

JOURNAL OF ATHLETIC TRAINING

Official Publication of the National Athletic Trainers' Association, Inc Volume 49, Number 3, Supplement, 2014

Free Communications Review

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Take this *Supplement* to Indianapolis and use it as a guide to the
Free Communications Sessions

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 2014 NATA Annual Meeting & Clinical Symposia in Indianapolis, Indiana 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, thematic posters, clinical case reports and our Student Exchange program posters. Abstracts of the research are printed here in the order of presentation at the NATA Annual Meeting in Indianapolis 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,



R. T. Floyd, EdD, ATC

President
NATA Research & Education Foundation Committee



James Thornton, MA, 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, Patsy Brown; and Rachael Oats, CAE 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 including: Kenneth Cameron, PhD, MPH, ATC; Jeff Driban, PhD, ATC, CSCS; Joe Hart, PhD, ATC; Tom Kaminski, EdD, ATC; Blaine Long, PhD, AT, ATC; Stephanie Mazerolle, PhD, ATC; Brendan P. McDermott, PhD, ATC; Melanie McGrath, PhD, ATC; Sara Nottingham, EdD, ATC; Darin Padua, PhD, ATC; Stephen Straub, PhD, ATC; Charles Thigpen, PhD, ATC, PT; Kavin Tsang, PhD, ATC; ATC and Michelle Boling, PhD, ATC (liaison to Convention Program Committee) for their long hours of abstract reviews and preparation for the Free Communications programming. 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*. We appreciate the feedback we have received from authors, and suggestions are always welcomed and discussed in committee meetings to further improve the process.

We look forward to seeing you in Indianapolis. Please take the opportunity to attend the Free Communications evidenced-based 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,



Jennifer E. Earl-Boehm, PhD, ATC

Vice Chair for Free Communications
NATA Research & Education Foundation Committee

JOURNAL OF ATHLETIC TRAINING

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The Medal for Distinguished Athletic Training Research

Sandra J. Shultz, PhD, ATC, FNATA, FACSM

University of North Carolina-Greensboro

Like many professionals in sports medicine, Sandy Shultz's love of athletics and passion for medicine led her to the career of athletic training. "Athletic training was suggested by my high school career counselor, and that was it: I haven't changed my mind since!" A native of California, Shultz graduated from California State University and went on to obtain her master's in exercise science from the University of Arizona. She served as the associate director of athletic training and rehabilitation at the University of California, Los Angeles, working with the women's basketball, softball, and volleyball programs. Her initial interest in research stemmed from her clinical practice and reflected the prevalence of ACL injuries among her female athletes. "Knee injuries were a big problem, especially in the PAC-10. I wanted to understand what was causing them."

Her interest in understanding the higher risk for ACL injury in females led her to the University of Virginia, where she earned her PhD in sports medicine. Now a professor in the Department of Kinesiology at the University of North Carolina at Greensboro, Shultz serves as Co-Director of the Applied Neuromechanics Research Laboratory. Throughout her professional career, her research has focused on the underlying factors that increase females' susceptibility to ACL injury, and her goals are to effectively identify and address such risk factors via ACL injury-prevention programs. In particular, Shultz has sought to understand the hormonal and genetic factors that contribute to interindividual variations in knee joint laxity and how these factors combine to increase one's susceptibility for knee ligament injuries. "Compared to my initial training, this has taken me into areas of research I would have never imagined. An important part of successful research is using a multidisciplinary approach and collaborating with other professionals in order to answer the bigger questions."

Shultz is an active member of multiple professional organizations, including the American College of Sports Medicine and the Orthopaedic Research Society, which provide multidisciplinary opportunities to share what is happening in athletic training with the medical community. She currently serves as a section editor for JAT and, in her free time, enjoys running with her dog, travelling, reading novels, and participating in the high school ministry at her church.

Throughout her career, Sandra has been blessed with great professional mentors. She thanks Julie Max, MED, ATC, and David Perrin, PhD, ATC, for their guidance and collaboration: "Both had a lot of faith in me and spurred me on to things I wouldn't have attempted otherwise. Dave was particularly instrumental in my development as a researcher." Shultz also recognizes Scott Lephart, PhD, ATC, and Kevin Guskiewicz, PhD, ATC, who modeled research excellence, as well as Randy Schmitz, PhD, ATC, for being her longtime collaborator and a vital contributor to her research. She thanks her parents, other family members, and friends for their continual love and support and her high school small group for keeping her grounded with reality and allowing her to "take regular breaks" from the professional world.



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

**Joseph M. Hart, III, PhD, ATC
University of Virginia**

“Improving the quality of a patient’s life and activity while working in collaboration with other health care professionals” is what excites Joe Hart most about the profession of athletic training. Dr. Hart is a certified athletic trainer and assistant professor of kinesiology at the University of Virginia. Originally from a small town in Connecticut, Hart had his first experience with athletic trainers while playing baseball in high school: “I knew I wouldn’t play professionally, so I decided to work on the other side helping athletes.”

Hart completed his master’s degree in athletic training at the West Virginia University. A highlight of his time there was his PBATS internship with the Pittsburgh Pirates. His girlfriend (now wife), Jen, was attending physician assistant school in Pittsburgh. “Jen was my first true professional collaborator. We still work well together today!” Joe and Jen have 3 children: Jordyn, Julia, and Andrew. He hopes his family understands they are the reason he works so hard: “I work to live, not the other way around.”

For the next 3 years, Hart worked at an outpatient clinic in Parkersburg, West Virginia, concentrating on lower extremity injuries and arthritis, where his interest in research on current treatments was sparked. He started by collecting data on pain and function in patients with arthritis who received viscosupplementation injections. Before long, local physicians were requesting he present his results. “The feedback was exciting. I knew research was going to be my career focus.”

Improving old techniques and looking at traditional medicine critically have continued to inspire Hart’s research. In 2005, he received his PhD in sports medicine from the University of Virginia. He is an enthusiastic advocate of evidence-based practice and encourages his students to challenge the facts and think outside the box. Hart is inspired by advances in science and technology and expects to continue using such tools in his future research.

Joe Hart has been blessed to have many wonderful mentors throughout his education and career. He thanks his many mentors: among them are Joe Leaman, MS, ATC; Chris Ingersoll, PhD, ATC; and Jay Hertel, PhD, ATC. Joe also recognizes Dave Diduch, MD, and Mark Miller, MD, the surgeons who took a chance and hired him as coordinator in sports and orthopaedic medicine. In addition to his wife and children, Joe thanks his mother, Beleda, for her continual support.

Receiving the New Investigator Award is a true honor and career highlight for Hart. “Being recognized by organizations such as the NATA and Foundation gives me lots of pride as a scientist and educator. It actually drives me to go to the next step!”



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**

**Timothy W. Tourville, PhD, ATC, CSCS
University of Vermont**

Similar to the way many college students feel when choosing an academic field of study, Timothy Tourville recalls, “Prior to college, I knew very little about the profession of athletic training. I didn’t know exactly what I wanted to do, but I had great experiences with athletics and wanted to be in a health care field.” Tim’s hometown is Sunapee, New Hampshire, and his academic career began at Keene State College, where his initial interest in evidence-based practice was sparked. At Keene State, his mentors fostered his appreciation for evidence-based practice through student mentoring programs and coursework. “Evidence-based practice and dissemination/application of new knowledge were constantly emphasized during our didactic and clinical education at Keene State.”

After graduation, Tim moved to Vermont, where he worked in a clinical sports medicine setting, predominantly with postsurgical orthopaedic patients, as well as those experiencing low back pain and osteoarthritis. “I wanted to learn more about the research process and how therapeutic exercise and modalities could be used to more effectively treat these conditions.” It was this curiosity that propelled his enthusiasm for research and education and became his motivation for obtaining his master’s degree with a focus in exercise science and later his doctorate in clinical and translational science, both at the University of Vermont.

Tim has been involved with the Vermont Association of Athletic Trainers (VAAT) for more than 15 years. In 2013, he received the VAAT Excellence in Athletic Training Award for outstanding contributions to the field. He is also a member of various professional associations, including the Orthopaedic Research Society, Osteoarthritis Research Society International, American College of Sports Medicine, and National Strength and Conditioning Association.

Tim’s current research at the University of Vermont in the Department of Orthopaedics and Rehabilitation focuses on post-traumatic osteoarthritis (OA). He intends to examine the earliest changes in OA that occur after acute knee trauma and then evaluate the mechanisms and predispositions of OA. “Osteoarthritis is the most disabling disease worldwide, and aside from the physical pain and dysfunction it creates for those afflicted, its long-term sequelae also pose a substantial financial burden to society.” The overarching goal of his research is to understand the earliest changes that occur after trauma and to evaluate the mechanisms that lead to progression of OA, which will provide therapeutic targets for further investigation.

Each of Tim’s mentors has played a crucial role in his professional development: “I feel extremely fortunate to have been surrounded by amazing educational, clinical, and research mentors.” Tim recognizes his undergraduate athletic training mentors at Keene State College, Robert Merrow Jr, MS, ATC; Joseph Gallo, DSc, ATC, PT; and Sherry Bovinet, PhD, ATC; his master’s degree advisor, Declan Connolly, PhD; and his postdoctoral fellowship advisor, Michael Toth, PhD. For the Doctoral Dissertation Award, “I certainly share this with my PhD advisor, Bruce Beynnon, PhD, at UVM, who has been an incredible research mentor and colleague.” I would also be remiss if I did not recognize David H. Perrin, PhD, ATC, for whom this award is named, who has served as an overwhelmingly positive role model and pioneer in AT and sports medicine research for so many professionals in our field.” In addition to his mentors, Tim thanks all of his family and friends, who have been supportive of his goals and aspirations. “My father, John, was a strong influence regarding my professional direction. My mother, Kathy, and siblings, Katerina and Michael, have been overwhelmingly supportive.” Tim currently lives in Vermont with his wife, Kelly Tourville, MEd, ATC, and their 2 sons, Reese and Cooper, where they enjoy all types of outdoor activities. “I would have never made it to this point or be able to pursue a career in academic science without the love, understanding, and support of my family and friends. I am extremely grateful to them all.”



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 continues to mentor students and serve as a leader in the profession. He is provost at University of North Carolina at Greensboro. He oversees five academic departments, nearly 75 faculty members and more than 1200 students. The school's Ph.D. program in the Department of Exercise and Sport Science has been recognized as one of the country's best programs. Dr. Perrin remains involved in the profession by teaching a class and advising doctoral students who are certified athletic trainers. He also continues to write in athletic training and has recently published three books.

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: Factors Associated with Concussion Recovery

Thursday, June 26, 2014, 8:00AM-9:15AM, Room 243; Moderator: Rusty McKune, MS, ATC

14303MOSP

Post-Injury Item Endorsement And Correlation Between Symptom Severity And Days Post-Concussion For The Graded Symptom Scale In Concussed Adolescent Athletes

Shepherd LI, Bay RC, Valovich McLeod TC: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

Context: Symptoms are an important self-report indicator of athlete recovery and are often used to determine when return-to-play progressions can begin. Recent work has begun to examine individual symptoms and symptom clusters as predictors of prolonged recovery; however there are few studies that have investigated post-injury individual symptom patterns in adolescent athletes. **Objective:** To tabulate the frequency with which the 22 items of the Graded Symptom Scale are endorsed by concussed adolescent athletes during weeks 1, 2 and 3 post-concussion and to estimate the relationship between severity of item symptomatology and days since concussion. **Design:** Prospective cohort. **Setting:** High school athletic training facilities. **Patients or Other Participants:** Adolescent athletes (n = 437, males = 326, females = 111, age = 16.0 ± 1.2) participating in interscholastic contact sports, who suffered a sport-related concussion diagnosed by an athletic trainer. **Intervention(s):** All subjects completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) test within 21 days post-concussion. The primary independent variable was days post-concussion. **Main Outcome Measure(s):** Dependent variables included the 22 individual symptom items from the ImPACT symptom inventory; whether each item was endorsed (any score > 0) and severity score (7-point Likert scale). Percentages of subjects who endorsed each item during weeks 1 (n=266), 2 (n=125) and 3 (n=46) post-concussion

were calculated. Spearman correlation coefficients (rs) were used to estimate the monotonic relationship between symptom severity and number of days post-concussion for each item. **Results:** Headache was the most commonly endorsed symptom during week 1 (71.1%), week 2 (37.6%) and week 3 (32.6%), for a weighted average of 57.4% across the 3 weeks. Weighted average endorsements for the remaining 5 most commonly endorsed symptoms, in descending order, were: difficulty concentrating (44.9%), drowsiness (34.1%), dizziness (33.2%) and sensitivity to light (33.0%). Numbness/tingling and vomiting were endorsed by only 8.0% and 4.4% of participants, respectively. The severity scores for all items were negatively correlated with days post-concussion, $p < .001$, except sleeping less ($p = .006$). Headache (rs = $-.50$), dizziness (rs = $-.40$), difficulty concentrating (rs = $-.39$), slowed down (rs = $-.39$) and sensitivity to light (rs = $-.39$) were most highly correlated with days post-concussion. **Conclusions:** Headache is one of the most commonly reported symptoms following concussion, and while its prevalence decreases with time, it was still endorsed by one-third of subjects up to three weeks post-injury. Along with headache, the other prevalent symptoms should be monitored closely following injury. While important as on-field red flags, numbness/tingling and vomiting are rarely reported. Modification of the graded symptom scale to reflect this should be considered. Athletes' symptom severity scores routinely decrease monotonically as time passes; however, in some, symptoms may linger. Clinicians must be aware that lingering symptomatology may indicate a longer recovery and take steps to address these persistent symptoms. Funded by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE)

