 0.11) compared to pre-injury testing (0.37 ± 0.26) . For the non-injured side, the H:M ratio decreased by 0.14, 0.18, and 0.19 at 24-hour (0.31 \pm 0.12), 1-week (0.27 \pm 0.13), and 1-month post-injury (0.26 ± 0.12) , respectively, from baseline (0.45 ± 0.05) . These decreases in spinal reflex excitability exceeded the established MDC (0.03) for the H:M ratio of the FL. Moderate effect sizes were observed for the injured side between the baseline and 24-hour post-injury assessments (d = 0.79). Large effect sizes were noted for the non-injured side between the baseline and post-injury assessments (d = 1.11 to 1.81). Conclusions: Data from this case series revealed that acute LAS might alter spinal reflex excitability of the FL. Further prospective study with an expanded sample size is needed to truly examine longitudinal changes in spinal reflex excitability of the FL following acute LAS, as well as confirm the information presented in the current case series.

An Examination of the Difference in Mechanical Laxity of the Ankle Following an Acute Lateral Ankle Sprain in Collegiate Student-Athletes Wisthoff BA, Gustavsen G, Kaminski TW: University of Delaware, Newark, DE

Context: 72% of individuals following a lateral ankle sprain (LAS) have shown residual symptoms and perceived ankle instability up to 18 months later, which may lead to the development of chronic ankle instability (CAI). Even though previous research has noted differences in mechanical laxity after an LAS compared to healthy controls; to our knowledge, no study has compared mechanical laxity prior to injury. **Objective:** To determine the difference in mechanical laxity of the ankle following an LAS. Design: Longitudinal cohort design. Setting: Athletic training research laboratory. Patients or Other Participants: Fifteen (6 male, 9 female) university student-athletes $(age = 20.4 \pm 1.3 \text{ yrs.}, height = 173.7$ ± 10.8 cm, mass = 68.9 ± 13.7 kg) who suffered an LAS. Interventions: Injury questionnaire and CAIT were administered to determine number of previous LAS and the presence of CAI at baseline. An instrumented ankle arthrometer was used to determine mechanical laxity of the ankle joint in two positions: anterior displacement (AD, mm) and inversion/eversion rotation (IE, degrees). Mechanical laxity was measured at two time points: 1) baseline and 2) 24-72 hours post-ankle sprain. Main **Outcome Measures:** Paired samples t-test analyses were performed to determine the differences in the means between baseline and post-injury for both AD and IE. Pearson correlation coefficients were used to determine a relationship between the number of previous LAS, CAIT, and the amount of time between testing periods to the laxity measures. Cohen's d effect sizes were also calculated. Results: There were no significant differences between baseline and post-LAS for AD (9.81 \pm $3.47 \text{ mm vs } 8.09 \pm 3.78 \text{ mm}$, respectively) and IE (46.6 \pm 15.3 degrees and 37.1 ± 14.8 degrees, respectively). However, there were medium effect sizes for the differences in the means for AD (d =0.5) and IE (d = 0.6). The number of previous LAS ranged from 0 to 3 and the average CAIT score was 27 ± 2.6 . The average number of days between the injury and post-LAS test was $1.3 \pm$.72 days (range 0-3). There was a significant relationship between the difference in AD from baseline to post-LAS $(-1.71 \pm 5.5 \text{ mm})$ and the number of days between testing sessions (721.9 \pm 384 days) (-.654, p = .008). There were no significant relationships between previous LAS and CAIT and the laxity measures. Conclusions: As more time passes between testing periods, a greater difference in AD laxity is apparent. This may suggest that reporting the amount of time between testing periods is important related to differences seen in laxity following an ankle sprain. The differences in both AD and IE from baseline to post-LAS, while not statistically significant, is most likely clinically significant.

Hip Abduction Strength and Endurance Deficits Are Not Present in CAI Patients Embree EC, Wise JB, Docherty CL:

Indiana University, Bloomington, IN

Context: Chronic Ankle Instability (CAI) is a condition in which there are recurrent feelings of giving way and instability after suffering an initial ankle sprain. It is common to have strength deficits in the ankle due to this injury and these same strength deficits are also seen in those suffering from CAI. Endurance is also an important component of injury prevention as the risk for injury increases near the end of an activity. It has been shown that mechanics of the ankle, knee and hip are related, and may be affected due to injury at one of those joints. Due to this, it is important to consider if hip abduction strength and hip abduction endurance are affected in a population of those suffering from CAI. **Objective:** To determine if there are strength or endurance deficits of the hip abductors in those with CAI compared to healthy controls. Design: Cohort design Setting: Research Laboratory Patients or Other Participants: Forty-two subjects were recruited for the study. Twenty-one subjects had unilateral CAI and 21 subjects had no history of ankle injury. CAI was determined as having a history of ankle sprains and scoring an 11 or more on the Identification of Functional Ankle Instability (IdFAI). Subjects were excluded if they had an acute ankle sprain within 2 weeks of testing, any surgery to the lower extremity and suffering from a lower extremity injury which has affected ADLs within the last two months. Interventions: Both groups participated in the same testing procedures. Hip abduction endurance was measured for both limbs using a timed isometric hold test. Subjects were in a sidelying position and the test leg was positioned in 30 degrees of hip abduction and rested on a leg stabilization device. Subjects were then asked to hold their test leg above the leg stabilization device until failure. Hip abduction strength was measured in both limbs in the same sidelying position by having subjects push up into a handheld dynamometer. The handheld dynamometer was placed on the lateral malleolus of the test limb, and participants were asked to push as hard as possible against the device. Main Outcome Measures: Hip abduction strength (Newtons) and hip abduction endurance (seconds) were compared between limbs (healthy and CAI) and group (healthy and CAI). **Results:** For hip abduction strength, we identified no significant limb by group interaction (p = .87), no significant difference between limbs (p = .79)(injured limb: 18.5 ± 4.8 Newtons; uninjured limb 18.5 ± 4.3 Newtons) nor a significant difference between groups was seen (p = .40) (Healthy 17.9 ± 4.4 Newtons; CAI 19.1 \pm 4.6 Newtons). For hip abduction endurance, we identified no significant limb by group interaction (p = .66), no significant difference between limbs (p = .11) (Injured limb 119.1 ± 40.8 seconds; Uninjured limb 127.5 ± 46.1 seconds) nor a significant difference between groups was seen (p = .64) (Healthy 120.4 \pm 34.7 seconds; CAI 126.3 \pm 52.2 seconds). Conclusions: No hip abduction strength or hip abduction endurance deficits were seen in those with unilateral CAI compared to healthy controls. It is suggested that clinicians focus their rehabilitation on strengthening deficits at the ankle instead of focusing on the hip abductors.

Contribution of Hip Abduction Strength on Dynamic Balance in Those With a History of Ankle Sprains

Wise JB, Embree EC, Docherty CL: Indiana University, Bloomington, IN

Context: Ankle sprains are common injuries that affect people of all ages, especially those who participate in athletics. It has been consistently reported that following an ankle sprain, balance is often negatively impacted. One of the many factors that can influence the ability to balance effectively is the hip musculature, specifically the hip abductors. However, very few studies have evaluated the relationship between hip abduction endurance and dynamic balance. **Objective:** To determine if there is a relationship between hip abduction strength and dynamic balance, and hip abduction endurance and dynamic balance in those with a history of an ankle sprain. Design: Non-experimental, correlation study. Setting: Laboratory. Patients or Other Participants: Fortynine, physically active subjects (19.9 \pm 1.3 years, 169.47 ± 8.14 cm, $67.33 \pm$ 13.24 kg, 16 male, 33 female) were recruited for the study with varying levels of dynamic balance abilities. All subjects had a history of at least one ankle sprain. Subjects were excluded if they had had an acute ankle sprain within the past two weeks, had a history of any surgery to the lower extremity, or had a lower extremity injury that caused time loss within the prior two months. Interventions: Dynamic balance was assessed using the Star Excursion Balance Test (SEBT) in the anterior (A), posterolateral (PL), and posteromedial (PM) directions. An SEBT composite (COMP) score was also calculated and recorded as a percent of limb length. Hip abduction strength was assessed using a maximal, isometric hip abduction test in a side-lying position with a handheld dynamometer as a percent of body weight. Hip abduction endurance was assessed using by a timed, side-lying hip abduction endurance test from a leg stabilization device set per-person at

45° with an inclinometer. Subjects were tested in one testing session and all tests were completed in a counterbalanced order with 1 minute of rest between tests. Main Outcome Measures: SEBT in the anterior (A), posterolateral (PL), and posteromedial (PM) directions, as well as composite (COMP) score (% limb length). Hip abduction strength (% body weight). Hip abduction endurance (seconds). Results: We identified a statistically significant relationship for each direction of SEBT (A: 66.3 ± 5.5 ; PM: 84.2 ± 7.4 ; PL: 78.2 ± 8.8) and for hip abduction strength (18.2 ± 5.2) (A: r = 0.42, p = .003; PM: r = 0.47, p = .001; PL: r = 0.30, p = .036; COMP: r = 0.48, p = .001). No statistically significant relationship was revealed between hip abduction endurance and the same SEBT directions (p > .05). <u>Conclusions:</u> The positive relationship revealed between hip abduction strength and dynamic balance is important in patients following an ankle sprain. Our data indicates that those who experience decreases in dynamic balance may also experience a decrease in hip abduction strength and vise-versa. A decrease in hip strength or dynamic balance can lead to changes in gate and can increase likelihood of further injury.

Validity of the Quick-FAAM for Individuals With a History of Lateral Ankle Sprain

Hartzell JT, Kosik K, Hoch JM, Gribble PA, Hoch MC: University of Kentucky, Lexington, KY

Context: The Foot and Ankle Ability Measure (FAAM) is a commonly utilized patient-reported outcome (PRO) to assess activity limitations and participation restrictions in individuals with chronic ankle instability (CAI). To reduce administration and scoring time, a shortened version of the FAAM (Quick-FAAM) was developed and preliminary studies have demonstrated sound psychometric properties. However, continued validation and development of the Quick-FAAM is needed for adoption into clinical practice. **Objective:** To examine the factor structure and validity of the Quick-FAAM in individuals with CAI and ankle sprain copers (ASC). Design: Cross-sectional. Setting: Laboratory. Patients or Other Participants: A total of 176 adults with self-reported CAI (130 females, age: 23.46 \pm 4.52 years, height: 169.08 \pm 9.44 cm, weight: 72.77 ± 14.40 kg) and 47 ASC (28 females, age: 25.09 ± 5.40 , height: 167.71 ± 8.71 cm, weight: 69.59 \pm 14.45 kg) volunteered to participate. Participants were included in the CAI or ASC groups based on previously established criteria. Interventions: Within a single session, participants completed the Quick-FAAM and the Cumberland Ankle Instability Tool (CAIT). Main Outcome Measures: The Quick-FAAM is a 12-item region-specific PRO that assesses the patients' level of function using a 5-point Likert scale. It was derived from the original 29-item FAAM in which 5 items from the activities of daily living subscale and 7 items from the sport subscale were retained. Quick-FAAM scores are converted to a percentage (0-100%), and greater scores indicate greater function. In preliminary research, the Quick-FAAM demonstrated strong internal consistency ($\alpha = 0.94$). The CAIT is a previously validated 9-item scale which assesses impairments associated

with CAI. CAIT scores range from 0-30, and greater scores indicate less ankle impairment. Unidimensional validity of the Quick-FAAM was assessed using principle components analysis, coverage redundancy using inter-item correlations, and internal consistency using Cronbach's a. Convergent validity was examined through Spearman rho correlation with CAIT scores. Knowngroups validity was established by examining the ability of the Quick-FAAM to discriminate between CAI and ASC participants using receiver-operator characteristic curves which determined a cutoff score, sensitivity, specificity, and area under the curve (AUC). Descriptive statistics (mean \pm SD) were calculated for all instruments. Alpha was set at $p \le 0.05$ for all analyses. Results: The Quick-FAAM demonstrated unidimensionality based on a single component exhibiting an Eigenvalue ≥ 1 (Eigenvalue = 7.31, Explained Variance = 60.91%). The Quick-FAAM demonstrated acceptable redundancy across items (average r = 0.57, minimum r =0.43, maximum r = 0.76) and excellent internal consistency ($\alpha = 0.94$). The Quick-FAAM (79.28 ± 16.08%) strongly correlated to the CAIT (18.88 \pm 6.42, r = 0.76, p < 0.001). The cutoff score for differentiating between CAI (74.57 ± 14.64%) and ASC (96.90 \pm 5.63%) was 94.79% (sensitivity = 0.96, specificity = 0.85, AUC = 0.95 (CI = 0.91-0.98), p < 0.001). <u>Conclusions:</u> The Quick-FAAM provides a valid, shortened alternative to the FAAM to assess ankle function in individuals with CAI. It also has the ability to discriminate between individuals categorized with CAI and ASC. Further research should examine test-retest reliability and minimal detectable change to further establish clinical utility.

Free Communications, Poster Presentations: Running Injuries

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Influence of Surface Types and Slopes on Tibial Impact Accelerations in Trained Distance Runners

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Context: Trained distance runners experience millions of repetitive lower-extremity impacts while training and competing on varying outdoor terrains, which may contribute to the development of overuse injuries over time and repetition. Training recommendations and clinical guidelines may benefit from an improved understanding of the role that both surface type and slope may play on lower-extremity impact forces in trained distance runners. **Objective:** To compare tibial impact accelerations in trained distance runners on three surface types (grass, asphalt, concrete) and three slopes (incline, decline, flat). We hypothesized that runners would experience the lowest tibial impact accelerations on the grass surface and incline slope compared to other surfaces and slopes. Design: Cross-over Trial Setting: Outdoor field setting. Trials were run on local sidewalk, grass, and roads. Patients or Other Participants: A convenience sample of thirteen trained distance runners (females = run ≥ 25 miles/week, males= run \geq 35 miles/week) with no history of injury in the past 6-months volunteered to participate (8 males, 5 females, 20.1 ± 1.0 years, 62.2 ± 7.9 kg, 173.3 ± 8.9 cm, 52.7 ± 10.7 miles run per week). Interventions: Participants completed two running trials for each of the nine conditions, combining the three surface type and three slope conditions. Each trial included running 20-meters at 80% of participant's maximal effort (determined from a pretest 1-mile time trial). Incline and decline slopes were run on 4° slope. Tibial impact accelerations were measured using a triaxial accelerometer secured to the distal anteriomedial aspect of the dominant limb shank. Main Outcome Measures: Peak tibial impact acceleration (g) were calculated using the mean acceleration of 8 strides during the central 10-meters during the two trials (4 strides/ trial). A 3x3 ANOVA with repeated measures and tukey's post-hoc comparisons were utilized to examine difference due to surface and slope conditions. Statistical significance set at priori at $p \le 0.05$. Results: Tibial impact accelerations were greater during decline $(8.0 \pm 0.1 \text{ g})$ compared to incline $(7.3 \pm 0.4 \text{ g})$ running (P = 0.02). There was no main effect for surface type. Impact accelerations were greater running on grass $(8.2 \pm 1.2 \text{ g})$ compared to the concrete surface (7.5 \pm 1.7 g) on the flat slope (P = 0.02), and greater running on grass $(7.7 \pm 1.4 \text{ g})$ compared to the asphalt surface (7.0 \pm 1.7 g) on the incline slope (P = 0.03). On the asphalt surface, impact accelerations were greater when running on the decline $(8.13 \pm 1.67 \text{ g}, P = 0.001)$ and flat $(7.79 \pm 1.44 \text{ g}, P = 0.03)$ slopes compared to incline slope $(7.0 \pm 1.7 \text{ g})$. Conclusions: Contrary to our hypothesis, our findings suggest that running on grass resulted in greater tibial impact accelerations than concrete on flat slope and asphalt on incline slope in trained distance runners. Additionally, running on a decline may lead to greater tibial impact accelerations. The results of the current study may be beneficial when developing training recommendations for patients returning from or at risk for overuse lower-extremity injuries.

Injury Predictors for Stress Fractures in Female Collegiate Endurance Runners Kowata H, Terada M: Ritsumeikan University, Kusatsu, Shiga-ken, Japan

Context: Stress fractures in the lower extremity are notoriously common overuse orthopedic issues particularly among female endurance runners. It has been previously suggested that bone mineral density (BMD), menstrual status, anthropometric markers, and previous history of stress fracture are commonly considered as significant intrinsic risk factors for stress fractures. However, little evidence shows prospectively definitive models of prediction specifically for stress fractures in female endurance runners competing at the collegiate level. Thus, it is of significance to examine the strength of predictive capability of BMD, menstrual status, anthropometric markers, and previous history of stress fracture for stress fractures, which ultimately leads to more efficient preventative strategies to reduce this deleterious lower extremity injury. **Objective:** Develop a prediction model for lower extremity stress fractures in female collegiate endurance runners using measures of BMD, menstrual status, anthropometric markers, and a previous history of stress fracture. **Design:** Prospective cohort. Setting: Research laboratory. Patients or Other Participants: Fifty-four highly competitive endurance runners from a college (n = 54; 19.18 \pm 2.02 yrs; 160.07 \pm $4.08 \text{ cm}; 47.20 \pm 7.46 \text{ kg}; \text{BMI} = 19.09$ \pm 1.32 kg/m²) participated in the study. Interventions: Prior to the 2014-2016 seasons, participants were screened with dual X-ray absorptiometry (DXA) scan. Participants completed a self-reported menstrual questionnaire. Athletic Trainers with the team tracked and reported lower extremity stress fracture incidences. Main Outcome Measures: The following BMD and body composition parameters were assessed: whole-body BMD (g/

cm²); segmental BMD (pelvis and lower leg); whole body fat percentage (%); and BMI. The longest no menstruation period and the age of menarche were evaluated with the self-reported menstrual questionnaire. Independent-t-tests were performed to assess differences in each outcome between the groups. For risk prediction, receiver operator characteristic (ROC) curves were employed to calculate area under the curve (AUC) and asymptotic significance values for each dependent variable to examine group prediction accuracy. A Chi-square analysis was used to examine the association of self-reported previous stress fracture with stress fracture sustained during the season. Significance was set a priori at P < 0.05. Results: There were no differences in any intrinsic factors consisted of BMD and body composition parameters as well as menstrual status between the injured and uninured groups (P >0.05). The AUC from the ROC analysis for BMD, body composition, menstrual status demonstrated poor predictive capability (range, 0.27-0.69, P > 0.05). Chi-Square analysis demonstrated that self-reported previous stress fracture history did not associate significantly with a stress fracture sustained during the competition season (P = 0.169, odd ratio = 2.71, 95% CIs = 0.64, 11.52). Conclusions: Our findings revealed that BMD, body composition parameters, menstrual status, and a previous history of stress fracture might not be associated with stress fracture sustained during the competitive seasons. Future study should investigate other modifiable predictors, such as training volume and regimen as well as neuromuscular function, that may implicate increased risk for stress fractures.