14439MOSP

Treatment Characteristics And Return-To-Play Timelines Following Sport-Related Concussion: A Report From The Athletic Training Practice-Based Research Network

Kostishak NM, Lam KC, Anderson BE, Welch CE, Valovich McLeod TC: A. T. Still University, Mesa, AZ

Context: Most studies describing the day-to-day management and return-to-play progression regarding sport-related concussions have used self-report surveys, reporting some variation in assessment tools and management practices used by athletic trainers (ATs). Examining patient and daily treatment characteristics through a review of electronic medical records (EMR) can provide a better understanding of the current management strategies and return-to-play timelines for concussed patients under the care of ATs. **Objective:** To describe the treatment and return-to-play characteristics during recovery from sport-related concussion. **Design:** A retrospective analysis of EMR. **Setting:** Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** 425 patients (male = 269, female = 156, age = 16.3 ± 1.8 years) diagnosed with a concussion by an AT. **Intervention(s):** The records of concussed patients from 54 AT-PBRN clinical practice sites between October 2009-October 2013 were reviewed. All records were completed by an AT utilizing a web-based EMR. Concussed patients were identified by concussion-specific ICD-9 codes (850.0, 850.5, 850.9). Treatments were identified by CPT codes (97006, 97110, 97750, 97530). **Main Outcome Measure(s):** Descriptive statistics (frequencies, percentages) were utilized to describe patient (sport, injury), treatment (type, number, and duration of treatment), and participation status characteristics. **Results:** A total of 1,701 encounters were recorded for the

425 concussed patients. Most patients participated in football (48%, n=204). The primary mechanism of injury was contact (88.5%, n=376) with the primary diagnoses classified as ICD-9: 850.9-concussion (84%, n=357). On average patients reported for 7.6 ± 5.7 visits with an average duration (number of days from the first to last encounter) of 14.74 ± 22.4 days. The main procedure performed was athletic trainer re-evaluation (CPT: 97006; 74.5%, n=1268) followed by therapeutic exercise (CPT: 97110; 8.7%, n=148), physical performance test or measurement (CPT: 97750; 6.5%, n=110), and therapeutic activities (CPT: 97530; 5.5%, n=93). Patients were restricted from play for 13.64 ± 22.59 days post-concussion. On average, patients were cleared for light participation 15.24 ± 16.95 , non-contact participation 16.12 ± 18.12 , and no restrictions 14.98 ± 17.50 days after injury. **Conclusions:** As expected, most of the treatment procedures were re-evaluations, with patients being followed-up on a regular basis during the first week after injury. The majority of patients had some participation restrictions during the initial two weeks post-concussion, which suggests conservative management and graduated return-to-play protocols are being used. These procedures follow best practices, in which concussions are being monitored regularly to track recovery. The variability in the number of patient visits and participation status time highlights the wide range of concussion recovery timeframes, further substantiating the need for individualized patient care. It is concerning that few ATs documented performance test measures, which would include the administration of adjunct assessment tools (eg. cognitive or balance tests). There is room for improvement of concussion documentation to ensure best practices and liability protection.

Acute Cognitive And Physical Rest Do Not Improve Concussion Recovery Time

Buckley TA, Munkasy BA, Clouse BP: Georgia Southern University, Statesboro, GA

Context: Cognitive and physical rest are the current standard of practice for managing the acute symptomatic period following a concussion. However, there is limited empirical evidence suggesting rest improves recovery following a concussion. **Objective:** The purpose of this study was to prospectively evaluate the effectiveness of an acute bout of cognitive and physical rest on recovery following a sports-related concussion.

Design: Prospective Longitudinal. **Setting:** University Athletic Training room. **Patients or Other Participants:** 50 student-athletes divided into a Rest group (18M, 19.8 ± 1.2 years old, 0.6 ± 0.7 previous concussions, 12.0% LOC rate, 28.0% PTA) and a No-Rest group (13M, 19.4 ± 1.3 years old, 0.8 ± 0.9 previous concussions, 12.0% LOC Rate, 44.0% PTA rate) based on the policies in effect at the time of their concussion. **Intervention(s):** In July 2012, the host athletic training staff and physicians changed the concussion management plan to include a day of cognitive and physical rest. Patients in the Rest group were withheld from physical and cognitive activities, including academic classes, for the remainder of the injury day and the following day whereas patients in the No-Rest group were not provided any accommodations post-injury. All patients in both groups completed the same standard return to participation protocol of achieving baseline values on all clinical tests, self-report symptom free, and completed a 6 day progressive exercise program. **Main Outcome Measure(s):** The number of days until the patient achieved baseline values on the Balance Error Scoring System (BESS), Standard Assessment of Concussions (SAC), computerized

neuropsychological testing (CNT), and self-report symptom free were compared between groups with independent sample t-tests. **Results:** There was no difference between the two groups for initial concussion presentation or in the change from baseline on the dependent variables of interest. The No-Rest group achieved asymptomatic status significantly faster than the Rest group (5.2 ± 2.9 days and 3.8 ± 1.9 days respectively, $P=0.047$). There was no difference between Rest and No-Rest group for time to baseline for the BESS (2.7 ± 1.9 days and 2.1 ± 1.3 days respectively, $P=0.183$), SAC (2.6 ± 1.9 days and 2.1 ± 1.5 days respectively, $P=0.368$) and CNT (5.7 ± 5.0 days and 7.1 ± 6.3 days respectively, $P=0.395$). **Conclusions:** A prescribed day of cognitive and physical rest was not effective in reducing the recovery time following a sports-related concussion in this college student-athlete population. Contrary to the study hypothesis, the No-Rest group was asymptomatic significantly quicker, 1.4 days, than Rest group despite having a higher number of female patients who tend to exhibit symptoms longer than male patients. These results agree with a previous study and suggest that light activity post-concussion may not be deleterious to the concussion recovery process.

Symptoms Among Concussed Athletes Examined For Prolonged Recovery By A Neuropsychologist

Snook EM, Nittoli VC, Shunk AW: St. Vincent Sports Performance, Indianapolis IN, and Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Sport-related concussions are receiving extensive media attention with questions being raised about factors that are associated with prolonged recovery (ie, >14 days). A common reason for athletes to seek neuropsychological evaluation after a concussion is the continuation of symptoms. **Objective:** To describe post-concussive symptoms among athletes seeking neuropsychological evaluation due to extended concussion recovery. **Design:** Cross-sectional. **Setting:** A sports performance center in the Midwestern United States. **Patients or Other Participants:** The sample included 50 successive patients (15.9 ± 1.9 years of age) that completed the ImPACT Symptom Scale as part of a comprehensive assessment for prolonged recovery concussion (4.0 ± 4.1 months since date of concussion) between January 2005 and June 2013. **Intervention(s):** Athletes completed a clinical interview and computerized testing that included the 22-item ImPACT Symptom Scale. **Main Outcome Measure(s):** The percentage of athletes experiencing post-concussive symptoms, gender differences in total symptom score and total number of symptoms reported, and the 10 most commonly reported symptoms. **Results:** A total of 44 of the 50 athletes (88%) reported experiencing at least one post-concussion symptom (mean symptoms 7.4 ± 5.6). There were no differences between males and females in the number of symptoms reported ($P = .67$) or total symptom score ($P = .20$). Among athletes reporting symptoms, headache ($n = 30$ athletes,

68.2%); difficulty concentrating, difficulty remembering, and irritability (each symptom with $n = 26$, 59.1%); feeling slowed down ($n = 25$, 56.8%), trouble falling asleep and drowsiness (each symptom with $n = 22$, 50.0%), light sensitivity ($n = 21$, 47.7%), and fatigue and mental foggiess (each symptom with $n = 19$, 43.2%) were the 10 most commonly reported symptoms.

Conclusions: The vast majority of concussed athletes seeking neuropsychological assessment for prolonged recovery and having completed the ImPACT Symptom Scale reported experiencing one or more symptoms at the time of neuropsychological testing. Commonly reported symptoms were headache, cognitive problems, and fatigue. These results suggest that those athletes being referred for, or seeking, neuropsychological assessment may be doing so in part because of difficult symptom management.

Evaluating The Recovery Curve For Clinically-Assessed Reaction Time Following Concussion Injury

Del Rossi G, Morris BJ, Rigaud W: University of South Florida, Tampa, FL

Context: Previous research has revealed that clinically-measured simple reaction time is prolonged 48 hours following a sport-related concussion. It is unknown how long clinical reaction time remains delayed following injury.

Objective: To determine the recovery curve for clinically-assessed simple reaction time following concussion injury. **Design:** Descriptive laboratory study. **Setting:** Athletic training facilities. **Patients or Other Participants:** Baseline simple reaction time using the ruler-drop test was assessed in over 300 high school athletes prior to the start of their athletic season. Eight participants (all males; 16.4 ± 1.2 years of age; 1 left-hand dominant, 7 right-hand dominant) suffered a concussion and completed the study protocol. **Intervention(s):** Participants were required to complete 8 individual trials of the ruler-drop test at 7 time intervals. Along with baseline testing, participants who suffered a concussion were required to complete testing sessions at Day 3, Day 7, Day 10, Day 14, Day 21 and Day 28 post-injury. The ruler drop test involves grasping a measuring stick that has been dropped and then using the length the ruler has travelled before being grasped to assess simple reaction time. Published research has revealed the ruler-drop test to have acceptable test-retest reliability, and to compare favorably with computerized measures of reaction time. **Main Outcome Measure(s):** Mean clinical reaction time was assessed for each of the 7 time intervals for each participant and those values were used in statistical tests. Reaction time was calculated (in milliseconds) using the formula for a falling body ($d = \frac{1}{2}gt^2$), where d is

distance, g is acceleration due to gravity, and t is time. To determine if there were significant differences between time intervals, a repeated-measures ANOVA was calculated and post hoc pairwise comparisons with Bonferroni adjustments were computed, if necessary. **Results:** Statistical tests revealed a significant effect for time interval ($F_{6,42} = 7.49, P = .002$) with an average reaction time of 237.2 ± 13.8 ms at baseline, and 253.7 ± 15.8 ms, 248.8 ± 19.7 ms, 245.0 ± 10.4 ms, 234.2 ± 14.5 ms, 231.8 ± 13.1 , and 231.9 ± 11.0 ms at Days 3, 7, 10, 14, 21, and 28, respectively. A total of 21 pairwise comparisons were performed. The new critical p-value calculated from applying the Bonferroni correction was $P = .002$. Unfortunately, following the Bonferroni adjustment none of the pairwise comparisons were found to be significant. **Conclusions:** Although post hoc tests did not identify statistically significant differences between any of the intervals, the trend in the data suggests that following a concussion it takes a high-school-aged patient, on average, 14 days for clinical reaction time to return to baseline levels. More research is needed to ascertain the usefulness of clinically-assessed simple reaction time as a means of tracking recovery from concussion injury.

Free Communications, Oral Presentations: Complex Injuries of the Central Nervous System

Thursday, June 26, 2014, 9:30AM-10:45AM, Room 243; Moderator: Brian Hainline, MD

14013FC

Transient Tetraplegia In A College Football Athlete

Felton SD, Guadalupe I: Florida Gulf Coast University, Fort Myers, FL, and Ave Maria University, Ave Maria, FL

Background: Athlete is a 22 year-old male NAIA football running back. The athlete had no prior medical history. Athlete was participating in practice performing a running drill when he suffered a helmet to helmet collision and fell immediately to the turf. The Certified Athletic Trainer (ATC) immediately went to his aid and the athlete was unresponsive. Athlete was breathing with a strong pulse. ATC maintained in-line head stabilization. Within the initial exam, the athlete was having difficulty with verbal communication with ATC and the athlete was unable to move his upper and lower extremities and subsequently had no sensations in the extremities. Assistant ATC summoned EMS and the athlete was placed on a spine board and transported to the local emergency room for further evaluation and exam. **Differential Diagnosis:** Central Cord Syndrome, Cervical Neck Pathology, Transient Brain Injury, Concussion **Treatment:** Upon arrival to the ER, athlete was further examined by Attending Physician. Athlete was awake, alert, and oriented x 3, Cranial nerves II-XII WNL, optic disks were crisp without evidence of hemorrhage and extraocular muscles were intact, facial sensation and movement were WNL with hearing preserved and tongue was within the midline. CT and MRI scans were ordered which revealed a broad-based disc bulge of C3-4 with some mild impression on the cord; however, there were no T2 signal changes that would be consistent with a spinal cord injury. Furthermore, no pre-vertebral swelling or injuries to the ligaments were noted on the STIR images. No fractures were noted. Over the next several hours while in the ER, the athlete demonstrated enhanced

function; however, his upper extremities continued to demonstrate weakness as compared to the lower extremities. The athlete was diagnosed with transient tetraplegia resulting from the C3-4 disc bulge with some contact of the cord without any compression of the myelomalacia. Athlete was placed in a cervical collar for 4 weeks and prescribed a steroidal protocol. At the 4 week follow-up evaluation, athlete was still complaining of some weakness, dynamic X-rays were ordered to examine for functional laxity. X-rays demonstrated normal excursion and no abnormal motion. Athlete was cleared for participation at 7 weeks post injury. Athlete elected not to return to playing football and has focused on other sport activities. **Uniqueness:** Transient tetraplegia was first described in 1986. Recently, the incidence rate of transient tetraplegia in high school football athletes has been translated into 0.17 per 100000 participants and 2.05 per 100000 participants at the collegiate level. In most cases, motor and sensory symptoms will coexist in patients; however, symptoms are completely transient and resolve within 10 minutes to 48 hours following the injury. Athletes who have suffered from transient tetraplegia are often found to have accompanying intervertebral disc disease, acquired cervical stenosis, and/or cervical instability. **Conclusions:** This case highlights the diagnosis of an athlete with transient tetraplegia and subsequent recovery. This case is extremely unique due to the limited incidence rate in athletes. Symptoms of injury may include a burning pain, tingling, complete loss of sensation in the extremities with motor changes ranging from no or partial weakness to complete temporary paralysis. This case further highlights the need for proper evaluation and management of a suspected cervical spine injury and the sports medicines team must precede with caution until further diagnostic evaluation can be completed to rule out a more severe injury.

14088UC

Somatic Dysfunction In An Interscholastic Lacrosse Player

McCann TJ, Rothbard M, Warwick J: Southern Connecticut State University, New Haven, CT, and Notre Dame High School, West Haven, CT

Background: A 14 year-old male interscholastic lacrosse player presented to the Athletic Trainer on the sideline with a severe headache after five minutes of competition. The patient's past medical history was significant for a cerebral concussion three weeks prior. He had been cleared to play two days earlier as per the required institutional return to play protocol, which included physical and cognitive rest, computerized neuropsychological testing, postural stability tests, a six-day graduated return-to-play protocol, and physician authorization. The on-site evaluation identified normal visual acuity, eye tracking, and reactive pupils that were equal in size. The Athletic Trainer ruled out potentially life-threatening orthopedic injuries; however, the patient began to display progressive physical, cognitive, and emotional distress and was immediately disqualified from play. Status post 15 minutes, the patient reported feeling nauseous and complained of somatic paresthesia. The patient assumed a forward shoulder posture and reported an inability to use his hands. Heart rate, initially taken at 88bpm, rose to 108bpm. The patient displayed bouts of rapid, irregular, labored, and shallow breathing. Further attempts to reassess neurologic status and vital signs were unsuccessful due to the patient's headache, deteriorating cognitive function, and increased emotional instability. **Differential Diagnosis:** headache, cerebral hemorrhage, post-concussion syndrome, and anxiety attack. **Treatment:** After an inability to calm the patient down, EMS was activated. Upon arrival at the emergency department, the patient was evaluated by the attending physician

and referred for neurological consultation. The neurologist definitively diagnosed the patient with an anxiety attack secondary to post-concussion syndrome. The patient was prescribed a sedative and an alpha adrenergic blocking agent to suppress cranial vascular activity, stabilized, instructed to follow up with his health care provider, and released. While following up with the Athletic Trainer, the patient revealed that he had been experiencing headaches since the initial concussion, but had been providing false feedback. The patient was referred to his pediatrician who prescribed physical and cognitive rest until all post-concussive symptoms resolved and disqualified him from athletic participation for the remainder of the season. Status post nine months, the patient is no longer experiencing headaches and was cleared by his physician for unrestricted activity for the winter interscholastic athletic season.

Uniqueness: Computerized neuropsychological and postural stability testing have been shown to be sensitive and specific for assessing neurocognitive and neurobehavioral sequelae of concussion. However, despite the use of such objective testing and following appropriate return to activity protocols, the patient was able to furnish false subjective information to gain medical clearance. **Conclusions:** Evaluating and treating concussed athletes to allow safe return to athletic participation is challenging. First, research suggests that athletic participants will hide concussion symptoms in order to continue playing. As such, a cultural shift is needed to change the “warrior mentality” of athletes unwilling to disclose when they are hurt. The presence of a post-traumatic headache indicating alterations in neurotransmitter function and metabolic derangements cannot be underestimated. Education about the importance and potential impact of post-traumatic headaches is paramount and is one of the most important

tools Athletic Trainers have to manage post-concussive symptoms. Secondly, neuropsychological and postural-stability tests can be useful for indicating post-concussive effects. However, dual/divided attention task testing, which combines neurocognitive and postural stability testing during graded exercise, provides greater sensitivity to changes in cognitive status and sensorimotor integration deficits. A systematic, multidimensional approach to managing concussions should include education, clinical evaluation, and objective exertional dual-task testing.

Seizure Disorder In A Division I Swimmer

Schuster TM, Linens SW, Stern A: University of Florida, Gainesville, FL; Georgia State University, Atlanta, GA; University of Virginia, Charlottesville, VA

Background: Twenty-one-year-old male Division I swimmer with a history of high hematocrit and hemoglobin levels, mild hypertension (non-medicated) and no family history of seizure. Patient suffered from Amaurosis Fugax (temporary loss of vision in one eye due to lack of blood flow to retina) in December 2011 that was cleared by ophthalmologist, hematologist and neurologist. Patient began therapeutic phlebotomy to reduce risk of high levels of Hg/Hct count and/or blood thickening. Therapeutic phlebotomy was continued if hematocrit level exceeded 50% for next 6 months, but patient cleared to swim. Two months later, patient was riding his motorized scooter when he felt “weird,” stopped at a stop sign and proceeded to seize for one to two minutes. He had no recollection of the last three blocks of his ride. Patient was transported via ambulance to hospital.

Differential Diagnosis: Cardioembolic stroke, syncope, metabolic conditions such as hypoglycemia, hyponatremia, migraine, transient ischemic attack.

Treatment: Patient was hospitalized for seven days and was evaluated by cardiologist, hematologist, and neurologist. Patient had positive MRI for mild hippocampal edema which is consistent with seizure but was otherwise normal. Patient also had a positive magnetic resonance venography that displayed a sinous venous thrombosis and was diagnosed with Erythrocytosis. Patient was prescribed Lovenox to be injected by syringe into the skin BID and 81 mg aspirin. Patient instructed not to drive for 6 months or to swim until cleared by neurologist. Patient experienced second seizure one month later

while sleeping. During a follow up appointment with neurologist patient was started on anticonvulsant, Keppra and 25 Mg Lamictal to be taken once daily. Dosage for Keppra was as follows: Week 1- 250 mg BID, week 2-500 mg BID, week 3-750 mg BID. A prolonged EEG was ordered and results were negative. Patient suffered third seizure three weeks later while walking on campus and was transported via ambulance to hospital. Evaluation was normal and no changes were made. Per phone conversation with neurologist Keppra dosage was increased to 1000 mg BID. Patient diagnosed with Epilepsy during follow up with neurologist seven days later. Patient was cleared to return to activity by neurologist after appropriate dosage of medication was found. Four months later, patient had follow up with physician before he left to study abroad; instructed to continue with medications already prescribed. Patient returned from study abroad five months later and reported he remained seizure free with no side effects from medication. Patient had follow up with physician five months later; instructed to stay on Keppra and Lamictal and should undergo therapeutic phlebotomy if hematocrit levels exceeded 50%. **Uniqueness:** Patient had been participating at an elite level asymptotically for numerous years and there is limited literature on the prevalence of epilepsy in elite level swimming especially in regards to return to play guidelines. **Conclusions:** Patient did not participate in spring 2012 season due to seizure activity. Athlete received invitation to participate in 2012 Olympic Games but did not due to lack of funding/administrative error by his country. Subsequently, he took a break from training that lasted for the duration of the summer and then studied abroad during the fall. Patient returned spring 2013 following his study abroad without any occurrence of seizure due to appropriate anticonvulsant dosage. Patient

swam the spring season and finished his eligibility before graduating in spring 2013. The following institutions have no current Epilepsy protocols: NATA, NCAA, USA Swimming, or FINA. The following institutions have posted articles about seizures, stating that athletes can swim if well controlled and with supervision: American College of Sports Medicine and the American Academy of Pediatrics.

Surgical Management Of A Seizure Disorder In A Division I Cross Country And Track Athlete Hile AM: West Virginia University, Morgantown, WV

Background: This case involves an 18 year old female cross country & track athlete with a history of seizure disorder from the age of 2. This athlete competed successfully for one year with conditional medical clearance from the team physician. During this year the athlete experienced an average of 8-9 seizure events per week combining both simple and complex partial seizures. Her simple partial seizure events presented as auras with an impending sense of fear or déjà vu. These auras would last 3 to 4 minutes and the athlete was aware during event. The complex partial seizure events presented as 90 second to 3 minute seizures with the athlete conscious but unaware. The athlete would remain in a rigid position with her right arm contracting and jerking while her head would sway from side to side. During 50% of the complex partial seizures the athlete also experienced incontinence. Following her first year of college this athlete expressed a strong desire to explore options to decrease her seizure episodes and improve her overall quality of life. **Differential Diagnosis:** Possible interventions identified were to continue conservative treatment and manage her seizure disorder through a combination of medications, surgical implantation of a vagus nerve stimulator or temporal lobe resection surgery. **Treatment:** Following extensive diagnostic testing including MRI, CT Scan, PET Scan, 24 Hour Monitoring, and Wada testing a single focal area of seizure activity was identified in the athlete's left hippocampus. Additional neuropsychology testing of the focal area also revealed a low risk to brain processes including memory, language, and speech. In consultation with the neurosurgeon the

athlete elected to undergo a temporal lobe resection surgery. In the procedure approximately five centimeters of the athlete's left hippocampus and two centimeters of the overlying cerebral cortex were removed. For two weeks following the surgery the athlete was put on extensive mental and physical rest to allow the swelling in the brain to decrease and the skull and skin incisions to heal. Following the rest period the athletic trainer directed a gradual progression rehabilitation protocol moving from walking, biking, other cardiovascular machines and running based on the athlete's tolerance and symptoms. A progressive resistance training program was also implemented and supervised by the athletic trainer. Eight weeks following the resection surgery the athlete resumed a full semester class load. This athlete made a full return to running and competed in her first cross country race four months after the surgical procedure. Currently the athlete is six months post surgical intervention and has been seizure free to this point.

Uniqueness: To my knowledge this is the only case of a high level athlete undergoing a temporal lobe resection and returning to compete in college athletics. Our clinical team could not find a similar case and therefore needed to create our own rehabilitation protocol for return to competition. The athletic trainer was also charged with providing an emotional support network for an athlete making a life changing surgical decision.