Traumatic Acetabular Fracture and Complex Regional Pain Syndrome in a Male Ultra-Distance Runner Schellhase KC, Schwartzberg

RS: University of Central Florida, Orlando, FL

Background: During a training run, a 44-year-old male amateur recreational ultra-distance runner caught his right toe in the looped shoelace of his left foot during the swing-through phase of gait. He immediately fell to the ground and reported lack of function, but no pain. He was transported to the emergency room in an ambulance. The patient had no history of hip or pelvic pain and no history of stress fractures over an 18 year running career that included multiple marathons and seven ultra-distance races. Differential Diagnosis: Differential diagnoses included hip dislocation, femoral fracture, pelvic fracture, and muscle strain. Treatment: X-rays revealed comminuted displaced fractures to a large portion of the posterior acetabular wall. The two orthopedic trauma surgeons chose to delay surgery to allow swelling to subside. On day three, one physician noted that the patient's lower extremity was internally rotated. X-ray and computerized tomography revealed the hip was dislocated; therefore, the patient was anesthetized, realigned, and placed in traction. Open reduction and internal fixation, including placement of 2 plates and 7 screws, was performed on the fourth day. On the fifth day after discharge, he reported by phone to an athletic trainer that his pain was uncontrollable and that his right foot was hot, swollen and red. He was sent to the emergency room to be evaluated for a deep vein thrombosis (DVT). Doppler ultrasound and EMG-nerve conduction study were negative. He was diagnosed with complex regional pain syndrome (CRPS) and prescribed tramadol, Lyrica ®, and amitriptyline. Symptoms gradually resolved as the patient was allowed to increase activity. One year after the injury, the patient was able to run 100 Km/62 miles per month

without concerning signs or symptoms. Uniqueness: Acetabular fractures represent only 2% of all fractures and are usually caused by high-velocity trauma car accidents (80.5%). Only five cases of traumatic acetabular fracture are outlined in the literature: four were posterior wall fractures, three were treated surgically, and none involved a distance runner. There are no known studies that examine the epidemiology of CRPS related to hip trauma; however, studies examining the incidence following surgery to the lower limb range between 4.4% and 31%. Conclusions: This athlete suffered an early complication, but after a year is not presenting with any late complications such as hardware failure, avascular necrosis, or osteoarthritis. A positive outcome is most likely when: the articular surfaces have minimal damage (pre-existing and post-injury), there are not concomitant fractures/injuries, and the surgeon is able to position the femoral head in good alignment under the acetabular dome. The majority (75%-80%) of patients have good or excellent results within 5 years and only 8% require hip arthroplasty.

No Relationship Between Performance on the Single-Leg Squat and Injury in Female Runners

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Context: Individuals who sustain the most common running-related musculoskeletal injuries (RRMI) have been shown to have altered hip and knee biomechanics during single-limb weight-bearing activities. Altered hip and knee biomechanics potentially contribute to RRMI as running individuals endure repetitive single-limb weight-bearing activities, which has potential for chronic injury to develop. Although lower extremity biomechanical alterations have been observed retrospectively, it remains unclear as to whether these observed deficits were present prior to injury or are a result of the injury. Furthermore, there is insufficient evidence to confirm if biomechanical running deficits can be identified using a clinical assessment tool. The single-leg squat (SLS) task is a reliable clinical assessment tool that can be used to identify altered lower extremity and core biomechanics in a clinical setting. It remains unclear if a specific score on the SLS is associated with development of a RRMI in recreational runners prior to starting a marathon training program. **Objective:** Determine the influence of RRMI on SLS performance, and the ability of the SLS to differentiate female runners that do or do not sustain a RRMI during a marathon training program. Design: Prospective Cohort. Setting: Research Laboratory. Patients or Other Participants: Fifty healthy female recreational runners (39.01 ± 9.44) yrs; 165.35 ± 7.43 cm; 64.78 ± 11.95 kg) enrolled in a marathon training program volunteered. Interventions: A baseline assessment of bilateral performance on the SLS was completed. One practice trial followed by five

consecutive squats, from a 20cm block, were scored in real-time. Following the 16-week program, participants were designated into a RRMI (n = 15) or injury-free (INJF) (n = 35) group based upon diagnosis of a lower extremity RRMI, defined as a lower-extremity musculoskeletal injury as a result of running and requiring the modification or removal of running for at least one planned training day. Main Outcome Measures: All SLS were scored by a single clinician using previously established grading criteria and rated as 1 being "poor", 2 being "fair", and 3 being "good." Mann-Whitney U tests were used to compare group means of the SLS score. Chi-square analysis was used to determine relationship between SLS score and group. Significance was set at P < 0.05. Results: Baseline scores of the SLS were not different between RRMI and INJF runners (U = 261; Z = -0.04; P = 0.96). No relationship between a clinical score on the SLS and development of RRMI (1 = 6.7%; 2 =80%; 3 = 13.3%) was observed (INJF: 1 = 11.4%; 2 = 71.4%; 3 = 17.1%; P = 0.80). Conclusions: Although the SLS task has been used to identify altered movement patterns in athletes, SLS performance does not appear to have a relationship with development of a RRMI in runners. Future research should determine if specific movement patterns during the SLS task are associated with development of RRMI.

Free Communications, Poster Presentations: The Hip Bone Is Connected to the Back Bone

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Relationship Between Isometric Lower Extremity Strength and Functional Measures in Physically Active Individuals

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Context: Musculoskeletal rehabilitation's goal is to restore function. To enhance this process it is important to evaluate factors that are associated with functional performance. **Objective:** To determine the relationship between strength at the ankle, knee, and or hip with functional measures in physically active individuals. Design: Cross-sectional. Setting: Research Laboratory. Patients or Other Participants: Eighteen physically active individuals (Female = 9, Age $= 22.6 \pm 3.10$ yrs, Height = 166.60 \pm $12.90 \text{ cm}, \text{Mass} = 78.0 \pm 36.9 \text{ kg}, \text{Godin}$ Leisure Time Exercise questionnaire = 56.4 ± 23.5) participated in this study. Participants were excluded if they had a history of ankle sprains, history of lower extremity injury within the past 6 months, history of lower extremity surgery, or a condition that could affect balance. Interventions: Each participant completed two one-hour sessions within 2 weeks in a counterbalanced order. Sessions were separated by at least 24hrs. During one session, strength measures at the ankle, knee and hip were completed in a counterbalanced order. Strength testing was completed via maximal isometric contractions against a hand-held dynamometer (HHD). During the other session the triple hop for distance (THD) and hexagon hop test (HHT) were completed in a counterbalanced order. THD involved participants make three consecutive single-limb hops for maximal distance. HHT involved participants completing a series of single-limb hops in and out of a hexagon on the floor. Outcome measures were collected on a randomized limb and in a counterbalanced order. One practice trial was performed prior to 3 scored trials that were averaged and used for analysis. Main Outcome Measures: Ankle strength was measured for dorsiflexion (DF), inversion (IN), eversion (EV), PF+EV, and DF+EV). Knee strength was measured for flexion (FLX) and extension (EXT), while hip strength was measured for internal rotation (IR), external rotation (ER), abduction (ABD) and adduction (ADD). All strength measures were normalized to body weight. Functional measures the HHT and THD, were normalized for weight (THD-W) and height (THD-H). Spearman correlations were used to examine the relationship between strength and functional measures. Alpha was set a-priori at p < 0.05. **Results:** There were significant correlations between THD-W (5.42 [4.71-5.98] cm/kg) and IR (p = 0.001, r = 0.72, $r^2 = 0.52$, 1.39 [1.22-1.87] cm/kg), ER (p = 0.038, r = $0.49, r^2 = 0.24, 1.69 [1.51-2.21] \text{ cm/kg}$ ADD $(p = 0.001, r = 0.69, r^2 = 0.48, 1.49)$ [1.3-1.87] cm/kg), ABD (p < 0.001, r = 0.794, r^2 = 0.63, 1.58 [1.4-2.02] cm/ Kg), EXT (p = 0.048, r = 0.48, $r^2 = 0.23$, 3.51 [3-3.98] cm/kg, FLX (p = 0.007, $r = 0.61, r^2 = 0.37, 2.41 [1.89-3.06] \text{ cm}/$ kg), EV (p < 0.001, r = 0.76, $r^2 = 0.58$, 2.8 [2.07-3.55] cm/kg), IN (p < 0.001, $r = 0.80, r^2 = 0.64, 2.8 [2.07-3.55] \text{ cm}/$ kg), DF (p = 0.001, r = 0.70, $r^2 = 0.49$, 2.94 [2.45-3.52] cm/kg), PFEV (p = $0.014, r = 0.57, r^2 = 0.32, 3 [2.62-3.75]$ cm/kg), and DFEV (p < 0.001, r = 0.75, $r^2 = 0.56, 2.51 [1.7-3.15] \text{ cm/kg}$). There were no significant correlations between HHT and strength at the ankle (p = 0.742 - 0.900), knee (p = 0.575 - 0.810), or hip (*p* = 0.121-0.951). Conclusions: A significant positive correlation between THD-W and strength was identified. Furthermore, about 50% of the variance in THD-W was explained by

strength. Therefore, increases in ankle, knee, and hip strength during the early stages of rehabilitation could lead to enhanced function throughout the rehabilitation process.

Low Back Pain in Recreational Golfers

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Context: Low back pain (LBP) is common in recreational golfers. Research investigating the prevalence of back pain and the causal factors associated with LBP is valuable for directing and improving preventative and rehabilitative care for this population. Objective: To determine if a relationship exists between recreational golfers with LBP and asymmetrical or poor hip range of motion (ROM) or standing trunk flexion (FTF). Design: Cross Sectional Study Setting: Three public golf courses in northeastern PA Patients or **Other Participants:** Forty-six golfers (26 men, 20 women; mean age, $53.7 \pm$ 14.35 years) who played for at least 1 year $(24.69 \pm 15.9 \text{ years})$, and did not hold professional status. Interventions: Participants were recruited via flyers and email notices sent to members and golf league participants. Data collection consisted of ROM measurements and completion of an electronic survey. A randomly generated 4-digit code was used to protect confidentiality and enabled pairing of the data for analyses. ROM data (Hip active internal rotation (IR) goniometric measurements and FTF) were collected, and golfers were then given a card which contained their code and a link to the electronic survey. The survey was a 20-item author-derived questionnaire, which assessed participant's demographics, golf injury history, and play. The second section included the Owestry Low Back Pain Disability Questionnaire (ODI). Main Outcome Measures: Independent t-tests established if there was a difference in hip ROM symmetry between golfers who reported no LBP to those who did. A oneway ANOVA determined if differences existed between reported LBP and length of warm up. Finally, selected bivariate Pearson's correlations were conducted to identify correlations between hip

ROM and ODI scores. Results: Of the 46 golfers, 12 (16.2%) reported experiencing joint pain. Fifteen (33.3%) reported having been diagnosed with a low back pathology. Four (5.4%) reported suffering an episode of LBP while playing golf that required them to discontinue play. Seventeen (36%) reported low back pain after playing golf. ODI scores ranged from .00 to .20 with a mean score of .03 (\pm .049). Most golfers surveyed (80%) reported performing some type of warm-up prior to teeing off. The average warmup time prior to playing was 5.16 (+5.82) minutes. There was a correlation between warm-up time and HCP (r = -.315, p =.035). There were no correlations between hip IR ROM and ODI; however, ODI was correlated with FTF (r = .297, p = .045). <u>Conclusions</u>: This is one of the few works to investigate risk factors for LBP in both males and females recreational golfers. Although many of the recreational golfers in this study reported having either previous or current LBP that affected their play, the ODI scores indicated they have minimal overall low back disability. Time spent warming up was associated with lower handicap, but was not associated with decreased ODI.

A Comparison of Spinal Motion During Three Different Patient Transfer Techniques

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Context: In many states, changes to EMS protocol have eliminated the use of the spine board (SB) in favor of a cervical collar and ambulance stretcher for spinal motion restriction. The SB or scoop stretcher (SS) is commonly used to transfer the patient from the ground to the stretcher, however they are immediately removed following transfer. It is possible that lifting and lowering a patient directly onto the ambulance stretcher (LS) using a technique similar to the lift and slide SB method would eliminate the risk of unwanted motion when placing the patient on or removing the SB or SS. Objective: To compare cervical motion during patient transfer using SB, SS and LS. Design: A randomized single-blind cross-over design. Setting: Grass field. Patients or Other Participants: Ten college students (age = 20.6 ± 1.51 y, height $= 182.37 \pm 6.96$ cm, mass $= 85.2 \pm$ 10.01 kg) without cervical pain or dysfunction. Interventions: Participants reported for a single session and were transferred supine from the ground to an ambulance stretcher using three different techniques. A fitted cervical collar was applied for each condition. SB transfer began with a 6-plus-person lift and slide. The SB was then used to lift and lower the participant onto the ambulance stretcher. In the final phase, the lift-and-slide was used to remove the SB. SS transfer had similar phases, with the SS placed underneath the participant, lifting the participant onto the stretcher and removing the SS. The LS only utilized the second phase, which consisted of the 6-plus-person lift and slide to lift the participants and lower them directly onto the ambulance stretcher. Three trials were completed for each condition and the order of conditions was randomized. The rescuers performing the moves were a combination of certified athletic trainers, emergency medical

technicians and athletic training students. Main Outcome Measures: Cervical motion was assessed during each phase using a Polhemus Fastrak electromagnetic tracking system. The maximal angular change in relative position in each direction and the total angular excursions in all three planes were compared between SB and SS during the first and third phases and between all three techniques during the second phase. **Results:** No differences were observed between the three techniques when comparing sagittal plane motions ($F_{2,18} = 1.17, p = .332$). However, a significant difference in total angular excursion ($F_{218} = 11.73$, p = .001) was observed for rotation, as the LS $(10.12 \pm 3.62^{\circ})$ resulted in greater motion than SB $(7.08 \pm 2.47^{\circ})$ and SS $(6.81 \pm 1.49^{\circ})$. Similar observations were made for total angular excursion in the frontal plane ($F_{2,18} = 18.58$, p = .001). Conclusions: The LS requires greater lifting height which resulted in greater frontal and transverse plane motion. However, the differences were less than 4°, thus the clinical significance can be questioned. Given that two out of three phases are eliminated, the LS might still be the safer technique.

Abnormal Low Back Pain in a Division I Athlete Florentino AM, Knight AC: Department of Kinesiology, Mississippi State University, Mississippi State, MS

Background: In September 2016, a 19-year-old female Division 1 tennis player was practicing serves when a sharp pain was felt on the right side of her lower back. The following day, the athlete reported lower back pain on the right side and into the right hamstring. Assessment revealed painful AROM of trunk flexion, right lateral flexion, hip flexion, and hip extension. Three weeks after the initial injury, athlete began complaining of nerve pain in sacroiliac, coccyx, gluteal and hamstring regions. Pain onset was sudden and non-specific. As the nerve pain became constant, it localized to the coccygeal region, with single leg movements, such as a lunge, causing the pain to move into gluteal and hamstring regions. Athlete has a history of scoliosis. Differential Diagnosis: Muscle spasm, herniated disc, facet dysfunction, coccydynia, nerve pain. Treatment: Athlete was referred for an MRI, revealing edema at the right L4-L5 facet region and a stress fracture at the right L4 vertebral pars interarticularis. A CT scan confirmed bilateral, non-union, pars interarticularis fractures (spondylolysis) at L3, L4, and L5 segments with minor anterolisthesis at L5 level (spondylolisthesis). When medication for nerve pain was not effective, a back specialist requested a pelvic X-ray, which revealed an increased sacral/coccyx curvature. The athlete underwent a series of five injections (steroid, epidural, transforaminal) over a five-month period, to assist with nerve pain. In January 2017, the athlete saw a physical therapist who found that prone press-ups into lumbar extension decreased the athlete's nerve symptoms. This evaluation was followed with a bilateral transforaminal injection at L5/S1 and a bilateral facet block injection at L4-L5 and L5-S1. This gave the athlete the most pain relief since initial injury.

With a modified practice schedule along with core exercises, the athlete was cleared for play and participated in the spring tennis season. In June 2017, the athlete had a second MRI and an EMG study as the pain had grown throughout the season. The MRI showed increased edema and cyst formation at right L4-L5 facet. The EMG study was normal. At this time, the athlete was removed from activity and began a postural restoration program as well as 20 minutes of underwater treadmill walking 4-5 times/week. The athlete followed this program for two months and it provided significant pain relief. In August 2017, the back specialist saw the athlete who concluded that excessive scar tissue had formed in an attempt to heal the fractures, and when performing lumbar extension, the scar tissue was compressing the nerves and the release from extension was causing the nerve pain. The specialist recommended a modified practice schedule, a flexibility and core rehabilitation program and prescribed diclofenac for pain. The diclofenac has significantly assisted in pain reduction. To date, the athlete is practicing three times a week and has competed in three fall tennis tournaments with significantly less pain. The athlete performs the postural restoration exercises before and after exercise. Uniqueness: While spondylolysis and spondylolisthesis injuries can be common in sports that require hyperextension, instances where radiculopathy is present or is the chief complaint is extremely rare. The athlete's presentation was also abnormal as presented with flexible hamstrings, tight hip flexors, painful forward trunk flexion and relief in trunk extension. Conclusions: Spondylolysis and spondylolisthesis injuries should be treated specific to the patient. Thorough evaluations are necessary to allow the practitioner to identify what elicits pain or discomfort. Finding an appropriate rehabilitative plan of action can make a positive difference in return to play.

Acetabular Labral Tear in a Female Patient With Chronic Upper and Lower Extremity Spasticity

Moore MA, Felton SD, Craddock JC, Klassen SI: Florida Gulf Coast University, Fort Myers, FL; Bonita Springs Sport and Physical Therapy, Bonita Springs, FL

Background: Level 4 Case study presents a 36 year-old female teacher (167.6 cm and 54.4kg). Patient's prior medical history included left upper and lower extremity spasticity from a traumatic brain injury when she was 8 years old. Patient first reported to an orthopedic specialists to have images taken after a fall while playing Frisbee, resulting with the patient landing on her posterior right hip. Patient was then given a referral to physical therapy where the patient complained of right anterior hip pain. Initial evaluation revealed antalgic gait secondary to pain. Patient was point tender over right anterior superior iliac spine, iliopsoas, proximal iliotibial band, and piriformis. Full Active ROM with exception of hip abduction active ROM at 20 degrees. Patient presented with a 4+/5 for manual muscle tests of hip flexion and abduction, 4/5 external rotation, 4-/5 internal rotation and full strength for hip extension and adduction. (+) Faber's Test for Pain, (+) Hip Scouring, (+) Anterior Impingement Test, (+) Thomas Test and (+) Trendelenburg's Test. Differential Diagnosis: Labral tear, Hernia, Athletic Pubalgia, Osteitis Pubis, OA, Bursitis, Referred pain from Lumbosacral region, Adductor strain, Snapping hip syndrome, Osteochondral defect, Femoral acetabular impingement, Hip dysplasia, Avascular necrosis of the Femoral head. Treatment: Patient began treatment immediately after initial evaluation, with goals to increase active ROM, correct faulty biomechanics, decrease pain and ultimately increasing strength and stability of the right hip. Focusing first on treating symptomatically, soft tissue mobilization was used to decrease the restricted motion of soft tissue and facilitate fluid exchange to aid the healing process. After, the patient was treated with electrical simulation in addition to cryotherapy. During the next three consecutive visits, therapy began with therapeutic exercises to increase stability at the acetabulofemoral joint. This is where the patent began to have difficulty completing lower extremity therapeutic exercises with a history of chronic spasticity. A modified extensive therapeutic exercise program was created to ensure proper rehabilitation of the patients right labral tear without the chronic spasticity hindering progression. Uniqueness: Acute labral tears is a fairly common hip injury. It is estimated that acetabular labral tears account for more than 20% of young adults who present with groin pain. However, chronic spasticity is not a common comorbidity with labral tears, and can largely impact the rehabilitation process with limitations of therapeutic exercises. Spasticity can cause pain, contractures, impairment of ambulation, and restrictions in activities of daily life. Evidence has indicated that electrical nerve stimulation has been used to reduce spasticity in patients, which enables stretching, mobility training and functional training to take place. Electrical stimulation is beneficial not only to the labral tear, but also to the patient's chronic left upper and lower extremity spasticity. This case is unique because there is no evidence-based research on the outcomes and efficacy of treating acetabular labral tears in a patient with chronic spasticity from a traumatic brain injury. Conclusions: This case highlighted the diagnosis and treatment of a patient suffering from an acetabular labral tear with chronic left upper and lower spasticity. This case further highlighted the success of electrical stimulation during treatment to enhance mobility and functional training, as well as decreasing pain. Furthermore the complexities of rehabilitation with a unique comorbidity were discussed, leading to a modified therapeutic exercise plan to limit pain and ensure proper rehabilitation of the acetabular labral tear without the chronic spasticity hindering progression.

Management and Treatment of Lumbar Sacralization in a College Volleyball Player Enriquez A, Felton SD, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: This Level 4 CASE report presented an athlete who was a 21-year-old female NAIA volleyball player standing, (167.64 cm, 60.32 kg) and is of Hispanic ethnicity. Athlete did not have any previous history of low back pain or symptoms prior to the end of prior volleyball season 1 year ago. Athlete reported to the athletic trainer after a practice during junior volleyball season complaining of achy, low back pain that recently began to affect her performance. Athlete stated she first felt the pain in her low back after a "twisting" motion occurred during practice the day before. Initial evaluation did not reveal any obvious deformities or signs of trauma. Athlete stated that most of her pain was over the SI joint and tailbone, mild pain in the gluteal region, but had full active ROM. Differential Diagnosis: SI joint sprain, Lumbar sprain, Lumbar Disc herniation, Sciatica Treatment: Athlete began a conservative approach to treatment with emphasis on pain management. When athlete first reported to the athletic training room for treatment, conservative contemporary therapeutic modalities including heat and electrical stimulation, set on symmetrical biphasic, were utilized for pain management. The athlete reported an increase of lower back tightness the next day; thus treatment modalities were modified to ice and pre-modulated settings for electrical stimulation were utilized instead. Athlete still reported no change in symptoms and pain level so she was referred to the team physician to be evaluated. Athlete underwent a full evaluation and an X-ray was conducted. X-ray imaging revealed athlete had lumbar sacralization, meaning her L5 vertabrae was fused to her S1 creating a sixth lumbar joint. Treatment after diagnosis entailed manual therapy, ultrasound, and stretching of the surrounding musculature. Athlete was also held from team activities for three weeks to limit stresses placed on her low back and then began spinal stabilization exercises. **Uniqueness:** Sacralization of the fifth lumbar vertabrae is a congenital anomaly that can affect the daily living of an individual as well as affect the functionality of the spine and limit certain movements. Many ensuing problems can occur from the fusion of L5 and S1 including nerve entrapment, low back pain, and increased load to the L1 to L4 lumbar vertabrae causing disc herniation. Currently, treatment focuses on pain management with the possibility of removal of the extra lumbar joint created from the fusion through surgical intervention. Conclusions: This case report illustrated the diagnosis, treatment, and management of an athlete with lumbar sacralization and her ability to continue to participate in collegiate sports. This case also served as an example of an athlete who was asymptomatic before a certain movement/action led to the medical diagnosis. This case study also discussed the implications of lumbar sacralization on the human body and its effects on movement as well as analyzed the effects of conservative treatments and the literature surrounding this condition.

Directed Meditation Has Minimal Short-Term Effect for Adults With Chronic Low Back Pain (LBP) Marenzi AL, Medina McKeon JM: Ithaca College, Ithaca, NY

Context: LBP is a leading cause of disability in adults in the US, yet current interventions are inconsistent for improving function and pain. **Objective:** To quantify the effect of directed meditation for decreasing disability in adults with chronic LBP. Data Sources: PubMed was searched using iterations of "meditation", "mindfulness", and "low back pain" through 9/17 and limited to studies published after 2012. A hand search followed. Study Selection: Selection criteria required studies 1) were performed on adults (>18years) with chronic LBP, 2) implemented a meditation or mindfulness program (Meditation); 3) incorporated a control condition, which could include health education, home-based exercise program, flexibility program, or rest (Standard Care). Data Extraction: Two investigators extracted the following 1) disability, as measured by the Roland Morris Disability Index (RDQ)[higher scores indicate worse symptoms]; and 2) physical or mental interference with daily life (Bothersome), caused by LBP [100-mm indicates most bothersome pain]. Means, standard deviations, and sample sizes were extracted at 8- & 26-weeks post-treatment. Hedge's g effect sizes (ES) [95% CIs] were calculated to determine group differences (Meditation vs. Standard Care) at the identified time points. Two summary models were also used to pool data separately for the 2 time points. The PEDro scale was used to identify potential threats to validity. Data Synthesis: Three studies satisfied criteria for inclusion. The control condition varied: a home-based exercise program, rest, and a health education/stretching program were each used as control conditions. At the 8-week time point, there was a weak effect for Meditation on improvement of LBP, as indicated by the RDQ (ES = 0.2 [0.0, 4.0], p = 0.02) and by the Bothersome outcome (ES = 0.3 [0.1, 0.6], p = 0.004). At 26-weeks, this trend did not improve for the RDQ; there was a stronger effect, however wide CIs that encompassed zero (ES = 0.6 [-0.4, 1.5], p = 0.24). For the 26-week Bothersome outcome, there was little change from 8-weeks (ES = 0.3 [0.01, 0.5], p = 0.04). PEDro scores ranged from 7 to 8/10. All 3 studies failed to blind the participants and therapists. Conclusions: There was little positive effect of short-term directed meditation on chronic LBP. However, all 3 experimental groups showed more improvement in disability and back pain interference than the controls. In particular, LBP-associated interference in daily life (Bothersome) did have a small, but consistent effect on reducing this perception. The ability to consciously regulate thoughts through meditation is a complex skill that needs time to master. For the included studies, the time points of 8- and 26-weeks may be too short for the participants to acquire this complex skill, and also to strongly affect a chronic condition. Although meditation did not strongly affect disability associated with chronic LBP in the short-term, their future research should focus on identifying which conditions are most likely to respond to meditation training and also the dosage necessary to evoke positive change.

The Relationship Between Duration of Symptoms and Pre-Operative Pain Catastrophizing Scores in Patients With Femoral Acetabular Impingement Kocan KR, Jochimsen KN, Noehren B, Jacobs CA, Duncan ST: University of Kentucky, Lexington, KY

Context: Femoral acetabular impingement (FAI), an anatomical deformity of the femur and/or acetabulum, has been shown to have high incidence rates among active individuals. Not all diagnosed with FAI experience pain. Recent studies in patients with FAI have found mental health to be a significant factor in severity of preoperative symptoms rather than the magnitude of the deformity. Pain catastrophizing (PC), an important psychosocial factor affecting a patient's ability to cope with pain, has proved to be reliable when assessing how a patient views their pain. Patients who score 19 or above on the Pain Catastrophizing Scale (PCS) demonstrate rumination, magnification, and a feeling of helplessness with pain sensations. Research reveals the PCS to be related to poor pain outcomes and disability in patients with total knee arthroplasty and low back pain. Unlike other musculoskeletal injuries, there is little research done on whether duration of symptoms is correlated with pain catastrophizing in patients who have symptomatic FAI. Objective: The purpose of this study was to determine if PC behaviors are more severe with patients diagnosed FAI who have had symptoms longer than six months compared to those with symptoms less than six months. Design: Cross sectional observation study. Setting: Orthopaedic clinical practice at an academic medical center. Patients or Other Participants: Symptomatic patients with radiographically-confirmed FAI and no previous history of hip arthroscopy. Subject group consists of 6 males and 17 females, with a mean age of 39 ± 10 years of age. Patients with any neurological condition that may alter pain processing

were excluded. Interventions: Patients completed the PCS and a self-reported duration of hip symptoms. Main Outcome Measures: An independent t-test was used to determine if PC scores differed between two groups: individuals with pain for more than six months (LONG; N = 17), and individuals with pain for less than six months (SHORT; n = 7). A Fishers Exact test was used to compare the number of people with PCS of 19 or above between the two groups. Results: While not statistically significant, PC scores tended to be higher for those in the LONG group (21.4 vs 13.0, p = 0.053). Similarly, the number of people who scored 19 or higher on the PCS was somewhat greater in the LONG group, albeit not significant (10/17, 59% vs, 1/7, 14%, p = 0.078). Conclusions: In this preliminary study, PC behaviors tended to be more common in FAI patients with a longer duration of symptoms. This pilot data suggests that reducing the time to appropriately diagnose and treat may lessen the severity of catastrophizing behaviors. Additional studies are necessary to determine if FAI patients with increased preoperative PCS scores and/ or longer duration of symptoms demonstrate worse postoperative outcomes and, if so, to develop coping interventions to ultimately improve outcomes.

Mediating Effects of Gluteal Function on the Relationship Between Femoral Alignment and Functional Valgus Collapse

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Context: An anatomical bias toward femoral internal rotation is a potential precursor to functional valgus collapse, a potential risk factor for ACL injury. Gluteus maximus and medius may play a critical role in mitigating the effects of sub-optimal femoral alignment. **Objective:** Determine the extent to which femoral anteversion (FA) and internal and external rotation hip ROM (ROM_{IR} and ROM_{ER}) are associated with functional valgus collapse during a single-leg forward landing task, and the extent to which these relationships are mediated by gluteal strength and activation. We hypothesized that 1) greater FA and ROM_{IR} and lesser ROM_{ER} would predict greater knee abduction, hip adduction, and hip and knee internal rotation joint angles and external moments, and 2) gluteal strength and activation would mediate the relationship between anatomy and biomechanics. Design: Cross-sectional Setting: Research laboratory Patients or Other Participants: Forty-five females $(20.1 \pm 1.7 \text{ yr}, 165.2 \text{ s})$ \pm 7.6 cm, 68.6 \pm 13.1 kg) and forty-five males $(20.7 \pm 2.0 \text{ yr}, 177.7 \pm 8.5 \text{ cm},$ 82.8 ± 16.3 kg), injury-free for six months. Interventions: FA and ROM were measured prone with the knee at 90°. Hip extension and abduction MVICs were obtained with a handheld dynamometer. 3D biomechanics and electromyography were obtained during five trials of the landing task. Main Outcome Measures: Forwardstepwise regressions determined the extent to which FA, ROM_{IR} and ROM_{ER} were associated with each biomechanical variable (first step), and the extent to which gluteal strength and activation
influenced these relationships (second step). **Results:** In males, less FA (part r range = -.31 - -.33) and greater ROM_{IR} (part r = .21) predicted greater initial $(R^2 = .13, p = .13)$ and peak $(R^2 = .22, p = .22)$ p = .02) knee internal rotation, and less peak knee external rotation ($R^2 = .14$, p = .18). On the second step, less hip abduction strength (part r range = -.34 --.41) strengthened the overall prediction of greater initial ($R^2 = .25$, p = .02) and peak ($R^2 = .39$, p = .001) knee internal rotation, and lesser peak knee external rotation ($R^2 = .26$, p = .03), and decreased the part correlations between anatomy and knee rotation (FA Δr range = .02-.06, $\text{ROM}_{\text{IR}} \Delta r = -.15$). In females, less FA (part r = -.18), greater ROM_{IR} (part r range = .21- .31), and greater ROM_{ER} (part r range = .23-.31), predicted greater initial ($\mathbb{R}^2 = .11$, p = .31) and peak (\mathbb{R}^2 = .28, p = .02) knee internal rotation. On the second step, increased gluteus maximus activation (part r range = .32-.37) strengthened the overall prediction of greater initial ($R^2 = .21$, p = .09) and peak ($R^2 = .42$, p = .001) knee internal rotation, and also strengthened the part correlations between anatomy and knee rotation (FA $\Delta r = .07$, ROM_{IR} Δr range = .09-.11). Conclusions: Across sex, less FA and greater ROM_{IR} predicted greater knee internal rotation, while gluteal function explained additional variance. Lower hip abduction strength mediated the relationship between anatomy and knee biomechanics in males, while greater gluteus maximus activation strengthened these relationships in females. Further research is needed to understand the extent to which the gluteals' can counteract poor femoral alignment in controlling dynamic knee rotation.

Evaluation of Core Strength and Fitness Exercises in Xcel Competitive Youth Gymnasts Thatcher A, Snyder Valier AR, Williams RM: AZ Sports Center Physical Therapy and Conditioning Inc, Chandler, AZ; A.T. Still University, Mesa, AZ

Context: The USA Gymnastics Xcel program allows gymnasts with varying skills the opportunity for competitive experiences. Evaluating core strength and fitness exercises related to unique needs of competitive gymnasts may benefit successful and injury-free participation. Little is known about core strength and fitness values on gymnastics-related exercises in gymnasts. **Objective:** To describe values for core strength and fitness exercises in youth Xcel competitive gymnasts. Design: Retrospective data review. Setting: Gymnastics facility. Patients or Other Participants: A convenience sample of records from 52 female USA Gymnastics Xcel Program gymnasts [Bronze-Silver group (BS): n = 39; age (years): 10.3 ± 1.7 ; height (in): 56.0 ± 4.7; weight (lbs): 79.0 ± 21.0 ; hours per week in gym: 7.1 ± 3.4 ; years in gymnastics: 3.7 ± 2.2 and Gold-Platinum group (GP): n = 13; age (years): $13.8 \pm$ 2.4; height (in): 60.8 ± 2.4 ; weight (lbs): 108.5 ± 25.6 ; hours per week in gym: 12.4 \pm 3.7; years in gymnastics: 8.2 \pm 3.3] were reviewed. Interventions: Independent variable was Xcel gymnastics level: BS or GP. Dependent variables were core strength and fitness exercises: plank holds for 120 seconds maximum (front, right, left), single leg bridge (SLB) hold for 60 seconds maximum (right, left), number of pike leg lifts, number of pull-ups, number of push-ups, hollow body hold for 60 seconds, and degrees from horizontal for double leg lower down (DLLD). Main **Outcome Measures:** Descriptive statistics for core strength and fitness exercises are presented (frequencies percentages, means ± SD, range). Results: BS gymnasts held front plank for 102.45 \pm 22.86 (range: 60.00-120.00) seconds and GP held front plank for 102.11 ±

22.22 (range: 65.00-120.00) seconds. Right plank holds were 42.40 ± 24.53 (range: 7.68-95.00) seconds in BS and 57.65 ± 21.31 (range: 18.00-83.00) seconds in GP. Left plank holds were 44.28 ± 27.75 (range: 2.30-120.00) seconds in BS gymnasts and 54.92 ± 30.32 (range: 16.00-105.00) seconds in GP. One of 39 (2.6%) BS and 4/13 (30.8%) GP gymnasts performed the hollow body hold for 60 seconds with an average time of 21.85 ± 15.96 (range: 0.00-60.00) seconds for BS and 34.69 \pm 20.95 (range: 0.00-60.00) seconds for GP. Sixteen of 38 (42.1%) BS and 7/13 (53.8%) GP gymnasts performed right SLB hold for 60 seconds (BS: $45.42 \pm$ 16.41 [range: 13:00-60.00]; GP: 51.73 \pm 13.66 [range: 19.00-60.00]), while 18/39 (46.2%) BS and 7/13 (53.8%) GP gymnasts performed left SLB hold for 60 seconds (BS: 43.04 ± 19.19 [range: 7.50-60.00]; GP: 52.56 ± 12.10 [range: 19.00-60.00]). On average, gymnasts performed 2.46 ± 3.40 hanging pike leg lifts (BS: 1.97 ± 3.08 ; GP: 3.92 ± 4.01), 1.84 ± 2.45 pull-ups (BS: 1.31 ± 1.84 ; GP: 3.58 ± 3.37), and 9.88 ± 5.84 pushups (BS: 9.13 ± 5.37 ; GP: 12.33 ± 6.84). Gymnasts were able to maintain neutral spine until legs reached 26.02 ± 15.83 degrees from horizontal (BS: 27.59 \pm 15.42; GP: 21.31 \pm 16.75) on the DLLD exercise. Conclusions: These data provide a first report on descriptive characteristics of gymnastics-related core strength and fitness exercises in youth Xcel competitive gymnasts. Knowledge of these values may initiate discussions about measuring gymnasts' core strength and fitness levels to tailor training programs to maximize performance and minimize injury risk.

Pain Catastrophizing Behaviors Are More Common in Patients With Femoro-Acetabular Impingement of the Hip Than Acute Anterior Cruciate Ligament Injuries Jochimsen KN, Mattacola CG, Duncan ST, Lattermann C, Jacobs CA: University of Kentucky, Lexington, KY

Context: Pain catastrophizers respond to anticipated or actual pain in a manner that is both maladaptive and unconstructive to rehabilitation. It has been shown that pain catastrophizing can change during the rehabilitation process in acute injuries, such as anterior cruciate ligament (ACL) reconstruction; however, it is often described as static in chronic conditions such as femoral acetabular impingement (FAI). Understanding the frequency and severity of catastrophizing is important in developing appropriate interventions. **Objective:** The purpose of this study was to compare the number of patients with moderate to severe catastrophizing behaviors between two injury groups (FAI and ACL). Additionally we aimed to examine the severity of the catastrophizing behaviors between these groups. We hypothesized that Pain Catastrophizing Scale scores (PCSs) would be significantly higher and more common in patients with FAI. Design: Cross-sectional Setting: Orthopedic sports medicine clinic Patients or Other Participants: A total of 65 patients (25 FAI, 8 M/17 F, age 39.6 ± 10.3 years, BMI $25.6 \pm 3.6/$ 40 ACL, 23 M/17 F, age 22.34 ± 4.15 years, BMI 23.9 ± 3.1) participated. Interventions: Patients completed the PCS at the time of surgery (ACL) or initial presentation (FAI). Main Outcome Measures: PCSs were compared between groups using an independent t-test, and the number of patients with PCSs greater than 19 was analyzed between groups using a Fisher Exact test. Results: PCSs were significantly greater for FAI patients than ACL patients $(19.3 \pm 13.0 \text{ vs. } 2.5 \pm 3.8, \text{ p} < 0.001).$ Significantly more patients with FAI

were considered catastrophizers using a PCS cut-off score of 19 (12/25 vs. 0/40, p < 0.001). <u>Conclusions:</u> Pain catastrophizing behaviors were significantly more common and severe in patients with FAI when compared to ACL injury. These findings support our hypothesis and suggest that the chronicity of the condition may result in more frequent and/or more severe catastrophizing behaviors. Future studies are necessary to determine if interventions aimed at decreasing catastrophizing behaviors in FAI patients may improve clinical outcomes.