Conclusions: This case demonstrates not only an athlete successfully competing with a seizure disorder but further also establishes that an athlete can undergo a temporal lobe resection procedure and return to a high level of sport activity. This case is important in establishing a management protocol for seizure disorders and for return to activity following temporal lobe resection surgery. Additionally the case highlights that athletic trainers are called upon to manage illnesses and

rehabilitation well beyond the scope of traditional athletic injuries. It was the athletic trainer that was the constant daily contact from management of the seizure disorder to eventual surgery and rehabilitation.

Circulatory Vertebral Artery Stroke In A Collegiate Male Gymnast

Lucci SE, Adams KKE, Ward WO, Potter MB, Hoch JM: The College of William and Mary, Williamsburg, VA, and Old Dominion University, Norfolk, VA

Background: A 21-year-old collegiate male gymnast reported to the athletic trainer with loss of peripheral vision in the left eye at the end of practice. During initial evaluation, the patient stated he did not sustain an impact that would have resulted in a concussion, and there were no additional neurological symptoms noted. The patient was then referred to an optometrist for further testing. The patient's relevant medical history was significant for a congenital C1/C2 fusion, also known as Klippel-Feil syndrome.

Differential Diagnosis: vertebral artery syndrome, retina detachment or optical pathology, neurological disorder.

Treatment: The optometrist's exam was unremarkable for an optical pathology, and the patient was referred to a cardiologist for further testing. The cardiologist performed a carotid ultrasound, which showed a possible occlusion of the vertebral artery. A CT scan was ordered to confirm the occlusion. After reviewing the results, an additional CT with contrast was ordered to differentiate between a complex migraine and true vertebral artery syndrome, and the patient was asked to consult with a neurologist. At this time, the team physician restricted the patient to light cardio workouts and discontinued gymnastics training until follow up with the neurologist. Two additional episodes occurred before follow up while the patient was away from school on break. The second of these episodes included numbness and tingling that went down into the patient's hands and resulted in short-term grip strength weakness. Following the consultation with the neurologist, all

three events were diagnosed as mini posterior circulatory vertebral artery strokes (CVAs). The neurologist also ordered an MRI and a transesophageal EKG, which revealed a small hole in the patient's left ventricle. The patient was referred to a cardiac specialist for consultation on the cause of the cardiac defect. The patient was also placed on a daily aspirin regimen and was held from activity for six-weeks, as this is the standard waiting period to determine if an aspirin regimen is sufficient treatment to prevent recurrence. The cardiac specialist determined that the hole was congenital and most likely causing clots to build over an extended period of time. Because of this, the specialist felt that recurrence was unlikely and as long as the patient continued the daily aspirin regimen, he could return to activity after six-weeks. Following six-weeks of rest, the patient was cleared to return to activity. One-week following return to activity, the patient experienced a fourth and much more severe stroke before practice. During this episode the patient experienced severe sensorimotor deficits and was transported to the hospital. Following numerous diagnostic tests, a diagnostic angiogram revealed that the cervical fusion was causing clots to form which were completely occluding the left vertebral artery when the patient turned his head 15-degrees to the right. The patient underwent a surgical angiogram to close off the left vertebral artery, shunting blood flow through the right vertebral artery. Following surgery and inpatient and outpatient rehabilitation, the patient was able to return to activities of daily living and was removed from all gymnastics related activities. **Uniqueness:** This type of stroke, also known as "Bow-Hunters" stroke, occurs frequently in archers from the continual compression of cervical structures due to their head and neck position during shooting. Strokes are extremely rare in individuals ages 18-44 and relatively

unheard of in an athletic population. Continued monitoring, proper referrals, and interprofessional collaboration and communication are necessary for positive outcome. **Conclusions:** Referral is critical in cases with possible neurological or vascular involvement. While this case is extremely rare, strokes do occur in the healthy and active population, and proper management is critical for the prevention of further complications and positive outcomes.

Free Communications, Oral Presentations: Clinical Education and Learning

Thursday, June 26, 2014, 11:15AM-12:15PM, Room 243; Moderator: Thomas Bowman, PhD, ATC, PES

14392FOPE

Reciprocal Learning Between Preceptors And Athletic Training Students In Clinical Education

Dodge TM, Guyer MS, Mazerolle SM, Bowman TG: Springfield College, Springfield, MA; University of Connecticut, Storrs, CT; Lynchburg College, Lynchburg, VA

Context: Athletic training preceptors have been identified as highly influential to the learning and socialization of athletic training students (ATs). Research has identified that at times learning in the clinical education setting can be reciprocal between the ATs and preceptor. However, the magnitude of the potential benefits and barriers to reciprocal learning in athletic training are not yet fully understood. **Objective:** Explore reciprocal learning from both the student and preceptor perspective with the objective of developing a better understanding of the concept. **Design:** Qualitative methods with asynchronous online interviewing. **Setting:** Three separate Commission on Accreditation in Athletic Training Education (CAATE) accredited undergraduate athletic training programs. **Patients or Other Participants:** Ten preceptors with an average of 5 ± 3.5 years of experience as preceptors, matched with their current ATs completing clinical education experiences (10) for a total of 20 participants. **Data Collection and Analysis:** All participants journaled responses to a series of open ended questions using Question Pro. Data were analyzed via a general inductive approach in order to uncover the most dominant themes. Data analysis took place in three distinctive steps including examining transcripts to gain a sense of the data, breaking down data into discrete parts and identifying major categories. To ensure trustworthiness of the data, we negotiated over the coding scheme until we came to agreement, completed peer review, and performed stakeholder checks. **Results:** Both preceptors and ATs agreed that reciprocal

learning occurs somewhat frequently during clinical education and that the experience is valued by both parties. Reciprocal learning experiences most often occur as a product of a learning environment that is characterized by mutual respect and open communication between ATs and preceptor. Preceptors often recognized the value in discussing new techniques with ATs as it contributes to their lifelong learning and helps them to stay current. The reciprocal learning process often initiates with a difficult clinical case to manage or more simply a question presented by the preceptor. Student preparedness and confidence were viewed as facilitators to reciprocal learning while poor communication, a lack of mutual respect and insufficient time for ATs/preceptor discussion were identified as barriers. **Conclusions:** Reciprocal learning is occurring during many clinical education experiences and is beneficial for both ATs and preceptors. Such experiences often emerge from a nurturing learning environment that is simultaneously challenging for the ATs. Reciprocal learning must be an organic and unforced occurrence, however AT programs can benefit from educating preceptors about ways to foster communication with ATs and recognize opportunities for reciprocal learning to occur. Preceptors should also be made aware of the potential benefits to reciprocal learning as it may entice them to be more open to learning new skills and see additional value in their roles as clinical educators.

14208FOPE

The Reliability Of Faculty And Preceptors' Evaluations Of Athletic Training Students' Clinical Skills

Nottingham SL: Chapman University, Orange, CA

Context: ATP faculty and preceptors are expected to evaluate athletic training students' performance in classroom and clinical settings. Limited information exists regarding the reliability of clinical evaluation of students. **Objective:** To investigate the inter- and intra-rater reliability of faculty and preceptors' evaluations of students' clinical skills. **Design:** Cross-sectional study. **Setting:** One CAATE-accredited undergraduate ATP. **Patients or Other Participants:** A volunteer sample of 15 preceptors and 4 faculty members with 6.68 ± 5.16 years of clinical teaching experience working in the college/university ($n = 12$), high school ($n = 5$), and rehabilitation clinic ($n = 2$) settings. Volunteers were recruited from one ATP because they had 1 year of experience using the assessment forms used in the study. **Intervention(s):** Clinical skill assessment forms were developed and face/content validated by three AT faculty one year before the study. Forms included guidelines for preceptors to evaluate students on a 4-point scale ranging from absent proficiency to highly proficient and a section for open-ended comments. Participants watched and rated four different videos of student skills: senior undergraduate applying ultrasound (M1), sophomore undergraduate applying ultrasound (M5), second-year undergraduate evaluating ankle injury (CE2), entry-level masters' student evaluating ankle injury (CE3). Participants rated all four videos on the first data collection day (DC1), then rated the same four videos 7 days later (DC2). Participants were asked to reflect on the process of rating students at the end of DC2. **Main Outcome Measure(s):** Participants' scores of each video at DC1 and DC2. Inter- and

intra-rater reliability were calculated using intra-class correlation coefficients (ICC) and comments were reviewed for themes. **Results:** Participants' mean ratings of each video were: M1DC1 = 3.2 ± 0.7 , M1DC2 = 3.2 ± 0.9 , M5DC1 = 2.8 ± 0.5 , M5DC2 = 2.8 ± 0.7 , CE2DC1 = 2.5 ± 0.6 , CE2DC2 = 2.7 ± 0.5 , CE3DC1 = 2.3 ± 0.5 , and CE3DC2 = 2.4 ± 0.7 . There was good intra-rater reliability for videos M1 (ICC = .73; 95% CI: .29-.90) and M5 (ICC = .79; 95% CI: .44-.91) and optimal intra-rater reliability for video CE2 (ICC = .80; 95% CI: .47-.93). Intra-rater reliability for video CE3 was poor at ICC = .47; 95% CI: .36-.78. Inter-rater reliability was inadequate for both data collection time periods (DC1: ICC = .30 and DC2: ICC = .67). In open-ended comments and discussion with the researcher, participants stated that they had difficulty evaluating students on clinical skills they don't use, such as ultrasound, and that it was difficult to evaluate the entry-level masters' student because they had limited interaction with this type of student. **Conclusions:** Although faculty and preceptors rated students consistently when evaluating them on most clinical skills, inter-rater reliability was poor. Participants' comments suggest that poor consistency may result from their inadequate familiarity with certain skills or type of student they are evaluating. When developing clinical skill assessment forms, faculty should create clear evaluation guidelines, train preceptors how to use forms, and ensure preceptors are familiar enough with students' knowledge and academic level to accurately evaluate their performance.

Standardized Patient Encounters Improve Student Confidence Toward Future Clinical Evaluations

Jarriel AJ, Armstrong KJ: Georgia College & State University, Milledgeville, GA

Context: Researchers in athletic training (AT) have reported that interacting with standardized patients (SPs) is a worthwhile and realistic experience for students. These encounters enhance students interviewing skills, confidence, clinical skill development, and interpersonal communication. As educators, we strive to provide learning opportunities that foster knowledge acquisition and skill development. Written examinations and clinical evaluations do not always mimic patient care, therefore students need real-time patient interactions to improve confidence. **Objective:** To determine if SP encounters improve student's confidence in performing future clinical evaluations. **Design:** Pre-Test, Post-Test Survey Design. **Setting:** Athletic Training Simulation Lab. **Participants:** 35 students from junior (n = 20) and senior (n = 15) AT cohorts from a public liberal arts institution in the Southeast. **Intervention:** AT students from each cohort completed 2 SP encounters per semester, totaling 4 different SP encounters during one academic year. The confidence rating scale was developed for the investigation and administered electronically immediately prior to and following each encounter. Cronbach's alpha determined internal consistency for the confidence rating items, with an alpha coefficient of .971. **Main Outcome Measure(s):** The confidence rating scale consisted of 17 Likert scale (1 = Strongly Disagree; 5=Strongly Agree) items regarding how the SP encounter impacted confidence toward completing future patient evaluations (eg, identifying history questions, selecting appropriate diagnostic tests, interpreting results of diagnostic

tests, formulating a treatment plan). Open-ended questions asked participants to describe how the encounter improved confidence. Descriptive statistics were computed for all survey items, and Wilcoxon signed-rank tests determined differences in pre-encounter and post-encounter confidence ratings. Qualitative data were analyzed using an interpretative coding method, categorizing individual comments into representative themes. Three different analysts evaluated the data for trustworthiness and accurate interpretation. **Results:** Overall, students from both cohorts reported that each of the SP encounters improved their confidence in completing future clinical evaluations. Specifically, students reported a significant increase between pre-encounter to post-encounter confidence ratings after the nutrition ($Z = -2.911$, $P = .004$), lower extremity ($Z = -3.261$, $P = .001$), concussion ($Z = -3.294$, $P = .001$), psychosocial intervention ($Z = -3.062$, $P = .002$), and general medical ($Z = -3.524$, $P < .001$) encounters. Three themes emerged from participant comments: improved clinical decision-making, transfer to clinical practice, and improved communication. **Conclusions:** Students gained confidence in nearly all areas related to obtaining a patient history, completing a physical examination, and interpersonal communication as a result of the SP encounters. The SP encounter provided a real-time clinical evaluation similar to clinical experience or patient care. By providing these educational experiences, students can become more comfortable interacting with patients in future clinical evaluations.