Free Communications, Poster Presentations: Therapeutic Modality Uses

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM Authors present June 24: Peer Paview Authors – Last Names A through M: 10:20AM 11:15AM; Peer

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Effect of Theraworx Relief on Night-Time Leg Cramps and Associated Symptoms

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Context: Nocturnal Leg Cramps (NLC) is a musculoskeletal disorder presenting as sudden, episodic, persistent painful, involuntary contractions of the leg muscles at night. Approximately 33% of individuals age 50 years and older report NLC with 50% of the population over the age of eighty reporting NLC. NLC are associated with poor sleep quality, quality of life and depression. Theraworx Relief[™] is a topical therapy containing magnesium sulfate and anecdotal evidence indicates this therapy reduces leg cramps among athletes. **Objective:** The purpose of this study was to determine the effect of Theraworx Relief[™] on the frequency and severity of NLC and associated symptoms, including sleep quality, quality of life and depression. Design: Double blind randomized clinical trial Setting: Outpatient chiropractic, physical therapy clinic **Patients or Other** Participants: 49 subjects who reported NLC at least three times per week Interventions: Subjects completed a 2-week period of no treatment followed by a 2-week treatment period. At the end of the first 2 weeks, subjects were randomized into 1 of 2 study groups, Theraworx Relief[™] (1) or Placebo (2). During the 2-week treatment period all subjects were instructed to apply their assigned topical treatment to their legs bilaterally before retiring in the evening. Main Outcome Measures: Subjects self-reported their sleep quality, quality of life and depression upon entering into the study (Baseline), following two weeks of no treatment (Post Control) and again following 2 weeks of either topically applying Theraworx ReliefTM or a placebo (Post Treatment). In addition, subjects completed a daily diary indicating the frequency and severity of NLC which were collapsed into weekly intervals. Results: At Baseline, the placebo (24) was similar to the Theraworx Relief[™] (25) on all outcomes and most demographics. Following the trial, 60% of the group receiving the Theraworx Relief[™] claimed a benefit, while 41% of the placebo claimed a benefit ($\chi^2 = 1.65$, p = 20). Theraworx ReliefTM exhibited significant declines in the frequency and severity of NLC between week 1 and 4. Subjects receiving Theraworx ReliefTM exhibited significant (p < .05) improvements between Baseline and Post Treatment and Post Control and Post Treatment on sleep quality, quality of life and depression. The placebo did not significantly change on any of these measures over time. Conclusions: Individuals who experienced NLC three or more times per week reported a significant reduction in leg cramps and improved their sleep quality, quality of life and depression and as a result nightly use of Theraworx Relief[™]. The current study presents evidence that Theraworx Relief may provide relief from NLC. Since Theraworx Relief[™] is an over the counter homeopathic treatment with a no know side effects, practitioners may prescribe this therapy in treating NLC.

Effect of Cryotherapy to a Muscle Compared to a Joint on Functional Performance Lauber CA, Dudash J, Hoffman M, Vandergrift M: University of Indianapolis, Indianapolis, IN

Context: Cryotherapy is a common intervention used to treat acute and chronic injuries, and it can be used to facilitate rehabilitation exercises. A common practice in athletic training is allowing a patient to return to activity after the application of some type of cryotherapy. However, the effect of applying cryotherapy to a muscle or a joint on functional performance is unclear. Objective: To investigate if cooling a muscle compared to cooling a joint affects functional performance in healthy, active individuals. Design: Controlled laboratory study Setting: Laboratory Patients or Other Participants: Fortyfive healthy, college student volunteers (21 males; 24 females) with ages ranging from 18 to 23 years (M = 20.67; SD = 1.09). Interventions: Subjects were randomly assigned to muscle (low leg) cryotherapy, joint (ankle) cryotherapy, or control (no cryotherapy) intervention for 20 minutes Main Outcome Measures: After a 10 minute warmup, subjects performed practice trials of a shuttle run and single leg vertical jump (SLVJ). Subjects performed three trials of a shuttle run (4 - 6.1 m)sprints) for time, and performed three trials of a SLVJ (Vertec) for height measured prior to and immediately following the intervention. A mixed model ANOVA with a Bonferroni Correction was used to determine significant interactions between intervention groups and times with an alpha level of .05 for statistical significance Results: For the SLVJ, there was a significant interaction between the intervention groups and time; F(2,42) = 3.349, p = 0.045; however, group differences were unable to be determined. The muscle intervention group had a significant decrease in jump height between pre- (M = 12.24,

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SD = 3.61) and post-test (M = 10.89, SD = 3.21; p = 0.01. For the shuttle run test, there were no significant interactions between group and time; F(2,42)= 0.747, p = 0.480. The joint (pre-M = 7.43, SD = 0.77; post-M = 7.56, SD =0.70); p=0.036, and muscle (pre-M =7.63, SD = 0.71; post-M = 7.79, SD =(0.78); p = 0.013 intervention groups had a significant increase in run times between pre- and post-test Conclusions: Cryotherapy application for 20 minutes to a muscle (low leg) significantly decreased SLVJ height and increased shuttle run time; while, cryotherapy application for 20 minutes to joint (ankle) significantly increased shuttle run time pre-to post-test. These results confound the literature, which predominately indicates functional performance is decreased after application to a muscle and is not decreased after application to a joint. In a situation where cryotherapy application is utilized on an individual prior to performance, a warm-up should be initiated prior to returning or beginning activity to prevent a decrease in functional performance.

The Effects of Intermittent Compression on Acute Muscle Recovery

Gillespie M, Powers ME, Henry KJ: Marist College, Poughkeepsie, NY

Context: Optimizing recovery during competition is beneficial for performance and injury risk. The inability to maintain performance in the second half of competition is frequently attributed to peripheral fatigue involving metabolite accumulation and muscle microtrauma. Thus, various techniques have been suggested to accelerate metabolite clearance and optimize recovery. Intermittent pneumatic therapy (ICT) using extremity compression sleeves is commonly used to enhance recovery and performance in the days following intense training. However, at this time the effects of ICT on acute recovery has not been assessed. **Objective:** To assess the effects of ICT on acute recovery during halftime of simulated competition. Design: A randomized single-blind cross-over design. Setting: Athletic training facility. Patients or **Other Participants:** Eight healthy recreationally active males and females $(age = 20.0 \pm 1.77 \text{ y, height} = 176.5 \pm$ 6.93 cm, mass = 72.28 ± 9.67 kg) who did not suffer from any ICT contraindications. Interventions: Each participant reported to the facility for three sessions separated by a period of one week. The first session was used for familiarization and to assess 20-m sprint time and maximum vertical jump height (Vert....). The next two sessions included a bout of exercise consisting of four 15-min quarters (Q1, Q2, Q3 and Q4) of intermittent high-intensity shuttle running, lasting approximately 60-min. Each quarter consisted of 10 repetitions of a shuttle running protocol that included 3x20-m of walking ($\approx 30\%$), two vertical jumps while attempting to hit a target centered at 80% of the Vert_{max}, 1 x 20-m maximal sprint, 3 x 20-m of fast-paced running ($\approx 65\%$), two more vertical jumps at the target, then 3x20-m of jogging (50%). At the end of Q2, participants completed one of two treatment conditions, ICT or control. The ICT condition utilized

the NormaTec MVP Recovery System (Normatec, Newton Center, MA) that was applied using manufacturer's instructions for a 10-min treatment. The control condition consisted of seated recovery with no modality for 10-min. When subjects returned for the third session, they were assessed under the remaining condition following identical procedures. Main Outcome Measures: The mean of 10 maximal 20-m sprints was determined for each quarter using a Brower timing system (Draper, UT). The mean height of 20 jumps performed in 60-sec was recorded using the Just Jump recorder and jump mat (Probotics, Huntsville, AL) at baseline and following each quarter. Results: No differences were noted when comparing mean jump height ($F_{321} = 1.98$, p = 1.25). Halftime treatment had an effect on sprint time ($F_{3,21} = 4.02$, p = .021), as Q3 $(3.64 \pm .28 \text{ s})$ and Q4 $(3.71 \pm .31 \text{ s})$ were significantly slower than Q1 (3.54 \pm .30 s) following the control condition. Q4 was also significantly slower than Q2 $(3.62 \pm .32 \text{ s})$. No differences were noted following ICT. Conclusions: ICT applied during a halftime improved sprint time recovery but did not affect muscle power. Thus, ICT can be considered beneficial for performance and injury prevention.

A Comparison of ThermoStim™ and Therapeutic Ultrasound and Their Effect on Achilles Tendon Temperature

McGovern E, Powers ME, Gildard M: Marist College, Poughkeepsie, NY

Context: Therapeutic ultrasound (US) is an effective deep heating modality that is commonly used in the management of tendon pathologies. The ThermoStim Probe™ (TS) is a soft-tissue mobilization tool that also allows a practitioner to deliver superficial heat or cold. Manufacturers claim that temperatures can reach 44°C and that target temperature can be reached within 60 sec. However, TS efficacy has not been reported in the literature. **Objective:** To examine and compare the effects of TS and US on achilles tendon temperature. Design: A randomized single-blind crossover design. Setting: Athletic training research laboratory. Patients or Other Participants: Ten healthy males and females (age = 21.4 ± 1.8 y, height = 171.0 ± 13.8 cm, mass = 79.3 ± 14.0 kg) who did not suffer from any contraindication to superficial heat or US volunteered. Interventions: Participants reported to the laboratory on two occasions separated by a minimum of one week. Upon arrival, for the first session, participants were randomly assigned to receive either TS or US treatment. The TS was administered using the Dynatronics Solaris® Plus 709 (Dynatronics, Salt Lake City, UT) with the probe placed over the posterior aspect of the tendon and maintained stationary throughout the treatment. The US was applied using the same Solaris unit with a 2 cm² soundhead and was administered continuously at a frequency of 3 MHz and an intensity of 1.0 W/cm2. The area of treatment was identical to the surface area of the TS. When the participants returned for the second session they received the remaining treatment using identical procedures. Main Outcome Measures: Upon arrival for each session, participants were prepped and a sterile IT-18 thermocouple (Columbus Instruments, Columbus, OH) was inserted at a depth of 2 cm to the thickness midpoint of the achilles tendon using previously described methods. Temperature was monitored and recorded using an Isothermex thermometer (Columbus Instruments, Columbus, OH). Once the tendon temperature stabilized, the treatment was administered and temperature was recorded every 5 sec. The treatment continued until temperature increased 5°C from baseline. At this time, the time to reach a 5°C was recorded and the treatment was discontinued. Temperature continue to be monitored and the time to decrease 1°C and the time to return to baseline were recorded. Results: Time to increase tendon temperature 5°C did not differ $(t_0 = .369, p = .721)$ between US (3.85 \pm 1.95 min) and TS (4.20 \pm 2.82 min). However, tendon temperature took significantly longer ($t_0 = 4.28$, p = .002) to cool 1°C following TS $(3.83 \pm 1.14 \text{ min})$ as compared to US (1.48 \pm .76 min). Likewise, tendon temperature took significantly longer ($t_0 = 4.58$, p = .001) to cool to baseline following TS (28.29 \pm 8.42 min) as compared to US (14.10 \pm 3.83 min). Conclusions: While neither treatment heated the achilles tendon faster, temperature remained elevated in the tendon following TS significantly longer than following US.

The Effect of Continuous Cryotherapy on Skin Blood Flow as Well as Skin and Intramuscular Temperatures

Trowbridge CA, Brothers RM: The University of Texas at Arlington, Arlington, TX

Context: Localized continuous cryotherapy units (CTUs) are used to treat musculoskeletal injuries. Although CTUs are beneficial there are some detrimental side-effects such as nonfreezing cold-induced injury (NCFI) resulting in tissue necrosis or neuropathy. We recently identified a prolonged period of cold-induced vasoconstriction that continues for hours even after the return of skin surface temperatures toward baseline. Therefore, the use of CTUs in a continuous application pattern may result in NCFI. Objective: To investigate the effect of active vs passive rewarming on skin and intramuscular temperature and skin blood flow (Sk_{RE}) following two bouts of 30 min of lower leg skin-surface cooling with CTU. Design: Within repeated measure design. Setting: Laboratory. Patients or **Other Participants:** Nine healthy males volunteered for study (age = 25 ± 2 yrs, mass = 87 ± 12 kg). All had no current lower extremity injuries. Interventions: Intramuscular temperature was assessed 1cm deep in proximal lateral gastrocnemius muscle along with laser Doppler flowmetry probes to measure skin surface temperature and blood flow. Cooling of the treatment area was provided via circulation of 1°C water through a bladder connected to an Artic Ice CTU. Following 5 min of baseline (BL) data collection with 34°C circulating water, there were 2 different 30 min bouts with 1°C water interspersed with 12 min 40°C circulating water (active rewarming). Following the 2nd cooling bout data was collected during 60 min of passive rewarming with no water circulating through the bladder. Main Outcome Measures: Means ± SD for 1cm intramuscular temperature (T_{μ}) and corresponding skin surface temperature (T_{SK}) and blood flow (Sk_{RF}) . Alpha was set apriori at 0.05. Results: First bout of cooling lowered T_{IM} (19.5 ± 3° C) and T_{SK} $(18.8 \pm 2^{\circ} \text{ C})$ relative to BLT_{IM} $(34.3 \pm 0.9^{\circ})$ C) and BLT_{sk} (32.9 \pm 0.7° C) (p < 0.01for each) and T_{IM} (29 ± 2° C) and T_{SK} (29.3 $\pm 2.3^{\circ}$ C) increased during active rewarming (p < 0.01 for each) remaining below

BL (p < 0.01 for each). Second bout of cooling reduced T_{IM} (17.2 ± 2.7° C) and T_{sk} (16.5 ± 1.5°C) relative to BL and active rewarming (p < 0.001 for each) and passive rewarming (p < 0.01 for each) increased T_{IM} (23.1 ± 1.1° C) and T_{SK} $(22.6 \pm 0.9^{\circ} \text{ C})$ but remained below BL (p < 0.01 for each). Sk_{BF} reduced relative to BL (23.6 \pm 10) during cooling 1st bout (7.8 ± 5.1) (p < 0.001) then increased with active rewarming (18.9 ± 12) (p = 0.01); however, $\mathrm{Sk}_{_{\mathrm{BF}}}$ was not different from BL (p = 0.15). Sk_{BF} reduced relative to BL and active rewarming after 2nd bout (6.8 ± 3.8) (p < 0.001 for each). However, during passive rewarming $Sk_{RF}(6.3 \pm 1.8)$ was not elevated relative to the end of the 2^{nd} cooling (p = 0.68) and remained below both BL and active rewarming (p < p)0.001 for each). Conclusions: These data suggest that active rewarming following a period of cryotherapy may be more effective at preventing the pronounced and sustained ischemia observed following passive rewarming. These findings may be beneficial at minimizing the potential detrimental side effects associated with cryotherapy treatment.



^{a,c} Different from baseline; ^b Different from Active Rewarming

Pulsed Shortwave Diathermy and Joint Mobilizations Restore Range of Motion in an Athletic Training Student With Adhesive Capsulitis

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Background: Male 23 year-old college student with adhesive capsulitis from an AC joint injury that occurred while playing intramural football, two months prior to being evaluated by his athletic training professor. He reported with loss of shoulder ROM in flexion (120/180 degrees), extension (30/60 degrees) and abduction (110/180 degrees). Differential Diagnosis: Rotator cuff strain, long head of the biceps strain, subdeltoid bursitis, shoulder pointer, fractured clavicle, 1st, 2nd or 3rd degree AC separation. Treatment: The patient was not seen by a physician and no diagnostic laboratory tests were performed. ROM was taken each day before treatment with a standard goniometer. The patient was treated with 2 induction drum pulsed shortwave diathermy (PSWD) units at the following parameters: 20 min, 27.12 MHz, 400 µsec, 800 hertz (100 watts). To restore flexion we performed posterior humeral glides; to restore extension we performed anterior humeral glides, and inferior humeral glides and traction were applied to restore abduction. Range of motion was taken at the end of each PSWD and joint mobilization session. The patient was treated 1 time each day for 3 days (M,W,F). Full ROM in all actions was restored in just 3 treatments. Beginning flexion was 120 degrees and ended at 180. Beginning extension was 30 degrees and ended at 60. Beginning abduction was 100 degrees and ended at 180 (all motions reached the opposite uninjured joint). Uniqueness: Two things make this case unique. First, PSWD was used to deep heat the capsule prior to the joint mobilizations. Second, the patients' ROM was fully restored in just 3 treatments. Conclusions: A regimen of PSWD and joint mobilizations was effective in restoring full ROM to a patient with adhesive capsulitis. Athletic trainers should consider using PSWD with their joint mobilizations in an effort to restore ROM to the shoulder. Based upon previous research, therapeutic ultrasound would not heat the entire shoulder since the thermal effects are limited to an area only 2 times the size of the soundhead (Garrett C, Draper DO, Knight KL, Durrant E. Heat distribution in the lower leg from pulsed short-wave diathermy and ultrasound treatments. *J Athl Train.* 2000;35(1):50-55). Development and Psychometric Properties of the Self-Efficacy for Home Exercise Programs Scale Picha KJ, Hoch MC, Heebner NR, Abt JP, Usher EL, Capilouto GJ, Uhl TL: College of Health Sciences, University of Kentucky, Lexington, KY

Context: Low self-efficacy has been identified as a barrier to rehabilitation exercise adherence. Few assessment tools have been designed to assess self-efficacy for home exercise programs. The Self-Efficacy for Home Exercise Program Scale (SEHEPS) was developed to help clinicians evaluate patients' self-efficacy for performing their prescribed home exercise program. **Objective:** To determine the reliability and validity of the SEHEPS within a patient population. Design: Cross-sectional. Setting: Outpatient sports medicine and physical therapy clinics. Patients or Other Participants: Fiftyfive patients (22 men, 33 women, age = 41.1 ± 16.9) with varying musculoskeletal conditions. Interventions: All patients were given a home exercise program at their initial physical therapy visit. Participants completed the SEHEPS and the Self-Efficacy for Exercise (SEE) scale during their initial visit. Main Outcome Measures: The SEHEPS is a 12-item patient-reported questionnaire that was designed to assess self-efficacy for prescribed home rehabilitation exercise. Patients rated their confidence on a 7-point Likert scale ranging from "not confident" to "very confident." Total scores were calculated as percentages and scores ranged from 0% (low self-efficacy) to 100% (high self-efficacy). The SEE is a reliable and valid 9-item scale that assesses self-efficacy for regular exercise. The SEE's Likert scale was modified to be the same as the SEHEPS thereby minimizing possible patient confusion. Total scores on the SEE ranged from 0 to 54 with a higher score indicating higher self-efficacy. Factor structure of the SEHEPS was assessed using principle components analysis. Factors with eigenvalues >1 that explained >5% of

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the variance were retained. Sampling adequacy was verified with the Kaiser-Meyer-Olkin measure (KMO > 0.5) and correlations between items were justified using Bartlett's test of sphericity (p <0.05). Internal consistency was measured using Cronbach's alpha. Convergent validity between the SEHEPS and SEE scale was evaluated with a Spearman correlation. An alpha level of .05 was used for all analyses. Results: All items in the SEHEPS weighted heavily on one component demonstrating unidimensionality (Eigenvalue = 8.73, Explained Variance = 72.7%; KMO = 0.885; x^2 (66) = 711.22, p < 0.001). This was evidenced by factor loadings of 0.72 to 0.93 around Component 1 for all 12 items. High internal consistency ($\alpha = 0.965$) was demonstrated. The SEHEPS (70.6%± 20.3%) was strongly correlated with the SEE scale $(36.8 \pm 11.3; r = 0.87, p < 0.01)$ indicating strong convergent validity. Conclusions: The SEHEPS demonstrated a unidimensional structure, suggesting that a single total score is an appropriate representation of patients' self-efficacy. The SEHEPS demonstrates excellent internal consistency and strong convergent validity with the SEE scale providing further support for the psychometric properties of this novel instrument. Overall, the SEHEPS is a clinically useful tool for evaluating a patient's self-efficacy for home-based musculoskeletal exercise programs in sports medicine and physical therapy clinics.

A Comparison of Neuromuscular Electrical Stimulation (NMES) Parameters for Postoperative Quadriceps Strength in Patients After Knee Surgery: A Systematic Review Conley CW, Howard JS, Jochimsen KN, Dressler EV, Lattermann C, Mattacola CG: University of Kentucky, Lexington, KY; Appalachian State University, Boone, NC

Context: Persistent postoperative quadriceps strength deficits are frequently reported after knee surgery. While the use of neuromuscular electrical stimulation (NMES) treatments to improve postoperative quadriceps strength has been broadly endorsed, the therapeutic effectiveness of NMES has varied within scientific literature. These inconsistent outcomes may be due to the wide range of treatment parameters and the clinical settings in which NMES interventions have been evaluated. These inconsistencies make it difficult for clinicians to know what are the optimal treatment parameters for patients. **Objective:** To perform a systematic review of randomized controlled trials in order to determine the effect of neuromuscular electrical stimulation (NMES) parameters on quadriceps strength after knee surgery. Data Sources: Databases (CINAHL, MEDLINE, SPORTDiscus, were systematically and PubMed) searched in May 2016. In addition, a hand search was performed for other references. Study Selection: Studies were included if they were randomized controlled trials comparing a postoperative NMES treatment with a standard of care quadriceps strengthening treatment. Studies were excluded if they did not measure quadriceps strength, did not report the NMES parameters utilized or quadriceps strength values, or if they applied NMES to numerous muscle groups. Data Extraction: Two authors assessed study quality through the PEDro scale for randomized controlled trials. One investigators extracted means and standard deviations from all included articles. Hedge's g effect sizes with 95% confidence intervals were calculated from the available data. Furthermore, due to baseline differences between groups in some studies the authors calculated baseline Hedge's g effect sizes. Lastly, the strength of recommendation taxonomy (SORT) was utilized to evaluate the overall strength of the clinical recommendation. Data Synthesis: Seven randomized controlled trials were included with an average PEDro score of 5 + 2. The Hedge's g effect sizes ranged from poor (-0.37; 95% CI = -1.00, 0.25) to strong (1.03; 95% CI = 0.15, 1.91). Based upon the SORT Quality of Evidence table the majority of the studies included were low quality randomized controlled trials categorized as level 2: limited quality patient oriented evidence. Conclusions: Overall there was inconsistent evidence among the included studies. Thus, grade B evidence exists to support the positive recovery of quadriceps strength after knee surgery. Based on the parameters from the studies demonstrating optimal effects on postoperative quadriceps strength, it is recommended to implement either a portable or AC based NMES treatment during the first post-operative week with the following parameters: rectangular biphasic or alternating current, frequency of 50Hz, maximum tolerable intensity, duty cycle of 1:2 or 1:3 ratio, and a large electrode size (>96 cm²). Furthermore, the patient is encouraged to voluntarily contract with the stimulation and in a position of 60-90 degrees of knee flexion.

Whole-Body Pre-cooling Mitigates Some Exertional Heatstroke Risk Factors Without Affecting Cold-Water Immersion Cooling Rates Wohlfert TM, Miller KC: Central Michigan University, Mt. Pleasant, MI

Context: Exertional heatstroke (EHS) is a leading cause of death in athletes. Reducing an individual's body core temperature before exercise (i.e., pre-cooling, PC) with cold water immersion (CWI) may prevent severe hyperthermia and EHS by increasing the body's heat storage capacity. However, if PC increased heat storage capacity and an athlete experienced EHS, CWI treatment durations could be prolonged. Moreover, PC may impair perceptions of exercise intensity and/or thermal stress thereby predisposing athletes to severe hyperthermia. **Objective:** We answered three questions: (1) Does PC with CWI affect rectal temperature (T_{rec}), heart rate (HR), ratings of perceived exertion (RPE), thermal sensation, and environmental symptoms questionnaire (ESQ) responses before, during, and after exercise? (2) Does PC affect CWI T_{ree} cooling rates following exercise-induced hyperthermia? (3) Does PC impact hydration status or sweat rates? Design: Randomized, crossover, counterbalanced, experimental study. Setting: Laboratory. Patients or **Other Participants:** Twelve physically active, healthy, participants (6 males, 6 females; age = 22 ± 2 y; mass = $73.5 \pm$ 7.9 kg; height = 171 ± 7 cm; body fat = $12 \pm 6\%$; body surface area = 1.9 ± 0.1 m²). Interventions: On PC days, participants entered an environmental chamber $(38.6 \pm 0.6^{\circ} \text{ C}; 36 \pm 2\% \text{ relative humid-}$ ity) and underwent 15 minutes of CWI $(10.0 \pm 0.03^{\circ} \text{ C})$. Then, they rested in the heat for 10 minutes before exercising to a T_{rec} of 39.5°C. Subsequently, they underwent CWI (9.99 \pm 0.03° C) until T_{ref} reached 38°C. On control (CON) days, participants performed the same procedures without the 15-minute PC intervention. Main Outcome Measures: T_{me} was recorded before and after PC; every

5 minutes during exercise; and every 30 seconds during CWI. CWI duration (i.e., time to 38°C) and T_{rec} were used to determine cooling rates. HR was recorded every 5 minutes during exercise. Thermal sensation was measured before PC; immediately before exercise; every 10-min during exercise; immediately post-exercise; and post-CWI. RPE was measured pre-exercise and every 10 minutes during exercise. ESQ responses were measured before PC; pre-exercise; post-exercise; and post-CWI. Means ± SD and medians±interquartile ranges were calculated. Dependent t-tests, Wilcoxon signed rank tests, and repeated measures analysis of variance (with Tukey-Kramer post-hoc tests) were used to assess differences between conditions when appropriate ($\alpha =$ 0.05). Results: PC lowered T_{rec} by 0.42 \pm 0.40°C pre-exercise. Consequently, participants exercised longer (PC = 66.7 \pm 16.3 min, CON = 45.7 \pm 9.5 min; P < 0.001), and at consistently lower T_m $(\sim 0.5 \pm 0.5^{\circ} \text{ C})$ and HR $(\sim 10 \pm 7 \text{ bpm})$. PC resulted in greater levels of hypohydration (PC = $-1.55 \pm 0.59\%$, CON = $-1.27 \pm 0.48\%$; P = 0.02) albeit at lower sweat rates (PC = $1.02 \pm 0.31 \text{ L} \cdot \text{h}^{-1}$, CON $= 1.22 \pm 0.39$ L·h⁻¹; P < 0.001). RPE (P = 0.34), and ESQ responses (P = 0.3) did not differ between conditions over time. Thermal sensation only differed between conditions at pre-exercise (PC = 3 ± 1 , $CON = 5 \pm 0.5; P < 0.05)$. Post-exercise CWI T_{rec} cooling rates were unaffected by $PC (PC = 0.18 \pm 0.14^{\circ} \text{ C} \cdot \text{min}^{-1};$ $\text{CON} = 0.19 \pm 0.05^{\circ} \text{ C} \cdot \text{min}^{-1}; P = 0.34$). Conclusions: PC delays the onset of severe hyperthermia and may prevent EHS by reducing T_{rec} and hypohydration. Since PC did not affect post-exercise CWI T cooling rates, clinicians should continue to use CWI to treat EHS even if athletes undergo PC.

Free Communications, Poster Presentations: Treatment for Chronic Ankle Instability

Ernest N. Morial Convention Center, Hall B; Wednesday, June 27, 10:00AM-5:00PM; Thursday, June 28, 10:00AM-5:00PM; Friday, June 29, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

A Randomized Controlled Trial Investigating the Effects of a 4-Week Ankle Rehabilitation Program on Static Balance Tasks in High School Athletes With Chronic Ankle Instability Cain MS, Goerger BM, Linens SW: Georgia State University, Atlanta, GA; University of Oregon, Eugene, OR

Context: Research shows rehabilitation programs incorporating resistance band and balance board exercises are effective at improving static balance of individuals with Chronic Ankle Instability (CAI); however, it is unknown if there is any increased improvement by combining the two exercises. Objective: Determine the effectiveness of three rehabilitation programs on static balance in adolescent patients with CAI. Design: Randomized Controlled Trial. Setting: High School Athletic Training Facility. Patients or Other Participants: Forty-three patients with CAI were block randomized into four rehabilitation groups: Resistance band (RB) (n = $12,171.24 \pm 10.13$ cm, 65.75 ± 11.16 kg, 16.42 ± 1.00 yrs), Biomechanical Ankle Platform System (BAPS) (n = $10,178.69 \pm 9.87$ cm, 77.57 ± 21.54 kg, 16.40 ± 0.97 yrs), Combination (RB/BAPS) (n = $10,170.69 \pm 12.14$ cm, 67.99 ± 16.49 kg, 16.20 ± 1.14 yrs), and Control (CON) (n = 11, 166.96 \pm 14.20 cm, 67.17 ± 22.94 kg, 16.45 ± 1.04 yrs). **Interventions:** Rehabilitation programs consisted of 3-sessions a week for 4-weeks. RB group performed 3-sets of 10-repetitions of ankle plantarflexion/dorsiflexion/ inversion/eversion with resistance band. Each week patient would progress to more difficult band. BAPS group performed 5 trials of clockwise/counterclockwise rotations changing direction every 10 seconds during each 40-second trial. Patient started on level 1 and could progress to level 5. RB/BAPS group completed RB and BAPS programs during each session.

CON group did not complete any exercises. Static balance was assessed prior to and following intervention. Time-inbalance test (TIB) and foot-lift test (FLT) required patients to maintain a single-leg stance on involved leg for 3-trials. Two 4x2 repeated measure ANOVAs were used for data analysis ($\alpha = .05$). Tukey's HSD post-hoc tests were conducted on significant interactions. Main Outcome Measures: Dependent measures were longest time held for TIB (up to 60-seconds) and average number of errors (i.e. foot lifts of involved leg or touching down with contralateral foot) for FLT (during a 30-second trial). Increased time for TIB and decreased number of errors for FLT indicated improved performance. Results: Main effects for time were significant for FLT (p < 0.003) but not for TIB (p = 0.881). Main effects for group were not significant for either TIB (p =0.520) or FLT (p = 0.674). Significant group by time interactions were found for TIB ($F_{339} = 5.92$, p = 0.002) and FLT $(F_{3,20} = 3.44, p = 0.026)$. Post-hoc testing showed improvement in TIB pre-to-post measures for intervention groups compared to CON group and significant differences in posttest scores showing RB group having significantly higher scores compared to RB/BAPS group (16.21 seconds) and CON group (22.25 seconds). Post-hoc testing showed an improvement in FLT pre-to-post measures for intervention groups compared to CON group and statistically significant overall change scores for RB/BAPS group compared to other 3 groups. Conclusions: Rehabilitation groups demonstrated improvement in static balance compared to CON group. Statistically significant improvement in static balance following rehabilitation via posttest scores were demonstrated for RB group on TIB and overall change scores for RB/BAPS group on FLT. Rehabilitation including RB may be more beneficial at improving static balance as evaluated by TIB and FLT static balance tests.

Effects of a Multimodal 4-Week Intervention on Range of Motion, Balance, and Ankle Strength in Those With Chronic Ankle Instability

Powden CJ, Hoch JM, Jamali BE, Hoch MC: Indiana State University, Terre Haute, IN; University of Kentucky, Lexington, KY; Old Dominion University, Norfolk, VA

Context: Isolated intervention strategies have been effective for addressing specific impairments associated with chronic ankle instability (CAI). However, the combined effects of these evidence-based interventions for balance, strength, and ROM have not been thoroughly evaluated in concert. **Objective:** To examine the effects of a 4-week multimodal rehabilitation program on ROM, strength, and balance in individuals with CAI. Design: Repeated-measures. Setting: Laboratory. Patients or Other Participants: Twenty adults (15 females; age = 24.4 ± 7.0 yrs; height = 169.29 ± 10.1 cm; weight = 70.6 ± 12.9 kg) with self-reported CAI participated. Inclusion criteria included ≥ 1 previous ankle sprain, ≥ 2 episodes of giving way in the previous three months, answering "yes" to ≥ 5 questions on the Ankle Instability Instrument, and ≤24 on the Cumberland Ankle Instability Tool. Interventions: Subjects participated in 12 supervised intervention sessions over 4 weeks that included progressive balance training, ankle strengthening, and talocrural joint mobilizations. Additionally, subjects completed daily home ankle strengthening and gastroc-soleus complex stretching throughout the 4 weeks. Main Outcome Measures: All outcomes were measured 4 weeks (baseline) and immediately prior (pre-intervention) to the first intervention session, 24-48 hours following intervention cessation (post-intervention), and 2 weeks following intervention cessation (follow-up). The weight-bearing lunge test (WBLT) assessed ankle ROM.

A hand-held dynamometer assessed isometric ankle dorsiflexion, plantarflexion, inversion, and eversion strength. The anterior, posteromedial, and posterolateral directions of the Y-balance test assessed dynamic postural control. The average of 3 trials was used for analysis for each outcome. Minimal detectable change (MDC) scores were calculated based on the baseline and pre-intervention measurements for each dependent variable. Separate repeated-measures ANOVAs examined differences in each dependent variable over time (pre-intervention, post-intervention, follow-up). Sidak post hoc comparisons with corresponding standardized response mean effect sizes (ES) were completed in the presence of significant main effects. Alpha was set a-priori at p \leq 0.05. **Results:** The WBLT improved at post-intervention $(9.75 \pm 3.49 \text{ cm}, p <$ 0.001, ES = 1.29) and follow-up (10.13) \pm 3.49 cm, p < 0.001, ES = 1.27) compared to pre-intervention (8.59 ± 3.54) cm, MDC = 0.54 cm). The Y-balance test was improved at post-intervention (Anterior: $61.57 \pm 5.89\%$, p = 0.013, ES = 0.72; Posteromedial: 105.97 $\pm 6.02\%$, p < 0.001, ES = 1.22; Posterolateral: $104.04 \pm 5.37\%$. p < 0.001, ES = 1.13) and follow-up (Anterior: $62.19 \pm 5.07\%$, p < 0.001, ES = 0.99; Posteromedial: $106.00 \pm 6.42\%$, p < 0.001, ES = 1.35; Posterolateral: $104.67 \pm 5.98\%$, p < 0.001, ES = 1.15) compared to pre-intervention (Anterior: $58.82 \pm 7.29\%$, MDC = 3.11%; Posteromedial: $99.03 \pm 6.96\%$, MDC = 4.57%; Posterolateral: 97.78 \pm 6.38%, MDC = 4.48%). Ankle strength was improved at post-intervention (Inversion: 4.57 ± 0.75 N/kg, p < 0.001, ES = 1.10; Eversion: 4.47 ± 0.81 N/kg, p < 0.001, ES = 1.15; Dorsiflexion: 4.24 ± 0.91 N/kg, p = 0.004, ES = 0.72; Plantarflexion: 5.37 \pm 1.01 N/kg, p < 0.001, ES = 1.2) and follow-up (Inversion: 4.78 ± 0.83 N/kg, p <0.001, ES = 1.47; Eversion: 4.53 ± 0.82 N/kg, p < 0.001, ES = 1.26; Dorsiflexion: 4.23 ± 0.75 N/kg, p = 0.015, ES = 0.73; Plantarflexion: 5.92 \pm 1.13 N/kg, p <0.001, ES = 1.70) compared to pre-intervention (Inversion: 3.8 ± 1.01 N/kg, MDC = 0.55 N/kg; Eversion: 3.66 ± 0.81 N/kg, MDC = 0.35 N/kg; Dorsiflexion: 3.86 ± 0.72 N/kg, MDC = 0.29 N/kg;

Plantarflexion: 4.41 ± 1.06 N/kg, MDC = 0.56 N/kg). <u>Conclusions:</u> A 4-week rehabilitation program significantly improved ROM, ankle strength, and postural control in people with CAI for up to 2-weeks after completing the intervention. The statistically significant improvements in all outcome measures were associated with strong effect sizes and exceeded the MDC which indicates these findings were clinically relevant.

The Effects of Joint Mobilizations on Dorsiflexion Range of Motion in Individuals With Chronic Ankle Instability: A Systematic Review With Meta-Analysis

Vallandingham RA, Gaven SL, Powden CJ: Indiana State University, Terre Haute, IN

Context: Limitations in dorsiflexion range of motion (DFROM) may affect an individual's ability to execute functional activities and may contribute to repeated ankle sprains and episodes of giving away in individuals with chronic ankle instability (CAI). Due to DFROM's significance, it is important to identify evidence-based strategies for improving DFROM in patients with CAI. Objective: To conduct a systematic review with meta-analysis to summarize the current literature on the effects of joint mobilization on DFROM in individuals with CAI. Data Sources: Electronic databases (PubMed, MEDLINE, CINAHL, SPORTDiscus) were searched from inception to January 2017. Search limits were full text publications written in English. Study Selection: Inclusion criteria required that studies examined the isolated effects of joint mobilizations, manipulations, or mobilization with movement(MWM) to enhance DFROM; subjects were defined as having CAI, functional ankle instability, mechanical ankle instability, or recurrent ankle sprains; examined changes in DFROM; provided adequate data for the calculation of effect sizes(ES) and 95% confidence intervals(95% CI). Data Extraction: Two investigators independently assessed methodological quality, level of evidence and strength of recommendation with the Physiotherapy Evidence Database (PEDro) scale and the Strength-of-Recommendation Taxonomy. Intervention and control/ sham pre-intervention and post-intervention samples sizes, means, and SDs were extracted for DFROM measurement. Data Synthesis: Of the initial 196 articles retrieved from electronic and hand searches, 10 articles were included. Of these 10 articles, nine articles examined pre-intervention to

post-intervention DFROM changes, while eight articles examined DFROM differences between a control/sham group and an intervention group. The magnitudes of intervention to control/ sham and pre-intervention to post-intervention differences were examined using bias corrected Hedges g ESs. Randomeffects meta-analyses were conducted for each comparison. Overall PEDro quality scores for pre-intervention to post-intervention ranged from 40% to 80% with a median score of 60%. The overall quality score for control/sham to intervention ranged from 60% to 80% with a median score of 70%. For pre-intervention to post-intervention comparison, there was an overall weak summary effect with non-overlapping 95% CI indicating DFROM improvements following joint mobilization intervention (ES = 0.34; 95% CI = 0.20, 0.48; p < 0.001). For control/sham to intervention comparison, there was an overall moderate summary effect with non-overlapping 95% CI indicating DFROM improvement following joint mobilization intervention (ES = 0.41; 95% CI = 0.14, 0.68; p = 0.003). **Conclusions:** There is Grade A evidence that DFROM mildly improved from pre-intervention to post-intervention following joint mobilization intervention. There was Grade B evidence that DFROM was mildly greater in the intervention group compared to the control/sham group. These findings demonstrate that joint mobilizations targeted at increasing posterior glide of the talus can improve DFROM. Furthermore, these improvements were identified immediately following intervention, after multiple treatments, and 6 months post-intervention. Future research should define ideal treatment parameters to maintain clinical effects.