Standardized Patients Provide A Reliable Assessment Of Athletic Training Students Clinical Skills

Armstrong KJ, Jarriel AJ:
Georgia College and State
University, Milledgeville, GA

Context: Standardized patient (SP) encounters present an opportunity for students to receive immediate feedback regarding his/her performance during a real-time clinical evaluation. This prompt formative feedback is a benefit of SP encounters compared to other clinical evaluation methods. Since SPs are trained to consistently portray the case, students can be assessed and receive immediate feedback within the same clinical encounter; however, no research has documented the reliability of the SP at assessing student performance. **Objective:** To determine if SPs provide a reliable means of assessing an athletic training (AT) student's performance in obtaining a patient history and completing a physical examination. **Design:** Reliability study. **Setting:** Athletic Training Simulation Lab. **Patients or Other Participants:** 2 SPs and 2 AT faculty at a public liberal arts institution in the Southeast evaluated AT students after 8 SP encounters. AT students from 2 cohorts completed 2 SP encounters per semester, totaling 4 different encounters during one academic year. Junior students ($n=20$) completed the nutrition, cervical spine emergency, knee, and low back encounters, while senior students ($n=16$) completed the shoulder, concussion, general medical, and psychosocial intervention encounters. **Intervention:** After each SP encounter, AT faculty and SPs completed a clinical performance checklist developed specifically for each encounter. The checklist included items related to obtaining a patient history (10–12 items each) and completing a physical examination (12–15 items each). Cronbach's alpha determined internal consistency for obtaining a patient history and

physical examination items, with an alpha coefficient between (.412 – .690) and (.706 – .779) respectively. **Main Outcome Measure(s):** Items on the clinical performance checklist were scored yes/no for each specific checklist item. For each SP encounter, composite scores were computed for both history and physical examination items from the AT faculty and SPs. Intraclass correlation coefficients (ICC) determined interrater reliability between AT faculty and SPs for history and physical exam items. **Results:** Overall, reliability coefficients between AT faculty and SPs were high. Specifically, the reliability coefficients were significant for history items for the cervical spine emergency (ICC = 0.671, $P = .002$), knee (ICC = 0.696, $P = .003$), low back (ICC = 0.622, $P = .002$), shoulder (ICC = 0.447, $P = .036$), concussion (ICC = 0.764, $P = .004$), general medical (ICC = 0.571, $P = .008$), and psychosocial intervention (ICC = 0.572, $P = .008$) encounters. The reliability coefficients were significant regarding physical exam items for the cervical spine emergency (ICC = 0.588, $P = .01$), low back (ICC = 0.766, $P > .001$), shoulder (ICC = 0.451, $P = .035$), concussion (ICC = 0.792, $P = .001$), and general medical (ICC = 0.878, $P > .001$) encounters. **Conclusions:** Overall, the SPs provided a reliable assessment of the AT students clinical performance for obtaining a patient history and completing a physical examination. Since ICC measures between AT faculty and SPs were not significant for all encounters, additional time is needed during initial and follow-up SP training regarding checklist items. Devoting additional time during SP training should increase the reliability of the SP.

Education Evidence-Based Forum: Integration of EBP in Clinical Practice

Thursday, June 26, 2014, 12:30PM–1:30PM, Room 243; Speakers: Cailee Welch, PhD, ATC; Dorice Hankemeier, PhD, ATC; Moderator: Brian Vesci, MA, ATC

Ankle Evidence-Based Forum: Ankle Instability

Friday, June 27, 2014, 8:00AM–9:00AM, Room 243; Speakers: Thomas Kaminski, PhD, ATC, FACSM; Phillip Gribble, PhD; Moderator: Jay Hertel, PhD, ATC, FACSM, FNATA

Free Communications, Oral Presentations: Rehab Technologies for Ankle Instability

Friday, June 27, 2014, 9:30AM–10:45AM, Room 243; Moderator: Terry Grindstaff, PhD, PT, ATC

14314MOTE

Effects Of Talocrural Joint Mobilizations On Restricted Ankle Dorsiflexion And Squatting Kinematics

Smith M, Begalle RL, Littleton AC, Myers JB, Padua DA: Sports Medicine Research Laboratory, Department of Exercise and Sport Science, University of North Carolina, Chapel Hill, NC

Context: Decreased ankle dorsiflexion range of motion (DF-ROM) is associated with increased knee valgus collapse. Knee valgus collapse is reported as a mechanism and risk factor for ACL injury. Interventions that improve DF-ROM may be important components of ACL injury prevention programs. Talocrural mobilizations improve DF-ROM; however, previous research has not examined the effects of talocrural mobilization on lower extremity kinematics. **Objective:** Determine the effects of talocrural joint mobilizations performed on passive DF-ROM and knee and ankle kinematics during double (DLS) and single leg (SLS) squat tasks in healthy subjects with restricted DF-ROM. **Design:** Randomized control trial. **Setting:** Research laboratory. **Participants:** Forty-three healthy participants (23 females, 20 males) with restricted ankle dorsiflexion ($\leq 40^\circ$ weight bearing lunge) were randomly assigned to the Mobilization (MOB) or Control (CON) group (CON: $n = 22$, age = 19.68 ± 1.17 years, height = 70.27 ± 1.77 cm, mass = 79.68 ± 24.82 kg; MOB: $n = 21$, age = 20.90 ± 3.35 years, height = 170.33 ± 1.73 cm, mass = 71.81 ± 17.24 kg). **Intervention(s):** The MOB group performed gastrocnemius/soleus stretching (2 x 30 seconds each) followed by weight-bearing talocrural mobilization with movement and Grade III anterior to posterior talocrural joint mobilizations (3 x 30 seconds each). The CON group performed same stretching protocol followed by a sham mobilization. **Main Outcome Measure(s):** A standard goniometer

measured ankle dorsiflexion with knee extended (DFKEROM) and knee flexed (DFKFROM). A digital inclinometer measured DF-ROM during a weight-bearing lunge (WBLROM). An electromagnetic motion analysis system quantified joint kinematics during the squat tasks. Joint displacement (DSP) values for ankle dorsiflexion (DFDSP), knee flexion (KFDSP) and knee valgus (KVDSP), were calculated during the squat tasks. All measures were performed pre- and post-test. Separate mixed-model, repeated measure ANOVA's compared groups (MOB, CON) across time points (pre-test, post-test) ($\alpha \leq .05$). **Results:** A main effect for time was observed for the DF-ROM measures and DFDSP during the double and single leg squats: WBLROM ($F = 32.65$, $P < .001$, pre-test = 34.24 ± 3.77 , post-test = 35.42 ± 3.67), DFKEROM ($F = 12.39$, $P = .001$, pre-test = 2.455 ± 3.99 , post-test = 4.29 ± 4.80), DFKFROM ($F = 18.83$, $P < .001$ pre-test = 7.53 ± 5.78 , post-test = 9.22 ± 5.14), DFDSP double leg squat, ($F = 5.078$, $P = .030$, pre-test = -25.57 ± 7.34 , post-test = -26.45 ± 7.76), and DFDSP single leg squat ($F = 14.862$, $P \leq .001$, pre-test = -23.18 ± 5.38 , post-test = -24.84 ± 6.51). There were no significant group-by-time interactions for any dependent variable ($P > .05$). **Conclusions:** All subjects, regardless of group, improved passive and active DF-ROM following the stretching intervention. However, the joint mobilizations did not provide an additive effect for improving DF-ROM. Also, there were no acute changes in knee valgus motion following improved DF-ROM. Future research should examine the effects of multiple talocrural joint mobilization treatment sessions on lower extremity biomechanics.

14232FOTH

The Effects Of 2-Weeks Of Sensory-Targeted Ankle Rehabilitation Strategies On Range Of Motion, Balance, And Self-Assessed Function In Those With Chronic Ankle Instability

Wikstrom EA, McKeon PO: University of North Carolina at Charlotte, Charlotte NC, and Ithaca College, Ithaca, NY

Context: Deficient sensory input from damaged ankle ligament receptors is thought to contribute to chronic ankle instability (CAI) associated impairments. Targeting sensory receptors, may enhance rehabilitation outcomes for those with CAI. **Objective:** To evaluate the effects of 2-weeks of sensory-targeted rehabilitation strategies (STARS) on dorsiflexion range of motion (DFROM) single limb balance (SLB), and self-assessed function in those with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients:** 63 patients with self-reported CAI (27 males, 36 females; age: 23.2 ± 4.8 yrs; height: 172 ± 8.9 cm; mass: 75.6 ± 14.7 kg) participated. **Intervention(s):** After baseline testing, patients were randomly allocated to 4 STARS groups: joint mobilization (JM), plantar massage (PM), triceps surae stretching (TS), or control (CON). Patients received 6, 5-minute treatments of their respective STARS over a 2-week period. Post-test measures were completed within 72-hours of the final treatment session. **Main Outcome Measure(s):** Patients performed 3 trials of the weight-bearing lunge test (WBLT) to assess DFROM, defined as the farthest distance (cm) from the great toe to the wall achieved when the heel remained on the ground and the ipsilateral knee touched the wall. Patients performed 3, 20-second trials of SLB on a firm surface with eyes closed while balance errors were recorded. Self-assessed function was measured using the Foot and Ankle Ability Measure (FAAM). Post to pre change scores (Δ)

were calculated. Change scores of the 3 STARS groups were compared to the CON using independent sample t-tests and Hedge's *g* effect sizes (ES) with 95% confidence intervals (CI). **Results:** For the WBLT, JM (Δ : 2.23 ± 2.13 cm; ES: 1.23 (0.48 to 1.97)) and TS (Δ : 1.38 ± 1.05 cm; ES: 1.24 (0.46 to 2.02)) resulted in improved changes ($P < .001$) with large ES and CI that did not cross zero compared to the CON (Δ : -0.19 ± 1.23 cm). PM (Δ : 0.71 ± 1.23 cm; ES: 0.66 (-0.07 to 1.40)) failed to improve DFROM ($P = .055$). For SLB, PM (Δ : 1.28 ± 1.60 errors; ES: 0.99 (0.23 to 1.74); $P = .005$) and JM (Δ : 0.67 ± 1.14 errors; ES: 0.76 (0.05 to 1.47); $P = .023$) resulted in improved changes compared to CON (Δ : -0.19 ± 1.72 errors) with large ES and CI that did not cross zero. TS (Δ : 0.18 ± 1.50 errors; ES: 0.40 (-0.32 to 1.12)) failed to reduce the number of SLB errors ($P = .238$). For the FAAM, PM (Δ : $7.07 \pm 6.52\%$; ES: 1.37 (0.58 to 2.17)) and TS (Δ : $8.48 \pm 9.51\%$; ES: 1.24 (0.46 to 2.02)) improved self-assessed function ($P < .001$) relative to the CON ($-2.08 \pm 5.91\%$) with large ES and CI that did not cross zero. JM (Δ : $4.01 \pm 9.70\%$; ES: 0.70 (-0.01 to 1.41)) also improved FAAM scores ($P = 0.033$) but the CI crossed zero. **Conclusions:** Both JM and TS improve DFROM. PM and JM improves single limb balance. Both PM and TS improve self-assessed function measured by the FAAM. Each STARS appears to offer unique contributions to rehabilitating those with CAI.