The Effects of Joint Mobilizations on Dynamic Postural Control in Individuals With Chronic Ankle Instability: A Systematic Review With Meta-Analysis Gaven SL, Vallandingham RA, Powden CJ: Indiana State University, Terre Haute, IN

Context: Due to the high rate of CAI and the negative impact this can have on an individual's economic and physical well-being, it is of utmost concern to define evidence-based strategies that are effective at treating the impairments associated with CAI. Objective: To conduct a systematic review with meta-analysis of the current literature investigating the effect of joint mobilization techniques on dynamic postural control in individuals with CAI. Data Sources: Electronic databases (PubMed, MEDLINE, CINAHL, SPORTDiscus) were searched from inception to January 2017. Search limits were full text publications written in English. Study Selection: Inclusion criteria required that studies examined the isolated effect of joint mobilization, manipulation, mobilization with movement (MWM); included subjects described as having CAI, functional ankle instability, mechanical ankle instability, or recurrent ankle sprains; examined changes in maximal DFROM and dynamic postural control; provided adequate data for the calculation of effect sizes (ES) and 95% confidence intervals (95% CI). Data Extraction: Two investigators independently assessed methodological quality, level of evidence, and strength of recommendation with the Physiotherapy Evidence Database (PEDro) scale and the Strength-of-Recommendation Taxonomy. Intervention and control as well as pre-intervention and post-intervention samples sizes, means, and standard deviations were extracted for the anterior, posteromedial, and posteromedial directions of the SEBT. Data Synthesis: Of the initial 196 articles retrieved from electronic and hand searches, six articles met the inclusion and exclusion criteria. Of these six, five articles examined pre-intervention to post-intervention SEBT changes, while four articles examined SEBT differences between a control or sham group and an intervention group. The magnitudes of intervention to control (intervention-control) and pre-intervention to post-intervention (pre-post) differences were examined using bias corrected Hedges g ESs. Random-effects meta-analyses were conducted. The overall quality score for dynamic postural control, pre-intervention to post-intervention, ranged from 40% to 80% with a median of 60%. The overall quality score for dynamic postural control, control to intervention, ranged from 40% to 80% with a median of 60%. For SEBT pre-intervention to post-intervention comparison, there was an overall weak effect for dynamic postural control improvements following joint mobilization intervention (ES = 0.37; 95% CI = -0.12, 0.87; p = 0.136). For SEBT control vs intervention comparison, there was an overall moderate effect for dynamic postural control improvement following a joint mobilization intervention (ES = 0.41; 95% CI = -0.41, 0.98; p = 0.143). The overall results were not statistically significant and included CIs that encompassed zero. Conclusions: There is grade B evidence that indicates conflicting effects of joint mobilizations on dynamic postural control in individuals with CAI compared to controls and pre-intervention. Dynamic postural control is an important factor for individuals with CAI and should be addressed during the rehabilitation process. Overall, the findings indicate the need for further research examining the effects of joint mobilizations on dynamic postural control to determine the optimal treatment parameters.

Talocrural Joint Mobilization Does Not Change Ankle Sagittal Plane Kinematics During Walking or Running Gait in People With Chronic Ankle Instability Allison RL, Hoch MC, McKeon PO: University of Kentucky, Lexington, KY; Ithaca College, Ithaca, NY

Context: Patients with chronic ankle instability (CAI) have demonstrated deficits in sagittal plane ankle kinematics during gait. These kinematic alterations may be the result of range of motion (ROM) restrictions of the ankle. Joint mobilizations can effectively increase ankle dorsiflexion ROM; however, it is unknown if this treatment can increase sagittal plane motion during gait. **Objective:** Examine the effect of a 2-week joint mobilization intervention on sagittal plane ankle kinematics during walking or running gait in adults with CAI. Design: Pretestposttest. Setting: Laboratory. Patients or Other Participants: Twelve adults (6 Females; age = 27.4 ± 4.3 years; height = 175.4 ± 9.7 cm; mass = 78.4 ± 11.0 kg) with self-reported CAI volunteered to participate. All participants reported a history of ≥ 1 ankle sprain, ≥ 2 episodes of ankle "giving way" in the past three months, ≥ 5 yes responses on the Ankle Instability Instrument, and ≤80% on the Foot and Ankle Ability Measure-Sport. Interventions: Participants completed a joint mobilization intervention which consisted of six separate treatment sessions over a 2-week period. During each treatment session participants received two, 2-min sets of Maitland Grade-II talocrural traction and four, 2-min sets of Maitland Grade III talocrural anterior-to-posterior joint mobilizations. Main Outcome Measures: Gait biomechanics were measured 1-week before the intervention (baseline), prior to the first intervention session (pre-intervention), and 24-hours following the final intervention session (post-intervention). At each data collection session, participants walked and ran on an instrumented treadmill at speeds of 1.32m/s and 2.64m/s, respectively.

Three-dimensional kinematics of the involved lower extremity were captured for 30s at each speed using a 15-camera motion analysis system. Ankle dorsiflexion-plantarflexion angles (°) at initial contact and stance phase maximum were calculated and averaged from five strides for each participant. Data from the baseline and pre-intervention sessions were used to examine reliability through intraclass correlation coefficients (ICC_{2,5}) and minimal detectable change (MDC₉₀) values for all dependent variables. Changes in ankle kinematics between the pre-intervention and post-intervention sessions were examined using dependent t-tests. Alpha was set at $p \le 0.05$ for all analyses. Results: Ankle dorsiflexion-plantarflexion kinematics were highly reliable for walking (initial contact: $ICC_{25} =$ 0.96, $MDC_{90} = 1.8^{\circ}$; stance phase maximum: $ICC_{2,5} = 0.97$, $MDC_{90} = 2.2^{\circ}$) and running (initial contact: $ICC_{25} = 0.96$, $MDC_{90} = 4.4^{\circ}$; stance phase maximum: $ICC_{25} = 0.99$, $MDC_{90} = 0.9^{\circ}$). However, no changes were identified in walking initial contact (pre-intervention: $-2.8 \pm$ 9.9°, post-intervention: $-1.7 \pm 10.4^{\circ}$; p = 0.47), walking stance phase maximum (pre-intervention: $20.4 \pm 4.2^{\circ}$, post-intervention: $20.7 \pm 4.4^{\circ}$; p = 0.77), running initial contact (pre-intervention: $-1.5 \pm 9.7^{\circ}$, post-intervention: $-2.8 \pm$ 9.9°; p = 0.25), or running stance phase maximum (pre-intervention: $20.4 \pm$ 3.2° , post-intervention: $20.4 \pm 4.2^{\circ}$; p = 0.92). Conclusions: The 2-week joint mobilization intervention did not affect ankle sagittal plane motion during walking or running gait. While joint mobilization is effective for increasing ankle ROM, it does not appear to translate into immediate changes in walking or running kinematics. Joint mobilizations may need to be coupled with targeted gait training to incorporate ROM improvements into functional movement patterns.

Improving Balance in Patients With Chronic Ankle Instability: A Clinical Prediction Rule for Balance Training

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Context: Context: Balance training is a common treatment for patients with chronic ankle instability (CAI) and has been shown to improve balance as well as patient-reported outcomes. Research has shown that not all CAI patients respond equally to therapeutic interventions such as manual therapies but treatment response variability following balance training remains unknown. Understanding treatment response differences and predictors of positive responses can help improve treatment effectiveness in CAI patients. **Objective:** Objective: To conduct a response analysis on existing data to identify treatment response patterns and predictors of treatment success following a dynamic balance training intervention in CAI patients. **Design:** Design: Secondary analysis of prospective studies. Setting: Setting: Sports medicine research laboratories. Patients or Other Participants: Patients: Seventy-three participants with CAI from 6 previous investigations $(age = 20.37 \pm 3.03 \text{ yr}; mass = 72.99 \pm$ 16.34 kg; height = 171.17 ± 9.56 cm). Interventions: Interventions: All participants completed an identical 4-week progressive balance training program. Balance exercises focused on static and dynamic balance (e.g. single leg standing and landing). Main Outcome Measures: Main Outcome Measures: A successful treatment was defined as a participant exceeding the minimal detectable change score for the SEBT posteromedial (SEBT-PM) reach direction (8.15%) at the post-intervention time-point relative to baseline. Potential predictor variables included participant (age, mass, height) and injury (number of lateral ankle sprains) demographics, patient-oriented outcomes (Foot and Ankle Ability Measure activities of daily living [FAAM-ADL] and Sport subscales), and clinician-oriented outcomes (anterior, posteromedial, posterolateral, and composite SEBT scores). All variables were entered into a logistic stepwise regression model to determine the most accurate set of variables to predict treatment success. Outcomes included the sensitivity, specificity, and positive likelihood ratio (+LR) of cutoff scores. Results: Results: Out of 73 participants, only 23 (38.36%) demonstrated a successful improvement in SEBT-PM balance after completing 4-weeks of balance training. Of all variables included, a baseline SEBT-PM reach distance ≤85.18% (sensitivity: 0.82 [0.64-0.92], specificity: 0.71 [0.57-0.82], +LR: 2.843 [1.74-4.64]) and baseline FAAM-ADL score ≤92.55% (sensitivity: 0.92 [0.77-0.98], specificity: 0.33 [0.21-0.48], +LR: 1.39 [1.11-1.75]) were both significant predictors of treatment success (p < 0.001). When present together (sensitivity: 0.79 [0.60-0.89], specificity: 0.80 [0.66-0.89], +LR: 3.93 [2.12-7.27]), there was a 70% post-test probability of a successful treatment. This reflects a 31.6% increase in the probability of an improvement in balance using these cutoff values. Conclusions: Conclusions: Without screening, 40% patients with CAI experience a meaningful improvement in dynamic balance following a 4-week progressive balance training intervention. This success rate is consistent with those observed following manual therapies in patients with CAI. A simple pre-treatment assessment using the SEBT-PM and the FAAM-ADL, clinicians can better identify CAI patients that are most likely to respond to the 4-week balance training intervention investigated. More specifically, CAI patients with worse self-reported function (FAAM-ADL \leq 92.55%) and worse dynamic postural control (SEBT-PM ≤ 85.18%) have an increased probability of having a meaningful improvement in dynamic postural control following the balance training intervention.

Nerve Conduction Velocity Following Ankle Rehabilitation in Individuals With CAI Hall EA, Chomistek AK, Koceja DM, Docherty CL: University of South Florida, Tampa, FL; Indiana University, Bloomington, IN

Context: Individuals with chronic ankle instability(CAI) experience deficits in nerve conduction velocity. Functional rehabilitation may prevent the recurring symptoms following the initial ankle sprain. **Objective:** The purpose of this study was to determine if a balance training or a strength training protocol improved nerve conduction velocity in participants with CAI. Design: Randomized controlled trial. Setting: Research Laboratory. Patients or Other Participants: Thirty-seven participants with CAI volunteered for this study. CAI was defined as having a history of ankle sprains and scoring an 11 or more on the Identification of Functional Ankle Instability (IdFAI). Subjects did not qualify if they had experienced an acute lower extremity injury within the past 3 months, had participated in formal rehabilitation within the past 3 months, had a history of lower extremity surgery or fracture that required alignment in the involved limb, or had any diagnosed neurological dysfunction, such as multiple sclerosis, Parkinson's Disease, or head injuries. Interventions: Participants were baseline tested in nerve conduction velocity and then were randomly assigned to one of three groups: Balance Training Protocol (BTP), Strength Training Protocol (STP), and Control (CON). The BTP group completed multiple hop to stabilization exercises ranging from static balance to dynamic hopping tasks. The STP group performed a progressive strength training program in all four ankle directions. A resistance band was used to provide resistance in the inversion, eversion, and dorsiflexion directions, while standing heel raises were employed for the plantar flexion direction. The STP group also completed progressive proprioceptive neuromuscular facilitation(PNF)

strengthening exercises in a diagonal pattern. The CON group completed a 20-minute bike exercise at mild to moderate resistance. Each participant completed their respective protocols for three times per week for six weeks. Nerve conduction velocity was tested again at the end of the six weeks. All testing was performed prior to warm-up to avoid an increase in skin temperature. Main Outcome Measures: The dependent variable was motor nerve conduction velocity(m/s) of the fibular nerve measured using a SierraWave II system (Cadwell Laboratories; Kennewick, WA). Repeated measures analysis of covariance (RMANCOVA) was conducted with time (pre and posttest) as the within subjects factor, group (BTP, STP, and CON), as the between subjects factor, and surface temperature of the leg, BMI, and age as the covariates. Results: The RMANCOVA did not result in a significant time by group interaction (p = 0.66) or main effect for time (p = 0.47). No groups significantly improved from pre-test (BTP: $37.08 \pm$ 4.19 m/s, STP: 37.08 ± 4.03 m/s, CON: 38.09 ± 4.66 m/s) to posttest (BTP: 37.85 ± 2.54 m/s, STP: 37.00 ± 3.85 m/s, CON: 38.00 ± 5.04 m/s). Conclusions: Six-week interventions were not able to improve nerve conduction velocity among individuals with CAI. Clinicians and future researchers should continue the rehabilitation beyond six weeks to identify if motor nerve conduction velocity can be improved.

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Effects of External Supports on Running Mechanics in Individuals With History of Lateral Ankle Sprains Gregory CJ, Koldenhoven RM, Higgins M, Hertel J: University of Virginia, Charlottesville, VA

Context: Individuals with a history of lateral ankle sprains (LAS) have demonstrated altered kinematics and kinetics during running. External ankle supports, such as bracing or taping, are commonly used to protect the ankle joint during activity after LAS. **Objective:** To evaluate the effect of ankle taping, bracing, and fibular reposition tape (FRT) on running biomechanics compared to shod in young adults with a history of LAS. Design: Randomized crossover study. Setting: Field setting. Patients or Other Participants: Twelve participants with history of LAS (6 males, 6 females, age = 22.0 ± 1.9 years; height $= 171.2 \pm 9.0$ cm; mass $= 76.7 \pm 9.3$ kg) participated. Interventions: Participants completed four 400m runs at a self-selected pace (rating of perceived exertion 5 to 6 on 10-point Borg scale) on an outdoor track. One of four conditions (shod, tape, brace, FRT) was applied in randomized order prior to each run. RunScribe[™] wearable sensors, consisting of a triaxial accelerometer and gyroscope, were heel-mounted on each shoe. Main Outcome Measures: Kinematic (maximum pronation velocity, pronation excursion, loading response sagittal excursion), kinetic (braking and impact g's) and spatiotemporal (cycle time, contact time, stride length, stride pace) variables were collected for each step and averaged across all steps in each run. For each biomechanical variable, a one-factor within subject analysis of variance (ANOVA) with repeated measures was used to compare conditions. Fisher's least significant difference (LSD) tests were used for post hoc analyses. Results: Significant differences were found across conditions for maximum pronation velocity (p < .001),

pronation excursion (p < .001), loading response sagittal excursion (p < .001), braking g's (p = .02) and cycle time (p= .05). Descriptive measures are in the Table. Briefly, post hoc analyses revealed compared to the shod condition, taping decreased the maximum pronation velocity, pronation excursion, and loading response sagittal excursion the most, followed by the braced condition. Braking g's were significantly higher in the shod condition compared to braced and taped conditions. Braking g's for the FRT condition were only significantly greater than the braced condition. Cycle time was significantly longer in the braced condition compared to taped and FRT conditions. Conclusions: Ankle taping and bracing were comparable in their ability to beneficially alter ankle kinematics and kinetics, while FRT caused minimal changes in running biomechanics. Clinically, taping and bracing may be beneficial for stabilizing and protecting the ankle joint during running in athletes with a history of LAS.

Table. Means with standard deviations within parentheses for each condition. P-values for the one-factor ANOVA comparing measures across the four conditions are in the right-hand column (bolded if $p \le .05$).