Balance Training Augmented With A Brief Combined Stars Treatment Is No More Effective Than Balance Training Alone In Those With Chronic Ankle Instability

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Charlotte, Charlotte, NC

Context: Balance training programs are commonplace in the rehabilitation plan for nearly all lower limb musculoskeletal injuries. Likewise, clinicians aim to restore proprioceptive function through manual modalities such as joint mobilization, joint traction, and massage. **Objective:** To determine if using sensory targeted ankle rehabilitation strategies (STARS) in combination with an established balance training protocol results in greater improvements in self-assessed disability and dynamic balance than balance training alone in those with chronic ankle instability (CAI). **Design:** Randomized Control Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** 21 subjects with self-reported CAI (age: 21.5 ± 2.1 yrs; height: 170.5 ± 13.6 cm; mass: 72.9 ± 23.5 kg) participated. **Intervention(s):** Subjects were randomly assigned to one of two groups: balance training (BT), or balance training with STARS (BTS). All subjects completed a 4-week (12 sessions, 3/week) balance training protocol on their involved limb consisting of hopping and reaching tasks and static balance tasks with eyes open and closed. Progression within each task was based on error free performance as opposed to a standard volume of repetitions. The BTS group received a 5-minute STARS treatment immediately prior to each balance training session. The STARS treatment consisted of the following sequence: 1-minute of triceps surae stretching, 30 seconds of talocrural joint traction, 30 seconds of Grade III A/P joint mobilizations, 2 minutes

of plantar massage, 30 seconds of talocrural joint traction, and 30 seconds Grade III A/P joint mobilizations. **Main Outcome Measure(s):** Self-assessed disability was measured using the Foot and Ankle Ability Measure for activities of daily living (FAAM) and sporting activity (FAAM-S). The Star Excursion Balance Test (SEBT) was used to assess dynamic balance in the anterior (SEBT-A), posteromedial (SEBT-PM), posterolateral (SEBT-PL) directions. Reach distances were normalized to leg length. Outcomes were assessed prior to the first training session and 24 hours after the final training session. Separate mixed model MANOVAs were run to determine the effect of Group and Time on the primary outcome measures. **Results:** Time main effects were observed for self-assessed disability ($P = .016$) and dynamic postural control ($P < .001$) improved following the therapeutic interventions. Follow-up univariate ANOVAs revealed that FAAM-S (pre: 68.90 ± 11.44 , post: 76.89 ± 10.99 ; $P = .016$), SEBT-A (pre: $62.92 \pm 8.00\%$, post: $67.56 \pm 7.60\%$; $P = .003$), SEBT-PM (pre: $79.01 \pm 8.00\%$, post: $86.61 \pm 8.57\%$; $P < .001$), and SEBT-PL (pre: $74.06 \pm 11.70\%$, post: $82.55 \pm 9.24\%$; $P < .001$) significantly improved after training. FAAM scores did not improve over time (pre: 86.82 ± 6.92 , post: 89.04 ± 6.50 ; $P = .196$). No group main effects ($P > .50$) or Group x Time interactions ($P > .603$) were revealed. **Conclusions:** A brief (5-minute) combined STARS treatment does not enhance the ability of an error based dynamic balance training program to improve self-reported disability or dynamic postural control in those with CAI. Future research is needed to determine if different treatment parameters (eg increased volume of STARS or timing of STARS delivery relative to balance training sessions) would enhance treatment outcomes for those with CAI.

The Effects Of 2 Weeks Of Sensory-Targeted Ankle Rehabilitation Strategies On Self-Assessed Function In Those With Chronic Ankle Instability: A 1-Month Follow-Up

McKeon PO, Wikstrom EA: Ithaca College, Ithaca, NY, and University of North Carolina at Charlotte, Charlotte, NC

Context: Deficient sensory input from damaged ankle ligament receptors is thought to contribute to chronic ankle instability (CAI) associated impairments. Targeting sensory receptors may enhance rehabilitation outcomes for those with CAI, however it is unclear how long these effects may persist after treatment. **Objective:** To evaluate the effects of 2 weeks of sensory-targeted rehabilitation strategies (STARS) on self-assessed function in those with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** 64 patients with self-reported CAI (27 males, 36 females; age: 23.2 ± 4.7 yrs; height: 171.8 ± 9.0 cm; mass: 75.4 ± 14.7 kg) participated. **Intervention(s):** After baseline testing on the Foot and Ankle Ability Measure (FAAM) Activities of Daily Living (ADL) and Sport subscales, patients were randomly allocated to 4 STARS groups: joint mobilization (JM), plantar massage (PM), triiceps surae stretching (TS), or control (CON). Patients received 6, 5-minute treatments of their respective STARS over a 2-week period. Upon completion of the 2-week intervention, all subjects were asked to return 1 month later to complete a follow-up FAAM-ADL and FAAM-Sport questionnaire. **Main Outcome Measure(s):** Self-assessed function was measured using the FAAM-ADL and FAAM-Sport subscales. The FAAM-ADL consists of 21 activities related to normal daily function whereas the Sport subscale contains 8 items of more challenging

sport-related activities. The main outcome measure of each scale is expressed as a percentage of total possible points (X/84 for ADL and X/32 for Sport). The 1-month post-STARS FAAM-ADL and FAAM-Sport scores (%) to pre-STARS change scores (Δ) were calculated. Change scores of the 3 STARS groups were compared to the CON using independent sample t-tests and Hedge's g effect sizes (ES) with 90% confidence intervals (CI). Alpha was set to $P < .10$. **Results:** Five subjects (1 male, 4 females) were lost to follow-up, leaving 59 subjects for analysis. For the FAAM-ADL, PM (Δ : $10.9 \pm 13.5\%$; ES: 0.9 (0.3 to 1.6), $P = .01$), TS (Δ : $9.7 \pm 8.5\%$; ES: 1.2 (0.5 – 1.9), $P < .01$), and JM (Δ : $5.7 \pm 8.6\%$; ES: 0.70 (0.1 – 1.3), $P = .03$) improved self-assessed function relative to the CON ($-0.1 \pm 5.8\%$) with large ES and CI that did not cross zero. For the FAAM-Sport, TS (Δ : $11.6 \pm 13.5\%$; ES: 0.7 (0.0 – 1.3), $P = .06$), and JM (Δ : $10.7 \pm 12.5\%$; ES: 0.6 (0.0 – 1.2), $P = .06$) improved self-assessed function relative to the CON ($2.0 \pm 12.2\%$) with moderate to large ES and CI that did not cross zero. PM (Δ : $11.9 \pm 19.7\%$; ES: 0.5 (-0.1 – 1.2), $P = .12$) also improved FAAM-Sport scores, but the CI crossed zero. **Conclusions:** Based on the effect sizes and confidence intervals, all three STARS treatment groups demonstrated improvements in their self-reported function during activities related to daily living and sport after 1 month, but the improvements in sport activities were not as substantial. The next logical step is to determine STARS effects on self-reported function in combination with other interventions known to improve self-reported function, such as progressive balance training, in those with CAI.

Hip Strengthening Protocol Effects On Neuromuscular Control, Hip Strength, And Self-Reported Deficits In Individuals With Functional Ankle Instability

Smith BI, Docherty CL, Curtis D, Alexander JL: A.T. Still University, Mesa, AZ, and Indiana University, Bloomington, IN

Context: Hip strength and proprioception deficits are often associated with functional ankle instability (FAI). Following a strength training protocol, increased strength has been identified, partially credited to neural factors. Therefore, strength training alone may be effective in improving both muscular and proprioceptive impairments. **Objective:** To examine the effect of a four-week hip strength training protocol on neuromuscular control, hip-strength, and self-reported functional deficits in individuals with FAI. **Design:** Pre-test/post-test repeated measures design. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Twenty-six college-aged participants (12 males and 14 females, age = 20.9 ± 1.5 years, height = 170.0 ± 12.7 cm, mass = 77.5 ± 17.5 kg) with FAI were recruited for this study. Presence of FAI was determined with the Ankle Instability Instrument and Cumberland Ankle Instability Tool. Subjects were randomly assigned to either the training or control group. Subjects were excluded from the study if they currently had pain or swelling at the ankle, a history of fracture or surgery at the ankle or were diagnosed with a neuromuscular dysfunction. **Intervention(s):** Training group participants completed a supervised hip strength training protocol using Theraband exercise bands (Hygenic Corporation, Akron, OH) for 4 weeks (3 times a week) with progressively increasing resistance. The control group did not participate in any rehabilitation during the same 4-week period. Four measures were captured on all

participants. These included: abduction and external rotation hip strength using a MicroFET2 handheld dynamometer (Hoggan Health Industries, Inc, Draper, UT), static balance using the Balance Error Scoring System (BESS), dynamic balance using the Star Excursion Balance Test (SEBT), and self-reported function using the Foot and Ankle Ability Measure (FAAM) and FAAM-Sport. **Main Outcome Measure(s):** Hip abduction and external rotation torque (Newtons), three SEBT reach distances (anterior, posterolateral and posteromedial), BESS total errors, FAAM and FAAM-Sport scores prior to and after the four week period. **Results:** At the post-test, the training group exhibited significant improvements compared to the control group in the following measures: abduction strength (training 446.3 ± 77.4 N, control 314.7 ± 49.6 N, $P < .01$), external rotation strength (training 222.1 ± 48.7 N, control 169.4 ± 34.6 N, $P < .01$) strength, SEBT scores in the anterior (training 93.1 ± 7.4 cm, control 90.2 ± 7.9 cm, $P < .01$), posteromedial (training 96.3 ± 8.9 cm, control 88.0 ± 8.8 cm, $P < .01$) and posterolateral (training 95.4 ± 11.1 cm, control 86.6 ± 9.6 cm, $P < .01$) directions, total errors during BESS (training 9.9 ± 6.3 errors, control 21.2 ± 6.3 errors, $P < .01$), and FAAM-Sport score (training 88.0 ± 12.6 , control 84.8 ± 10.9 , $P < .01$) **Conclusions:** A 4-week hip strength training protocol improved hip strength, static and dynamic balance, and self-reported function in patients with FAI. These findings suggest that including hip strengthening can be beneficial in the conservative management and prevention of recurrent instability associated with FAI.

Free Communications, Oral Presentations: Quality of Life After Lower Extremity Injury

Saturday, June 28, 2014, 8:00AM–9:15AM, Room 243; Moderator: Kenneth Lam, ScD, ATC
14197FOMU 14272MOMU

An Acute Ankle Lateral Ankle Sprain Significantly Decreases Physical Activity Across The Lifespan

Hubbard-Turner T, Wikstrom EA, Turner MJ: University of North Carolina at Charlotte, Charlotte, NC

Context: Ankle sprains remain the most common musculoskeletal pathology. They are often thought to be a relatively innocuous injury; however, the long term impact of ankle sprains on function, specifically physical activity is unknown. **Objective:** To determine the lifelong effect of an ankle sprain on voluntary physical activity levels in mice. **Design:** Prospective randomized control clinical trial. **Setting:** Controlled, research laboratory. **Participants:** Thirty male mice (CBA/2J). **Intervention(s):** Mice were individually housed in a cage and randomly placed into 1 of 3 groups at 7 weeks of age: the transected CFL group, the transected ATFL/CFL group, and a SHAM group. All mice were individually housed 3 days after surgery; a solid surface running wheel was introduced to all mice and daily running wheel measurements were recorded. **Main Outcome Measure(s):** Physical activity levels (distance, duration, speed) were recorded daily and average activity level for each week was calculated across their lifespan (through approximately 85 weeks of age). **Results:** Daily distance run was significantly lower in the ATFL/CFL group compared to the CFL and SHAM groups ($p = 0.018$) through 85 weeks of age. At 3 months of age (1 month after ankle sprain), the mice in the ATFL/CFL group ran on average 3.6 ± 2.3 km/day, compared to 4.2 ± 2.3 km/day for the CFL only group and 5.0 ± 3.5 km/day for the SHAM group ($p = .001$). At 6 months of age the ATFL/CFL group ran on average 2.1 ± 1.1 km/day, compared to 2.7 ± 1.2 km/day for the CFL only group and 3.8 ± 1.5 km/day for the SHAM group ($p = .015$). At 12 months

of age the ATFL/CFL group ran on average 2.2 ± 0.8 km/day, compared to 2.4 ± 0.9 km/day for the CFL only group and 2.6 ± 0.8 km/day for the SHAM group ($p = .019$). At 18 months of age the ATFL/CFL group ran on average 1.1 ± 0.6 km/day, compared to 1.6 ± 0.6 km/day for the CFL only group and 1.8 ± 1.0 km/day for the SHAM group ($p = .04$). **Conclusions:** Mice with a more severe ankle sprain (ATFL/CFL) had significantly decreased physical activity across the lifespan compared the CFL only and SHAM group. Additionally although not significantly different the CFL only group was less physically active compared to the SHAM group. Physical inactivity is classified as one of three highest risk behaviors in the development of cardiovascular disease, cancer and other chronic diseases such as diabetes and obesity, and is the second highest alterable cause of cardiovascular arterial disease. This decreased physical activity level secondary to a one time ankle sprain could have significant impact on the health and well-being of the patient.

Knee Injury History Impacts Health-Related Quality Of Life In Adolescent Athletes

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Context: Knee injuries are common in sports and can result in significant time loss from participation. Health-related quality of life (HRQOL) characterizes the perceived impact an injury has on various health domains from the patient's point-of-view and is considered to be an essential component of patient-centered care. Current evidence suggests that, despite returning to full participation, physically active adults with a previous knee injury experience lower HRQOL than those with no knee injury history. It is unknown if this relationship is present in adolescent athletes. **Objective:** To determine the impact of knee injury history on HRQOL in adolescent athletes. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of 143 high school athletes (male = 80, female = 63) who were medically cleared for unrestricted sport participation. Participants were classified into two groups based on a self-report of a previous knee injury: positive knee injury history (HIS) ($n = 32$, age = 15.4 ± 1.3 years, height = 164.9 ± 10.0 cm, mass = 70.6 ± 14.8 kg) and no knee injury history (NO-HIS) ($n = 111$, age = 15.1 ± 1.4 years, height = 163.1 ± 10.1 cm, mass = 67.0 ± 15.6 kg). **Intervention(s):** The independent variable was knee injury history. Participants completed two pediatric-specific patient-rated outcome measures during one testing session: the pediatric version of the International Knee Documentation Committee Form (Pedi-IKDC) and the Pediatric Quality of Life Inventory (PedsQL). Both instruments have published measurement properties. **Main Outcome Measure(s):** Dependent variables were the Pedi-IKDC total score,

PedsQL total score, and four PedsQL subscale scores (physical, emotional, social and school functioning), with higher scores indicating better HRQOL. Independent-samples Mann-Whitney U tests were utilized for group comparisons. Alpha was $p < 0.05$, two-tailed. **Results:** The most common knee injury reported by the HIS group was ligamentous sprain (28.1%), followed by tendinopathy (12.5%) and general knee pain (12.5%). The HIS group reported significantly lower scores than the NO-HIS group for the Pedi-IKDC total score ($p \leq .001$; HIS = 80.5 ± 20.8 , NO-HIS = 96.5 ± 9.5) and for the PedsQL total ($p = .002$; HIS = 84.3 ± 10.8 , NO-HIS = 90.4 ± 9.1), physical functioning ($p = .013$; HIS = 86.3 ± 14.3 , NO-HIS = 92.7 ± 8.3), and school functioning ($p = .008$; HIS = 77.8 ± 16.5 , NO-HIS = 85.6 ± 15.0) scores. No group differences were reported for the emotional functioning ($p = .109$; HIS = 83.1 ± 18.3 , NO-HIS = 89.2 ± 15.0) or social functioning ($p = .131$; HIS = 88.8 ± 13.2 , NO-HIS = 92.7 ± 11.7) subscales. **Conclusions:** Our findings suggest that adolescent athletes with a previous knee injury generally experience lower HRQOL than their peers with no knee injury history, particularly for knee-specific HRQOL, physical functioning and school functioning. These results are similar to those reported in collegiate athletes and military cadets, and suggest that clinicians should be aware that athletes may experience HRQOL deficits despite returning to full participation. Future studies should determine the clinical meaningfulness of group differences related to HRQOL. To our knowledge, this is the first study to utilize the Pedi-IKDC in an adolescent athletic population. Future studies should continue to investigate the clinical utility of the Pedi-IKDC in an adolescent athletic population.

A Comparison Of Health Related Quality Of Life, Knee Function, And Physical Activity In Young Subjects With And Without A 2nd ACL Injury

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Context: Recent studies have reported an estimated 15% to 20% of patients who have undergone primary ACL reconstruction will sustain a subsequent ACL injury to the surgically reconstructed or contra-lateral knee. Patients' knee function and activity level have been found to be at or near normal following primary reconstruction. However, limited data exist that illustrate the impact subsequent ACL injuries have on Health Related Quality of Life (HRQOL), Knee Function (KF) and Physical Activity (PA). **Objective:** Compare HRQOL, KF and PA in subjects with and without subsequent ACL injury. **Design:** Retrospective study. **Setting:** All patients from a single sports medicine clinic age 15 – 30 ($N = 443$) who tore their ACL and underwent ACL reconstruction surgery (12 to 72 months previously) were asked to participate. **Participants:** Two hundred sixty five (60%), (female = 119, male = 146), age = 20.6 ± 4.0 yrs. completed the surveys 40.6 ± 17 months post primary ACL reconstruction. **Intervention(s):** A survey was sent (mailed and/or online) to each participant to obtain information on subsequent ACL injury. Current HRQOL was assessed with the SF12 v 2.0 Physical Composite Summary Score (PCS) and Mental Composite Score (MCS). The US population PCS and MCS mean scores = 50.0 ± 10.0 with higher scores indicating greater HRQOL. KF was assessed with the International Knee Documentation Committee scale (IKDC) (scores = 0 to 100, 100 = unlimited knee function. PA was assessed with the Tegner Activity scale (TA) (score = 0 to 10,

higher score = greater activity). **Main Outcome Measure(s):** Dependent variables included the differences (mean \pm sd) in PCS, MCS, IKDC and TA scores. Differences were assessed with t-tests ($p \leq 0.05$). **Results:** Twenty six subjects (9.8%) sustained a second ACL injury on their reconstructed knee while fourteen subjects (5.2%) sustained a contra-lateral ACL injury 18.2 ± 11.6 months following reconstruction. There was no difference ($p = 0.884$) in MCS scores (ACL injury = 53.2 ± 7.7 , No injury = 53.0 ± 7.2). The PCS scores for subjects with subsequent ACL injury were lower ($p = 0.034$) than the non-injured subjects (ACL injury = 53.6 ± 6.2 , No injury = 55.8 ± 4.0). IKDC scores for subjects with another ACL injury were lower ($p = 0.004$) than the non-injured subjects (ACL injury = 78.8 ± 16.5 , No injury = 87.1 ± 10.1). TA scores for subjects with another ACL injury were lower ($p = 0.020$) than non-injured subjects (ACL injury = 6.6 ± 2.2 , No injury = 7.5 ± 1.9). **Conclusions:** The young population is not only the most at risk for primary tear but also re-injury. Although they may be able to recover to near baseline after a primary reconstruction this study illustrates that patients who sustain a subsequent ACL injury have reduced HRQOL, KF and PA compared to patients without a second ACL injury.

Health-Related Quality Of Life Is Lower In Division I Collision Athletes Compared To Contact And Non-Contact Division I Athletes

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Context: Collegiate athletes who participate in physical activity may be at an increased risk of suffering from chronic stress, injuries, and overtraining especially in higher impact sports. However, there is little known about how previous participation in college athletics may limit current physical activity and/or decrease their current Health Related Quality of Life (HRQoL).

Objective: To evaluate differences in current HRQoL in former collision, contact, and non-contact Division I athletes. **Design:** Case control **Setting:** Online Survey **Patients or Other Participants:** Five hundred thirty-five former Division I student-athletes (ages 40-65 years) were recruited through alumni databases at a large Midwestern University. Two hundred seventy-five responses were received (response rate 51.4%) however, 232 responses were usable for analysis (167 males, 65 females, 53.36±7.11 years). Forty-three participants were excluded because the surveys received were incomplete.

Intervention(s): Participants completed a web-based survey (Qualtrics, Provo, UT) responding to questions on the NIH Patient-Reported Outcomes Measurement Information System (PROMIS). Seven PROMIS scales used, which included: sleep disturbance, anxiety, depression, fatigue, pain interference, physical function, and satisfaction with participation in social roles. An additional questionnaire was constructed to record demographic and current exercise information. The independent variable was group (collision, contact, and non-contact athletes). Group classification was based on the

American College of Pediatrics classifications. **Main Outcome Measure(s):** Each PROMIS scale score ranged from 0 to 100, which was calibrated using a T-score metric with the U.S. general population equal to a mean of 50 and a standard deviation of 10. Higher scores for sleep disturbance, anxiety, depression, fatigue, and pain interference indicate poorer health, while higher scores on the physical function and satisfaction with participation in social roles scales indicate better health. A between-subjects multivariate ANOVA was performed on seven dependent variables: sleep disturbance, anxiety, depression, fatigue, pain interference, physical function, and satisfaction with participation in social roles. Bonferroni post-hoc test was used to identify any specific differences between the groups. A priori alpha level set at $p < 0.05$. **Results:** The combined dependent variables were significantly affected by group ($F_{7, 223} = 14.07$, $p < 0.001$, $\eta_p^2 = 0.50$, $1 - \beta = 0.99$). Univariate analyses for the effect of group was significantly related to physical function, depression, fatigue, sleep disturbances, and pain interference ($p < 0.05$). Specifically, the biggest differences were seen in the physical function [collision vs. non-contact (mean difference: 8.70 ± 2.01 , 95%CI: 0.71 to 10.99)], depression [collision vs. non-contact (mean difference: 8.10 ± 1.58 , 95%CI 4.30 to 11.90); collision vs. contact (mean difference: 5.48 ± 1.63 , 95%CI: 1.55 to 9.42)], and pain interference [collision vs. non-contact (mean difference: 8.26 ± 1.64 , 95%CI: 4.30 to 12.22); collision vs. contact (mean difference: 5.96 ± 1.70 , 95%CI: 1.86 to 10.06)]. **Conclusions:** Overall, HRQoL was significantly worse for the collision athletes than the other two groups for the physical function, depression, fatigue, sleep disturbance, and pain interference scales.

Adolescent Athletes Demonstrate Rapid Improvements In Health-Related Quality Of Life Following Sport-Related Injury: A Report From The Athletic Training Practice-Based Research Network

Welch CE, Snyder Valier AR, Bay RC, Sauers EL, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Changes in adolescent athletes' health-related quality of life (HRQOL) following sport-related injury are largely unknown. While pre-injury normative data were reported on general HRQOL for adolescent athletes, few studies have attempted to understand whether adolescent athletes' HRQOL improves, remains the same, or worsens during recovery following injury. **Objective:** To determine short-term changes in HRQOL among adolescent athletes immediately following sport-related injury. **Design:** Repeated Measures. **Setting:** Secondary school athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** 75 patients (41 males, 34 females; age = 16.2 ± 1.1 ; height = 68.6 ± 4.1 cm; mass = 71.1 ± 17.1 kg) participating in interscholastic athletics who suffered a sport-related injury documented by an athletic trainer (AT) within the AT-PBRN. **Intervention(s):** Adolescent athletes who suffered a sport-related injury completed The Pediatric Quality of Life [(PedsQL) internal consistency = .68-.88] during athletic training treatment sessions during post-injury week 1 [(W1); range = 0 – 5 days post-injury] and week 2 [(W2); range = 10 – 15 days post-injury]. The PedsQL is a multi-dimensional, generic measure of HRQOL that is scored from 0 – 100; higher scores indicate better health. Patients received usual care from the AT; type and frequency of treatments were not

accounted for in this study. The independent variable was time (W1, W2). **Main Outcome Measure(s):** Dependent variables included PedsQL total score (TS) and 5 subscale scores [physical functioning (PF), psychosocial functioning (PSF), emotional functioning (EF), social functioning (SOF), school functioning (SCF)]. Descriptive statistics (mean \pm SD) were reported and Wilcoxon Signed-Rank tests ($P < .05$) were used to identify differences between W1 and W2. **Results:** There were significant improvements for PedsQL TS and all subscales, except SCF. Participants' scores increased by: 6 points on TS ($P < .001$; W1 = 79.2 ± 13.2 , W2 = 85.3 ± 11.3), 10 points on PF ($P = .001$; W1 = 67.3 ± 24.7 , W2 = 77.6 ± 19.1), 4 points on PSF ($P < .001$; W1 = 85.6 ± 12.1 , W2 = 89.4 ± 10.6), 6 points on EF ($P < .001$; W1 = 83.6 ± 16.5 , W2 = 89.8 ± 12.9), and 2 points on SOF ($P = .026$; W1 = 91.1 ± 11.6 , W2 = 93.6 ± 10.5). While no significant differences were found on SCF, scores increased by 2 points ($P = .134$; W1 = 82.1 ± 18.3 , W2 = 84.7 ± 16.6). **Conclusions:** These findings provide a better understanding of the short-term changes in adolescent HRQOL immediately following injury and may assist clinicians in creating treatment plans that optimally target patient-oriented deficits. At two weeks post-injury, PedsQL scores are generally higher than earlier scores obtained within the first week following injury. This finding suggests that deficits in HRQOL following sport-related injury may be transient in nature and will improve during the second week of recovery. However, while PF improved within one week, scores for this domain remain suboptimal at two weeks post-injury. Clinicians should be mindful of an athlete's progression if they do not see significant improvements in HRQOL scores during the second week of recovery. This study did not evaluate the interventions provided by ATs following sport-related injury and

additional research is needed to assess the effectiveness of athletic training services provided to injured adolescent athletes. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Knee Evidence-Based Forum: Maintaining Long-Term Joint Health Following Acute Knee Injury: A Discussion of Risk and Therapeutic Intervention