		Shod (SD)	FRT (SD)	Taped (SD)	Braced (SD)	p-value
Kinematic	Max Pronation Velocity (°/sec)	767.8 (228.3)	721.2 (213.6)	528.8 (193.6)	562.1 (178.3)	<.001
	Pronation Excursion (°)	-17.1 (6.6)	-17.2 (6.2)	-11.9 (4.7)	-12.9 (5.1)	<.001
	Loading Response Sagittal Excursion (°)	23.9 (7.7)	22.7 (8.9)	19.2 (6.1)	20.9 (5.9)	<.001
Kinetic	Braking gs (gs)	12.1 (0.9)	12.0 (1.1)	11.6 (1.0)	11.6 (1.2)	0.02
	Impact gs (gs)	11.7 (0.9)	11.3 (1.1)	11.5 (1.3)	11.4 (1.6)	0.68
Spatiotemporal	Stride Length (ft)	3.4 (0.4)	3.3 (0.6)	3.2 (0.6)	3.3 (0.5)	0.27
	Stride Pace (ft/sec)	5.0 (0.7)	4.9 (1.0)	4.8 (1.0)	4.9 (0.8)	0.54
	Cycle Time (ms)	677.0 (42.6)	672.1 (44.2)	669.3 (44.6)	677.8 (43.7)	0.05
	Contact Time (ms)	233.0 (25.6)	230.4 (27.8)	227.0 (34.1)	227.5 (28.4)	0.24
Effort	Post-RPE	6.0 (0.9)	5.9 (0.9)	5.7 (0.9)	5.9 (0.9)	0.46
	Lap Time (seconds)	88.5 (10.3)	89.5 (14.2)	91.4 (15.2)	92.0 (14.5)	0.27
	Pre-Heart Rate (BPM)	86.7 (12.8)	87.1 (14.7)	87.5 (13.8)	87.3 (15.5)	0.86
	Post-Heart Rate (BPM)	178.9 (13.5)	177.0 (11.0)	179.1 (13.0)	177.3 (14.0)	0.63

Author Index

A

Abeles B, S-15 Abt JP, S-367 Ackerman TA, S-360 Acocello S, S-103, S-125, S-126, S-269 Acocello SN, S-108, S-123 Adams KB, S-142 Adams WM, S-72, S-148, S-203 Adesina O, S-207 Aguilar AJ, S-49, S-299 Aguilar D, S-169 Akehi K, S-256 Alexander E, S-289 Allen AA, S-134 Allen DC, S-96 Allers VA, S-63 Allison RL, S-373 Allred CD, S-267 Amalfe SA, S-302, S-305 Ambegaonkar JP, S-63, S-79, S-171, S-173, S-247 Amrani KA, S-195 An R, S-41 An YW, S-98, S-113, S-124 Andersen SG, S-273 Anderson BE, S-44, S-45, S-241 Anderson HJ, S-161 Anderson K, S-162 Anderson M, S-33 Anderson MN, S-282, S-283, S-302, S-303 Andrejchak M, S-121 Antosiewicz S, S-301, S-307 Appelbaum LG, S-28 Armstrong CW, S-182, S-230, S-231 Armstrong JL, S-278 Armstrong LE, S-203 Arnold BL, S-316 Atanda A Jr, S-17 Attanasio S, S-211 Attanasio SA, S-210

B

Bach C, S-292 Baellow A, S-330, S-335 Baer DJ, S-101, S-285, S-326 Baez SE, S-36 Bailey J, S-63, S-77 Baker C, S-212 Baker CS, S-132 Baker LB, S-204 Baker R, S-232 Baker RT, S-232, S-233, S-234, S-239 Ballard EA, S-154 Ballard R, S-41 Barandica S, S-74 Barber Foss KD, S-218 Barczak NE, S-305 Barnard BJ, S-330 Barnes ER, S-206 Barnes KA, S-204 Barone NA, S-264 Barrett AS, S-164, S-167 Barrett JL, S-127, S-129 Bartz-Smith S, S-291, S-318 Battaglini CL, S-28, S-75 Baumeister J, S-98, S-113 Bay RC, S-44, S-45, S-55, S-276 Bearden AC, S-119 Bear DJ, S-108, S-198 Beard MQ, S-148, S-254, S-354 Beattie PF, S-67 Beck JJ, S-213 Begalle RL, S-42, S-152, S-180, S-331 Begg M, S-338 Begin MM, S-63 Begley C, S-320 Beidler E, S-33 Bell DR, S-76, S-79, S-143, S-158 Bell RA, S-88 Beltz EM, S-65, S-67 Belval LN, S-71, S-203 Benson A, S-299, S-328 Berkoff DJ, S-185 Berry DC, S-88, S-300 Berry VA, S-322 Bertsos ML, S-164 Besand KB, S-190 Best T, S-135 Betz BD, S-61, S-355 Beutler AI, S-34 Bevilacqua ZW, S-304 Bice M, S-256 Biehl MM, S-152 Biese K, S-143 Biese KM, S-121 Bindel ME, S-131 Binkley HM, S-203 Birchmeier T, S-190 Birchmeier TB, S-250 Blackburn JT, S-112, S-191, S-200, S-201 Blackburn T, S-75 Black WS, S-147 Bodine LE, S-108, S-198 Bodkin S, S-156 Bodkin SG, S-84, S-157 Bodurtha R, S-19 Boergers RJ, S-311

Boling MC, S-63, S-64, S-77, S-336 Bookbinder HA, S-158 Booth MS, S-30 Bothwell JM, S-65, S-146, S-190 Botto T, S-322 Boucher LC, S-219 Bovbjerg VE, S-58, S-216 Bowles R, S-346 Bowman TG, S-127, S-138, S-197, S-278, S-304, S-308, S-309, S-311 Bradney DA, S-197, S-278, S-304, S-308, S-309 Bramblett JC, S-223 Brancaleone MB, S-219 Braun T, S-326 Breedlove KM, S-220, S-304, S-308, S-309 Breitbach AP, S-177, S-236 Bretzin AC, S-282, S-283 Breymeier MM, S-35, S-161 Briggs E, S-177 Brismee JM, S-312 Brockmeier SF, S-193 Broglio SP, S-198, S-267 Brooks MA, S-48, S-79, S-136 Broshek DK, S-198 Brothers RM, S-366 Brown CN, S-133 Brown S, S-241 Bruce CM, S-347 Bruce SL, S-164 Bruening DA, S-21 Bruno P, S-311 Buckley TA, S-17, S-38, S-48, S-220 Bull AT, S-294 Burcal CJ, S-347, S-373 Burland JP, S-65, S-67, S-188, S-189, S-192, S-211 Burns KN, S-38 Bush J, S-53 Buskirk G, S-338

С

Cabell GH, S-101, S-266 Caccese JB, S-48 Cadmus-Bertram LA, S-79 Cage SA, S-228, S-295, S-322, S-328, S-339 Cain MS, S-370 Callahan MJ, S-42 Calvi JL, S-292 Cameron KL, S-75, S-78, S-92, S-265, S-267, S-279 Campbell DE, S-267

Volume 53 • Number 6 (Supplement) June 2018 S-376

Campbell K, S-266 Campbell KR, S-101 Cantu RC, S-134 Capilouto GJ, S-367 Carlson JM, S-39 Carneiro KA, S-28 Carney MB, S-269 Carpentieri S, S-327 Casa DJ, S-56, S-71, S-72, S-148, S-203, S-210, S-211 Castel JC, S-87 Caswell AM, S-63, S-79, S-240 Caswell SV, S-79, S-171, S-173, S-240, S-247, S-306, S-307, S-310 Cattano NM, S-35, S-131, S-145, S-161 Cavallario JM, S-115, S-117, S-178, S-179 Chae S, S-233, S-234 Chae SA, S-232 Chahla J, S-69 Chang EW, S-270 Chang M, S-57 Chaput M, S-162 Charles-Liscombe RS, S-225 Chaudhari A, S-135 Cheever KC, S-274 Chen Z, S-29 Chicarella M, S-322 Chin A, S-19 Chiu R, S-223 Choe MC, S-28 Chomistek AK, S-374 Chong Gum BA, S-213 Christian ME, S-154 Christie CM, S-88 Chun Y, S-232, S-234 Chun YM, S-233 Cieszko E, S-318 Cinque ME, S-69 Ciocca M, S-299 Clair D, S-253 Clanton TO, S-284 Cleaves G, S-286 Clemmer BP, S-116 Clifton DR, S-135, S-219 Cobb JL, S-31 Coleman KA, S-129, S-130 Collins CL, S-102, S-194, S-312 Collins KA, S-160 Colston MA, S-103, S-132 Colvin GR, S-154 Combs J, S-226 Combs PR, S-101, S-270, S-302 Comstock RD, S-135 Condon TA, S-49, S-299 Conley CW, S-368 Connaboy C, S-122

Connolly DS, S-324 Coon SG, S-272 Cooper GL, S-210 Copeland BW, S-278 Corbett RO, S-60, S-62 Cordone J, S-287 Cortes N, S-63, S-79, S-171, S-173, S-247, S-306, S-307, S-310 Courson R, S-268 Covassin T, S-92, S-275, S-282, S-283 Craddock JC, S-73, S-222, S-227, S-255, S-289, S-290, S-324, S-342, S-358 Cramer RJ, S-25 Crawford SK, S-340 Cripps AE, S-280 Crisafulli GA, S-64, S-158, S-336 Csonka J, S-125 Cuchna JW, S-52

D

Curtis N, S-285

Dalton SL, S-194, S-312 Daltry RM, S-108, S-198 D'Amico NR, S-264 Daniell B, S-32 Dargo LD, S-237 Darr K, S-352 Dartt CE, S-165, S-167 David SL, S-237 Davis B, S-245 Davis C, S-250 Davis ER, S-44 Davis H, S-200 Davi SM, S-188, S-189, S-192 Davis RJ, S-71 Day M, S-312 Decker D, S-291 Decoster LC, S-280, S-281 DeCraene WP, S-347 Degerstrom SD, S-243 DeJong A, S-258 de la Motte SJ, S-34, S-164, S-165, S-167 Del Rossi G. S-72 DePhillipo NN, S-69, S-226 Desmarteau TJ, S-222, S-255 Deuster PA, S-165 Devaney LL, S-19, S-67 DeZeeuw T, S-137 DiAntonio B, S-147 DiCesare C, S-218 Diduch DR, S-112, S-188 Diekfuss JA, S-218 Dietze C, S-227 DiFabio MS, S-220

DiMasso AE, S-164 DiStefano LJ, S-34, S-63, S-64, S-65, S-67, S-77, S-78, S-203, S-211, S-336 DiTrani Lobacz A, S-98, S-113, S-124 D'Lauro C, S-267 Docherty CD, S-169 Docherty CL, S-171, S-246, S-257, S-349, S-350, S-374 Dodds TK, S-249 Dompier T, S-247 Dompier TP, S-266 Donahue CC, S-165, S-167 D'Onofrio AM, S-25, S-26 Donovan JJ, S-292 Donovan L, S-148, S-182, S-354 Donovan LT, S-230, S-231 Dorman AV, S-92 Dougal ZD, S-115 Doughton JH, S-119 Draper DO, S-87, S-88, S-91, S-367 Dressler EV, S-368 Driban JB, S-200 Dudash J, S-363 Dudley J, S-218 Duffy R, S-330 Duncan ST, S-360, S-362 Dunham WF, S-132 Dunn R, S-307 Dybwad L, S-43

E

Eagle SR, S-122 Earp JE, S-192 Eason CM, S-148 Eberman L, S-241 Eberman LE, S-30, S-53, S-95, S-96, S-115, S-168, S-178, S-179, S-180, S-214, S-237, S-243 Eckard TG, S-49, S-78 Edler JE, S-115 Edler IR, S-237 Elbin RJ, S-264 Embree EC, S-349, S-350 Emerson DE, S-262 Emerson DM, S-176, S-206 Endres B, S-211 Endres BD, S-56 Enriquez A, S-358 Ensign K, S-137 Erdman N, S-264 Etnoyer-Slaski JL, S-363

F

Fabries B, S-108, S-123 Faherty M, S-125 Famer B, S-162 Farris J, S-103 Faso N, S-137 Fauntroy VN, S-173 Fay D, S-242 Feland JB, S-21 Feld SD, S-53 Feltner CO, S-40 Felton SD, S-73, S-222, S-227, S-255, S-289, S-290, S-324, S-342, S-358 Fermin S, S-232, S-233, S-234 Ferris M, S-272, S-273 Fiesler T, S-322 Figler R, S-346 Fisher ML, S-61, S-355 Fitch CA, S-65, S-230 Fitzpatrick M, S-287 Fletcher S, S-236 Florentino AM, S-357 Ford CB, S-101, S-270, S-302, S-305 Ford KR, S-63, S-64, S-77, S-336 Forlenza CJ, S-311 Foster AL, S-295 Foster FO, S-304 Foster T, S-314 Fowkes-Godek S, S-205, S-207 Francisco J, S-19 Frank B, S-63 Frank BS, S-49, S-75, S-77 Frank EM, S-53, S-109, S-118 Franz JR, S-82, S-112, S-201 Fraser JJ, S-150, S-261, S-264 Fraser MA, S-194 Freisinger GM, S-151 Fuller NJ, S-213 Funk CD, S-150 Funk JW, S-145

G

Gabler CM, S-297 Gallagher PM, S-206 Gallegos DM, S-228, S-295, S-339 Gallenberger M, S-48, S-105, S-196 Gallenberger MA, S-196 Gallucci AR, S-195 Games KE, S-95, S-96, S-154, S-168, S-180 Gange K, S-153 Garcia AJ, S-263 Garcia SA, S-201 Gardner E, S-287 Gardner L, S-95 Garrett BM, S-278 Garrett WZ, S-337 Garrison JC, S-65, S-146, S-190 Gaven SL, S-61, S-355, S-371, S-372 Gear WS, S-249 Geers B, S-250 Gentry JA, S-342 Gerena-Levy J, S-301 Gerig J, S-289 German NA, S-237 Gibson BW, S-317 Gibson KM, S-332 Gilbert KK, S-312 Gildard M, S-318, S-365 Gildner P, S-92 Gillespie M, S-364 Glaviano NR, S-230, S-231, S-260, S-333, S-335, S-338 Glover B, S-347 Glutting JJ, S-48 Godek T, S-207 Goerger BM, S-370 Goetschius J, S-193, S-352 Goins JM, S-67, S-321 Golec S, S-289 Golightly YM, S-59 Gomez CJ, S-139 Goodale AC, S-225 Gooding TM, S-225 Goodkin HP, S-198 Goodwin JS, S-191 Gorrell P, S-72 Goss DL, S-151 Goto S, S-65, S-146, S-190 Goza JP, S-295 Granito D, S-329 Gray C, S-286 Green AL, S-194 Green B, S-217 Greene MA, S-103 Green SL, S-197 Gregory CJ, S-375 Gregory CM, S-142 Gregory MA, S-249 Gribbin TC, S-164, S-165, S-167 Gribbin TG, S-167 Gribble PA, S-22, S-23, S-85, S-256, S-351, S-354 Grimsley EE, S-317 Grindstaff TL, S-162, S-230 Grondin AN, S-190 Grooms D, S-270 Grooms DR, S-98, S-99, S-119, S-120, S-144, S-189, S-247, S-251, S-268 Gruber D, S-344 Gubanich PJ, S-314

Guerrero MJ, S-221 Guida E, S-126 Gulbranson K, S-367 Gurchiek LR, S-330 Guskiewicz KM, S-28, S-101 Gustavsen G, S-21, S-23, S-110, S-349 Guy J, S-253 Gwinn G, S-337

Η

Hackney AC, S-75, S-112, S-201 Hackney K, S-153 Haddad G, S-329 Haggard C, S-253 Hallberg CT, S-278 Hall EA, S-374 Hallsmith K, S-79 Hallsmith KR, S-63 Hankemeier DA, S-115, S-117, S-238 Hannon JP, S-65, S-146, S-190 Hansen-Honeycutt J, S-171 Hansen-Honeycutt JA, S-173 Hardin SN, S-50 Harkey M, S-200 Harper RC, S-210 Harris N, S-175 Harrison K, S-356 Harter RA, S-15, S-133, S-347 Hart J, S-84 Hart JM, S-57, S-62, S-112, S-156, S-157, S-158, S-188, S-193, S-333 Hartley EH, S-25 Hartley EM, S-25, S-26 Hartzell JT, S-351 Hatheway Lewis M, S-169 Hawkins JR, S-235 Heebner NR, S-367 Heiderscheit BC, S-332 Heidt D, S-126 Heinerichs S, S-131 Henning JM, S-241 Hennink-Kaminski H, S-92 Henry KJ, S-356, S-364 Hepburn L, S-306, S-307, S-310 Hernden K, S-259 Hertel J, S-60, S-62, S-84, S-112, S-150, S-158, S-188, S-193, S-261, S-330, S-333, S-375 Heumann KJ, S-235 Hibberd EE, S-185 Higgins M, S-259, S-375 Higgins MJ, S-32 Hile AM, S-296 Hilliard MW, S-153 Hixson KM, S-312

Journal of Athletic Training

Hoch JM, S-36, S-61, S-324, S-344, S-351, S-370 Hoch MC, S-25, S-26, S-36, S-61, S-66, S-248, S-265, S-351, S-367, S-370, S-373 Hoffman M, S-363 Hoffman NL, S-40 Hogg JA, S-360 Hollingworth AT, S-280, S-281 Holmes AA, S-29 Holmes S, S-201 Holt L, S-299 Hoots KM, S-172, S-294 Hopkins JT, S-21 Horan MP, S-321 Horris HB, S-44, S-45 Hosier KD, S-251 Hosokawa Y, S-56, S-71, S-148, S-211 Hostetter G, S-15 Housman JM, S-133, S-347 Houston MN, S-36, S-61, S-92, S-265, S-267, S-279 Howard AF, S-212 Howard JD, S-73 Howard JS, S-212, S-292, S-298, S-368 Howell DR, S-38 Hsieh K, S-41 Huang YL, S-334 Hubbard-Turner T, S-160, S-373 Huemme KL, S-210 Huggins RA, S-56, S-71, S-210, S-214 Huibregtse ME, S-304 Hume PA, S-134 Hunnicutt JL, S-142 Hunt TN, S-277 Hutto SA, S-249 Huxel Bliven KC, S-44, S-45, S-105, S-106, S-107, S-239 Huxford R, S-63 Hyldahl RD, S-88, S-91

I

Ingersoll CD, S-182, S-230 Ingram BM, S-27 Ip WYV, S-90 Isaka T, S-348

J

Jacobs CA, S-360, S-362 Jacobs DC, S-342 Jaffri A, S-335 Jaffri AH, S-84, S-251 Jamali BE, S-370 Jamerson S, S-262 James CR, S-181, S-312 Jancaitis GA, S-55 Jang J, S-228 Jardine JF, S-71, S-148 Jaric S, S-124 Jeon H, S-159 Jochimsen KN, S-360, S-362, S-368 Jochum JE, S-43 Johnson BR, S-267 Johnson CD, S-122 Johnson DL, S-341 Johnson EN, S-148 Johnson MT, S-154 Johnson N, S-85 Johnson NF, S-256 Johnson P, S-329 Johnson RS, S-302, S-303 Johnson ST, S-58, S-216, S-334 Johnson ZD, S-164, S-167 Johnston CD, S-191 Johnston KJB, S-299 Jones K, S-74 Jones KE, S-269 Joseph C, S-221, S-223 Jun H, S-232, S-234 Jun HP, S-233

K

Kahanov L, S-326 Kaiser EJ, S-308 Kaminski TW, S-21, S-23, S-48, S-110, S-349 Kangas KJ, S-39 Kang M, S-213 Kaptaine Z, S-245 Karimizadeh Ardakani M, S-82 Karli D, S-338 Kasamatsu TM, S-243 Kattiria SY, S-280, S-281 Kawata K, S-29, S-272, S-273, S-304 Kay MC, S-27, S-92 Kazman JB, S-167 Keenan LC, S-108, S-198 Keith TR, S-60, S-62 Kelly MR, S-206 Kelly TF, S-267 Kelshaw P, S-63, S-79, S-306, S-310 Kelshaw PK, S-307 Kennedy NI, S-69 Kerr Z, S-63 Kerr ZY, S-56, S-72, S-92, S-266 Kershaw ZT, S-297 Kilbourne BF, S-127 Killinger TP, S-235 Kim CS, S-245 Kim H, S-230 Kim J, S-234 Kim JS, S-245, S-270

Kim KM, S-245, S-270 Kim MJ, S-245 Kimura B, S-20 Kim Y, S-17 Kindstrand N, S-15 King A, S-223 Kingma JJ, S-257 King ST, S-335 Kinkaid W, S-367 Kirsch A, S-156 Kirsch DK, S-237 Klassen SI, S-358 Kliethermes S, S-196 Kliethermes SA, S-136, S-196 Klock A, S-205 Knarr BA, S-162 Knight AC, S-357 Knight AR, S-324 Knighton S, S-328 Knittle S, S-286 Kocan KR, S-360 Koceja DM, S-374 Kocik AD, S-306 Koenig RC, S-154 Koester MC, S-216 Koldenhoven RM, S-84, S-261, S-375 Kontos AP, S-264 Kontost AP, S-122 Konz S, S-185 Kosik K, S-351 Kosik KB, S-22, S-23, S-85, S-256 Koudelka J, S-19 Kovaleski JE, S-330 Kowata H, S-352 Kravey JK, S-203 Kroshus E, S-266 Krout DS, S-323 Krueger R, S-272, S-273 Krysak SM, S-160 Kucera KL, S-59, S-72, S-185, S-211, S-241, S-315 Kuchenberg M, S-43 Kuehne JT, S-184 Kuenze C, S-76, S-190, S-250 Kuznetsov NA, S-82

L

Lafe CW, S-133 LaFortune NA, S-277 Lake AW, S-346 LaMarche J, S-288 Lam KC, S-46, S-47, S-51, S-107 Lamond LC, S-48 Landes EJ, S-206 Landrum M, S-318 Lanier AS, S-162 LaPrade RF, S-69, S-226 LaSorda M, S-207 Lattermann C, S-342, S-362, S-368 Lauber CA, S-363 Laudner KG, S-185 Laurente A, S-301 Laursen RM, S-243 Lauver JD, S-352 Leach J, S-218 Leddon CE, S-15 Lee EC, S-203 Lee J, S-247 Lee JGL, S-266 Lee JM, S-17 Lee SY, S-232, S-233, S-234 Leghart S, S-274 Lempke LB, S-264, S-302, S-303 Lepley AS, S-188, S-189, S-190, S-192 Lepley LK, S-188, S-189, S-192 Levine J, S-313 Lewis MD, S-335 Li B, S-15 Lincoln A, S-306, S-310 Lincoln AE, S-306, S-307 Lindley HN, S-190 Lindley TR, S-178, S-179 Lindsey B, S-310 Linens SW, S-370 Linnan LA, S-92 Lipinski C, S-338 Lipinski CL, S-182 Lisee C, S-190, S-250 Lisee CL, S-76 Liu K, S-21, S-23, S-110 Llanos CE, S-290 Locke C, S-257 Lockhart JT, S-331 Lockwood CM, S-111, S-166 Lohman Bonfiglio CM, S-312 Lopez RM, S-72, S-148 Lopez V, S-134 Luc-Harkey BA, S-112, S-149, S-201 Lundin MJ, S-161 Luparello B, S-356 Lyles T, S-97 Lynall RC, S-38, S-40, S-121, S-302, S-303 Lynch T, S-338

M

MacDonald RL, S-242 Mace KL, S-177 Mack GW, S-91 Maginnis SF, S-116 Malin SK, S-32 Malvasi SR, S-265, S-279 Mangum LC, S-258, S-259, S-260, S-333 Mansell JM, S-44 Manspeaker SA, S-238 Ma R, S-134 Marcano ED, S-134 Marenzi AL, S-359 Mariano MH, S-52 Marrone W, S-19 Marshall AN, S-28, S-46, S-47, S-107, S-260, S-333 Marshall DL, S-164 Marshall SP, S-28 Marshall SW, S-34, S-59, S-72, S-75, S-78, S-92, S-101 Martin B, S-338 Martin BM, S-226, S-284 Martinez JC, S-323 Martin J, S-247 Martin K, S-84 Martin M, S-117 Mattacola CG, S-362, S-368 Matuseski N, S-74, S-253, S-313, S-327 Mauntel TC, S-75 Mazerolle SM, S-127, S-128, S-129, S-130, S-138 McAdam JS, S-111, S-166 McAllister-Deitrick J, S-33 McAllister T, S-267 McCall M, S-262, S-263 McCann RS, S-22, S-23, S-85 McCann ST, S-326 McConnell W, S-21, S-23, S-110 McCrea M, S-267 McCullough JI, S-136 McDermott BP, S-207 McDevitt J, S-217, S-356 McDonald C, S-48, S-105 McGinnis IW, S-31 McGinnis KD, S-111, S-166 McGinty GT, S-267 McGinty S, S-205, S-207 McGovern E, S-365 McGrath ML, S-85, S-100 McGuine TA, S-48, S-79, S-105, S-196 McIntyre K, S-356 McKeon PO, S-30, S-66, S-248, S-373 McLeod IA, S-28 McLeod MM, S-142 McLoughlin TJ, S-182 McNulty E, S-152 McPherson AM, S-169, S-171 McPhillips D, S-346 McTernan KH, S-344 Medina McKeon JM, S-30, S-37, S-66,

S-80, S-144, S-152, S-248, S-359

Meehan III WP, S-38

Memmini AM, S-147 Merritt NC, S-170 Mesman D, S-328 Mesman DL, S-228, S-322 Mettry MT, S-134 Meyer M, S-272, S-273 Meyers MC, S-276 Michener LA, S-15 Mihalik JM, S-270 Mihalik JP, S-28, S-101, S-302, S-305 Miko SC, S-119 Miller EM, S-151 Miller KC, S-207, S-369 Mills H, S-224 Miraldi SFP, S-78 Mistry DJ, S-28 Mitchell J, S-44 Mize K, S-103 Moatshe G, S-69 Moffit DM, S-276 Moffit TJ, S-201 Mollner KE, S-132 Monsma E, S-262, S-263 Monsma EV, S-67 Montalvo AM, S-20 Montgomery MM, S-201 Mooney SN, S-345 Moore CD, S-231 Moore EM, S-97, S-262 Moore MA, S-358 Moore MT, S-39, S-293 Moore T, S-125 Moran AD, S-25, S-26 Moran RN, S-274, S-275 Morello AE, S-227 Morrison K, S-207 Morrison KE, S-35, S-145, S-161, S-205 Morris RF, S-210 Morris SN, S-102 Mulligan R, S-19 Munkasy B, S-277 Murray AM, S-231 Mutchler J, S-277 Myer GD, S-218 Myers A, S-284 Myers JB, S-59, S-182, S-185

Ν

Nakajima MA, S-38 Nedimyer AK, S-149 Needle AR, S-119 Neil ER, S-30, S-95, S-243 Neiper D, S-286 Neumann JL, S-171 Nguyen A, S-63, S-64, S-77, S-158, S-336 Nicolai MA, S-88 Nicol E, S-313 Niewold N, S-196 Niewold NK, S-196 Nindl BC, S-122 Nissen C, S-322 Nitz AJ, S-131 Nnaeto CA, S-317 Nocera MA, S-101 Noehren B, S-360 Noeldner F, S-256 Norcross MF, S-58, S-216, S-334 Norkus S, S-287 Norte GE, S-112, S-182, S-188 Norte SB, S-338 Nottingham S, S-129 Nottingham SL, S-129, S-130, S-243

0

O'Connor KL, S-267 O'Connor PJ, S-40 O'Donnell PG, S-267 Odum EM, S-108, S-123 Oglesby LW, S-195 O'Hagan K, S-190, S-250 Oldham JR, S-220 Onate J, S-247 Onate JA, S-98, S-135, S-219 O'Neal-Belmont BJ, S-222 Ormond KE, S-103 Ortaglia A, S-67 Ostrowski JL, S-172 Overhiser AO, S-324 Owens J, S-207 Oyama S, S-184

P

Padilla D, S-327 Padua DA, S-34, S-49, S-75, S-78, S-112, S-121, S-201 Pahnke MD, S-204 Pak J, S-314 Paladin SJ, S-345 Palumbo M, S-274 Pamukoff DN, S-201 Pandit KV, S-134 Parham CS, S-240 Park DH, S-245 Park K, S-99 Pasquina PF, S-267 Paulson G, S-180 Paver SR, S-53, S-109, S-118 Pavlu M, S-141 Peck KY, S-34, S-78, S-92, S-267, S-279 Perry M, S-21, S-23, S-110 Persch A, S-135

Peters JM, S-212 Peterson BC, S-210 Peterson R, S-153 Peterson TD, S-51 Petit KM, S-282, S-283 Pettaway A, S-232, S-233, S-234 Pexa BS, S-182 Pfaller A, S-48, S-105, S-196 Pfaller AY, S-196 Pfeifer CE, S-67 Pfeiffer S, S-159 Phillips J, S-50 Phillips JM, S-219 Phillips K, S-329 Picha KJ, S-367 Piche L, S-254 Picinich LA, S-311 Pickerill ML, S-133, S-347 Piehlmaier D, S-266 Pierpoint LA, S-72 Pierre DM, S-134 Pietrosimone B, S-112, S-191, S-200, S-201 Pietrosimone BG, S-75, S-149 Pike AM, S-138, S-210, S-211 Pitney WA, S-53, S-109, S-118, S-239 Plummer HA, S-15 Pollard-McGrandy A, S-300 Pope J, S-79 Posner MA, S-78 Post E, S-76 Post EG, S-79, S-143 Potteiger K, S-53, S-109, S-239 Powden CJ, S-61, S-170, S-180, S-249, S-355, S-370, S-371, S-372 Powell JR, S-30 Powers ME, S-318, S-356, S-364, S-365 Prata GM, S-311 Pritchard K, S-245 Pritchett K, S-262 Pryor RR, S-72, S-210, S-213 Putukian M, S-302, S-305 Pye M, S-245

Q

Quintana C, S-280

R

Rager JL, S-115, S-128 Raisbeck LD, S-99 Ranapurwala SI, S-101 Ransone JW, S-292 Rausch MA, S-268 Raymond C, S-284 Rediger T, S-228 Reed BD, S-237 Reeder M, S-235 Reed M, S-205 Reed NP, S-323 Reeves S, S-236 Register-Mihalik JK, S-27, S-28, S-72, S-92, S-101, S-197, S-211, S-278 Reichert CL, S-61, S-355 Reimel AJ, S-204 Reisler TC, S-133 Renollet MR, S-249 Resch JE, S-32, S-150, S-198, S-258, S-264 Rexrode BL, S-278 Reynolds N, S-144 Rhea CK, S-82, S-99 Rhode A, S-300 Richards JG, S-17 Richason MD, S-246 Richter SD, S-105, S-107 Rigby JH, S-87, S-88, S-91 Rigsby K, S-185 Riordan SM, S-284 Rippon L, S-301 Ritter KG, S-105 Rivera LA, S-173 Rivera MJ, S-180 Roach SP, S-279 Roberts E, S-196 Roberts EJ, S-196 Roberts MD, S-111, S-166 Robinson K, S-28 Robison HJ, S-80 Rodeo S, S-28 Rolow JM, S-221 Romero J, S-253 Roos K, S-38 Roos KG, S-59 Root HJ, S-65, S-67, S-241 Rosamond WD, S-59 Rosen AB, S-17, S-85, S-100, S-228, S-230, S-340 Ross SE, S-82 Rothbard M, S-141 Rouah B, S-221 Rubingh SL, S-125 Rudolph AJ, S-340 Runestad S, S-213 Runyon LM, S-30 Russ AC, S-31 Russ AR, S-44 Russel S, S-333 Ryan C, S-286 Ryan ED, S-182 Ryan W, S-256

Journal of Athletic Training

Sagadore T, S-42 Salesi K, S-125 Saliba S, S-84, S-156, S-251, S-258, S-259, S-260, S-261, S-330, S-335 Saliba SA, S-112, S-188, S-193, S-264, S-333 Samer NM, S-298 Samson CO, S-133 Sandrey MA, S-373 Sanfilippo JL, S-136, S-332 Sauers EL, S-46 Saul NR, S-77 Savage JL, S-92, S-282, S-283 Saville S, S-245 Sawyer QL, S-137 Sawyer S, S-181 Scarneo SE, S-56, S-67, S-72, S-203, S-211 Schaefer DA, S-79, S-143 Schappacher S, S-255 Schatz P, S-264 Schellhase KC, S-235, S-353 Schmidt JD, S-268, S-302, S-303 Schmidt MD, S-40 Schmidt ML, S-39 Schmitz RJ, S-99, S-360 Schnittjer AJ, S-120 Schrader JW, S-171 Schwartzberg RS, S-353 Schwartz TA, S-112, S-201 Schwarz A, S-48, S-105, S-196 Schwarz AM, S-196 Schwarz NA, S-330 Sciascia AD, S-131 Scifers JR, S-154, S-172, S-294, S-317 Scott RA, S-181 Seeley MK, S-21 Sefton JM, S-111, S-166 Self C, S-228 Selkow NM, S-42, S-152, S-180, S-331 Sell T, S-125 Semrow KM, S-131 Senoo K, S-348 Shafer C, S-314 Shaver G, S-277 Shea ME, S-95, S-96, S-168 Sheehan K, S-144 Sheridan S, S-16 Shervington K, S-289 Shultz SJ, S-99, S-360 Silbernagel KG, S-124 Silva NG, S-316 Simon JE, S-119, S-120, S-137, S-144, S-246, S-247, S-251, S-268

Sims K, S-53 Sinclair Elder AJ, S-314 Siparsky P, S-338 Sitler M, S-274 Sitler MR, S-219 Sizer PS, S-181, S-312 Slater L, S-57 Slater LV, S-158 Slaughter NJ, S-51 Slone HS, S-142 Smith AB, S-263 Smith BM, S-91 Smith JJ, S-101, S-285, S-326 Smith R, S-226 Smoot MK, S-341 Sniffen K, S-177 Snyder MM, S-51, S-140, S-221 Snyder Valier AR, S-55, S-105, S-106, S-211, S-241, S-242, S-315, S-361 Sobczak S, S-312 Song K, S-82 Son SJ, S-21 Sosnoff J, S-41 Sowers DR, S-125 Soyk M, S-196 Soyk MG, S-196 Springer AD, S-338 Stacer J, S-257 Stanley LE, S-121 Starkey C, S-119, S-120, S-251, S-268 Stearne D, S-145 Stearns RL, S-56, S-71, S-148, S-211 Steen J, S-274 Steffen RM, S-340 Stein JK, S-169 St. John KC, S-285 Stodden DF, S-67 Stokes LI, S-117 Stonestreet C, S-328 Struminger AH, S-17 Study K, S-256 Sturch BM, S-279 Sugimoto YA, S-82 Sullivan BS, S-336 Susa TR, S-39 Svoboda SJ, S-34, S-265, S-267, S-279 Swanik CB, S-17, S-98, S-113, S-124 Swartz EE, S-316 Sweeney J, S-253

T

Takahashi E, S-232, S-233, S-234 Takahashi KZ, S-230 Talley P, S-38 Taniyama D, S-348 Tanksley EC, S-292 Taylor JB, S-63, S-64, S-77, S-336 Taylor L, S-241 Teel EF, S-28, S-302, S-305 Teets A, S-300 Terada M, S-22, S-23, S-85, S-348, S-352 Terhune W, S-224 Thatcher A, S-105, S-361 Thiriot K, S-88 Thomas AC, S-85, S-159, S-160, S-347 Thomas GM, S-332 Thomas SJ, S-16 Thompson T, S-152 Thompson XD, S-147 Thrasher AB, S-117, S-140, S-223, S-237 Tierney RT, S-31, S-219, S-274 Timlin JJ, S-317 Timmons MK, S-185 Topp R, S-363 Torp DM, S-148, S-354 Torres-McGehee TM, S-97, S-262, S-263, S-321 Trigsted S, S-76 Trigsted SM, S-63, S-64, S-77, S-79, S-143, S-158, S-336 Trowbridge C, S-90 Trowbridge CA, S-366 Truman AS, S-308 Tucker M, S-297 Turman KA, S-162 Turner MJ, S-160

U

Uhl TL, S-131, S-367 Ungaro CT, S-204 Unruh S, S-256 Usher EL, S-367

V

Vakula MN, S-201 Vallandingham RA, S-371, S-372 Valovich McLeod TC, S-28, S-137, S-276, S-280, S-281 Vanata D, S-344 Vandermark LW, S-148, S-203 Vander Vegt CB, S-27 Vandever L, S-262 Vaniman AL, S-293 Van Lunen BL, S-52, S-178, S-179 Van Valkenburg C, S-226 Vetroczky N, S-43 Vickers MA, S-108, S-123 Victoria C, S-134 Vineyard AP, S-146

W

Wade M, S-328, S-339 Wagner D, S-141 Waite N, S-352 Wakefield G, S-97 Waldman E, S-15 Walker S, S-97 Walker SE, S-52, S-53, S-115, S-117, S-127, S-128, S-178, S-179, S-241 Wallace D, S-322 Wallace J, S-33, S-275, S-284 Wallace JS, S-226, S-274, S-289 Walton SR, S-32, S-198 Wan HM, S-276 Warmath D, S-93, S-266 Warne A, S-223 Warner BJ, S-228, S-295, S-322, S-328, S-339 Warner LK, S-295 Warnick DE, S-340 Wasserman E, S-57 Wasserman EB, S-102, S-105, S-106, S-194, S-312 Watson AM, S-79 Watson DJ, S-151 Watson EL, S-119, S-298 Weatherby NL, S-203 Weaver TA, S-335 Weber ML, S-268 Weber SR, S-262, S-321 Wehring SP, S-176 Weidner TG, S-117 Welch Bacon CE, S-30, S-115, S-117, S-137, S-175, S-177, S-178, S-179, S-211, S-241, S-243, S-315 Wellin B, S-257 Wells AM, S-87 Wellsandt E, S-17 Werner JL, S-314 Weyand J, S-301 Wheeler BM, S-280, S-281 Whicker CR, S-64, S-158 White D, S-322 Whittaker A, S-247 Wichman C, S-162 Wikstrom EA, S-49, S-82, S-121, S-149, S-373 Wildehain R, S-247 Wilkenfeld DA, S-317 Wilkerson GB, S-103, S-108, S-123, S-125, S-126, S-132, S-269 Wilkins RW, S-99 Williams AR, S-321 Williams J, S-329

Williams RM, S-105, S-106, S-211, S-241, S-315, S-361 Williams S, S-331 Williams SJ, S-341 Wills J, S-284 Wilson B, S-320 Wilson S, S-288 Winkelmann ZK, S-53, S-96, S-154, S-168, S-214 Winkle C, S-103 Winterstein A, S-93 Winterstein AP, S-266 Wirsching A, S-304 Wise JB, S-349, S-350 Wise SL, S-203 Wisthoff BA, S-349 Witter RG, S-309 Wohlfert TM, S-369 Woodring S, S-306 Wood T, S-41 Workman P, S-299 Worley M, S-207 Worley ML, S-205 Worley R, S-314 Woxholdt CK, S-192 Wright CJ, S-316 Wright WG, S-219, S-274 Wujciak D, S-253 Wu WF, S-38

Y

Yahng L, S-29 Yan A, S-250 Yang HS, S-181 Yang J, S-135 Yeargin SW, S-207 Yentes JM, S-85 Yom J, S-120, S-247 Yonz C, S-224 Young RA, S-140 Yuan W, S-218 Yu B, S-185

Z

Zaichenko D, S-37, S-144 Zarzour R, S-125 Zengel O, S-286 Zhang M, S-200 Zimmerman JA, S-132 Zoghbi AC, S-73 Zuk EF, S-63, S-64, S-65, S-77, S-336

Journal of Athletic Training