Saturday, June 28, 2014, 9:30AM–10:30AM, Room 243; Discussants: Brian Pietrosimone, PhD, ATC; Joseph M. Hart, III, PhD, ATC; Moderator: Jeffrey Driban, PhD, ATC, CSCS

Free Communications, Oral Presentations: Injury Epidemiology

Saturday, June 28, 2014, 11:00AM–12:15PM, Room 243; Moderator: Kenneth Cameron, PhD, MPH, ATC

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Incidence, Mechanisms, And Severity Of Game-Related High School Football Injuries Across Artificial Turf Systems Of Various Infill Weight

Meyers MC: Idaho State University, Pocatello, ID

Context: Today's new generations of artificial turf are increasingly being installed to duplicate or exceed playing characteristics of natural grass. Rather than playing on the polyethylene turf fibers, shoe: surface interaction actually occurs between the cleat and the various proprietary sand/rubber infill composites of varying weight. At this time, the influence of surface infill weight on football trauma is unknown. **Objective:** To quantify incidence, mechanisms, and severity of game-related high school football trauma across artificial turf systems of various infill weight. It is hypothesized that there will be no difference in injury incidence between surface infill weight. **Design:** Prospective cohort study. **Setting:** High school football games. **Patients or Other Participants:** A total of 43 high schools participating across four states over 3 competitive seasons. **Intervention(s):** Artificial turf systems were divided into four sand/rubber infill weight groups based on lbs per square foot: (A) > 9.0, (B) 6.0 – 8.9, (C) 3.1 – 5.9 and, (D) 0.0 – 3.0. **Main Outcome Measure(s):** Surface infill weights were evaluated for injury incidence, injury category, injury time loss, player position, injury mechanism and situation, primary type of injury, injury grade and anatomical location, field location at time of injury, injury severity, head, shoulder, and lower extremity trauma, cleat design, turf age, and environmental factors using univariate analyses. **Results:** Of the 847 high school games documented, 301 games (35.5%) were played on infill (A), 231 (27.3%) on infill (B), 189 (22.3%) on infill (C), and 126 (14.9%) on infill (D). A total of 1,979 injuries were documented, with significantly

lower total injury incidence rates (IIR), [18.8 (95% CI, 18.3-19.1) vs 23.3 (22.4-24.0) vs 31.6 (30.5-32.2) and 22.1 (20.8-22.9)], substantial IIRs [3.9 (95% CI, 3.4-4.5) vs 4.8 (4.1-5.4), 7.7 (7.1-8.3) and 6.1 (5.2-5.9)], trauma from player-to-player collisions [8.7 (95% CI, 8.2-9.0) vs 11.0 (10.5-11.5), 16.4 (15.5-17.1) and 9.8 (9.4-10.0)], playing surface impact trauma [2.6 (95% CI, 2.1-3.1) vs 4.2 (3.6-4.8), 5.6 (4.8-6.2) and 4.4 (3.5-5.2)], and less muscle trauma [6.1 (95% CI, 5.5-6.6) vs 9.7 (9.4-9.9), 13.7 (12.8-24.4 and 8.7 (8.0-9.2)], while competing on infill weighing >9.0 (A) versus 6.0 -8.9 (B), 3.0 – 5.9 (C), and 0.0-3.0 (D), respectively. Significantly lower trauma ($P < .05$) was also observed across concussions, muscle-tendon overload, time loss, skill positions, injury mechanism and situation, lower and upper extremity joints, adverse weather conditions, and turf age while competing on infill (A) versus infill (C). **Conclusions:** As the artificial infill surface weight decreased, the incidence of game-related high school football trauma significantly increased across numerous playing conditions. This is the first study to investigate the influence of artificial infill surface weight on the incidence of game-related high school football trauma. Since this study is in the early stages, findings warrant further investigation.

Lateral Ankle Sprain Trends In Basic Combat Training Soldiers

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Context: Ankle sprains are the second most common injury in Basic Combat Training (BCT) Soldiers, resulting in a high number of lost training days. Ankle sprains are also known to contribute to future ankle sprains and other pathologies. Reducing injuries and lost training time while improving Soldier care is an Army objective. **Objective:** A better understanding of the injury incidence is necessary in order to develop ankle injury prevention protocols. **Design:** Observational, cohort study. **Setting:** Army BCT Battalions. **Patients or Other Participants:** Army male trainees ($N=14,769$) completing 9 weeks of Army BCT, 192d infantry Brigade, Ft Benning GA in 2012. **Intervention(s):** Training week of BCT. Basic Combat Trainees complete specific training and physical fitness activities each week of the nice week training cycle. Ankle sprains and treatments were tracked by training week to determine if the injury incidence was related to time in cycle. Injuries were reported to and tracked by Certified Athletic Trainers responsible for Soldier care. Confirmed ankle sprains included positive orthopedic tests (anterior drawer, talar tilt, tap test, squeeze test), palpation, functional assessment, and appropriate mechanism of injury. Injuries included both first time and repeated ankle sprains. Data was confirmed weekly by the Warrior Athletic Training (WAT) program clinical coordinator and WAT program director, and inputted into the specialized injury tracking system. **Main Outcome Measure(s):** Total number of sprains and injury treatments for ankle sprains in BCT training units was analyzed by training cycle week using a linear regression model. **Results:** Total number of ankle sprains = 195, with 644 ankle

sprain treatments completed. Forty-one sprains occurred week one, and six during week nine. A linear regression was conducted to evaluate injury results. Training week was found to be a significant predictor of the frequency of ankle sprain $\beta = -0.89$, $t(22992) = -5.177$, $p < 0.0001$. Training week also explained a significant portion of the variance in the number of ankle sprains, $R^2 = 0.793$, $F(1,22992) = 26.80$, $p = 0.001$. Training week was also found to be a significant predictor of the frequency of ankle treatments $\beta = -0.932$, $t(22992) = -6.80$, $p < 0.0001$. Training week also explained a significant portion of the variance in the number of ankle treatments, $R^2 = 0.869$, $F(1,22992) = 46.26$, $p < 0.0001$. **Conclusions:** Ankle sprain incidence and number of treatments decreased linearly as Soldiers progressed through BCT. This directly supports other data from our work that shows an increased stiffness/decreased ROM in ankle eversion, dorsiflexion and inversion as well as calf muscle strength after BCT. This information can assist in the development of ankle injury prevention protocols in Army training.

Epidemiology Of Injuries And Treatments In Twenty-Five High School Sports: Preliminary Analyses From The National Athletic Treatment, Injury And Outcomes Network (NATION)

Dompier TP, Hayden R, Snook EM, Simon JE, Marshall SW: Datalys Center for Sports Injury Research and Prevention, Indiana University, Bloomington, IN, and University of North Carolina-Chapel Hill, NC

Context: Few studies have reported both the nature and frequency of injuries and associated care provided by Athletic Trainers (AT) in the high school setting. The care provided by ATs in the high school setting can range from protective measures such as taping and bracing, applying modalities such as ice bags to more time intensive therapeutic exercises and manual therapies. **Objective:** To describe nature and frequency of both injuries and the associated care provided by ATs in the high school setting. **Design:** Descriptive epidemiology. **Setting:** There were 75 high schools included over 2 academic years. The ATs used an online Injury Surveillance Tool (IST) to report demographic, injury and treatment information. The IST allows athletic trainers to document information about injuries, exposures, treatments and patient-reported health outcomes as part of a larger study. **Patients or Other Participants:** There were a total of 25 sports accounting for 1563 individual team seasons. The male sports contributed 755 (48.30%) team seasons across 12 sports and the 13 female sports contributed 808 (51.70%) team seasons. **Intervention(s):** The independent variables included in this analysis were sport and sex. **Main Outcome Measure(s):** Injuries included incidents requiring assessment by the AT or other healthcare providers. Treatments included preventative measures, modalities, therapeutic

exercise, manual therapy and other healthcare procedures. The frequency of injury and treatments are reported for each sport. All proportions include 95% confidence intervals (CI). **Results:** There were a total of 41,295 injuries and 177,406 treatments reported for an average of 4.39 (95%CI: 4.25, 4.34) per injury. The number of treatments for a single injury ranged from 1 to 159. Men's sports contributed 67.84% if the injuries and 66.99% of the treatments. The average number of treatments provided per injury in men's sports was 4.11 (95%CI: 4.07, 4.17) and women's sports averaged 4.28 (95%CI: 4.20, 4.36) treatments per injury. Injuries treated for women's sports received more treatments per injury than men's sports (ratio=1.04; 95%CI: 1.02, 1.06). Football contributed the most injuries (16,305 or 129.40 per team season) and treatments (75,677 or 600.61 treatments per team season). Men's Swimming contributed the fewest number of injuries (100 or 2.50 per season) and fewest treatments (6.03 per team season). The average number of treatments per injury ranged from 3.02 in Men's Crew to 5.64 in Football. In women's sports, Tennis reported the lowest average number of treatments per injury (3.84) and Indoor Track reported the highest (5.65). **Conclusions:** Injuries suffered by student-athletes in high school sports require a substantial number treatments and care provided by ATs in the high school setting. Differences exist between men's and women's sports. Future analyses should consider the severity, specific injury type, and types of treatments.

An Analysis Of The Days To Return To Play Following Hamstring Strains Among American Collegiate Soccer Players

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Context: Among American collegiate soccer players, the incidence rate and the event characteristics of hamstring strains differ between male and female players, but comparisons in the return to play (RTP) time have not been reported. **Objective:** To compare RTP time between male and female collegiate soccer players who incurred hamstring strains and analyze the influence of event characteristics on the RTP time for each sex. **Design:** Descriptive epidemiology study. **Setting:** Colleges and universities that voluntarily participated in the NCAA Injury Surveillance System (ISS) for men's and women's soccer during fall seasons from 2004-2009. **Patients or Other Participants:** A total of 510 hamstring strains (males=309, females =201) were reported to the ISS during the data capture period. **Intervention(s):** At each participating institution, athletic trainers reported athlete-exposures and injury event data via the online ISS. **Main Outcome Measure(s):** Nonparametric statistics were used to evaluate RTP time differences between sexes and categories of each event characteristic (pre-season or in-season, practice or game, different player positions). Negative binomial regression was used to model the RTP time for each sex. Analyses were performed separately for first-time (n=418) and recurrent strains (n=92). Descriptive statistics are reported in days to RTP as median (interquartile range). **Results:** There were no statistically significant differences in RTP time between sexes for first-time (males=7

[4 to 12] days, females=6 [3 to 9] days, $P=0.06$) or recurrent hamstring strains (males=11 [5 to 16] days, females=5.5 [4 to 12] days, $P=0.06$). Regarding first-time strains among males, RTP time was significantly increased when the strain occurred during games (9 [4 to 17] days) versus practices (6 [3 to 10] days, $P=0.002$) and the in-season (7 [4 to 14] days) versus preseason (5 [3 to 10] days, $P=0.005$). Compared to players injured during practices, forwards injured during games had 60% longer RTP time ($P<0.001$) and midfielders had 21% longer RTP time ($P=0.002$). Among females with first-time strains, there were no significant differences in RTP time between any characteristics. Regarding recurrent hamstring strains among males, RTP time was statistically increased when the strain occurred during the in-season (11 [6 to 17] days) compared to preseason (7.5 [3 to 12] days, $P=0.04$). Among females, RTP time was extended if the recurrent strain occurred to forwards during games (forwards=11 [9 to 14] days, midfielders=2 [2 to 4] days, defenders=4 [3 to 5] days, $P=0.02$). **Conclusions:** Although there were no statistically significant differences in RTP time after hamstring strains between male and female collegiate soccer players, each sex had unique event characteristics that influenced RTP time. These event characteristics also varied for each sex depending upon hamstring strain recurrence status. These results may help inform evidence-based prevention and treatment plans addressing hamstring strains in collegiate soccer players.

Epidemiology Of Injuries In Age-Only And Age-Weight Playing Standards In Youth Football

Hayden R, Snook EM, Simon JE, Marshall SW, Dompier TP: Datalys Center for Sports Injury Research and Prevention, Indiana University, Bloomington, IN, and University of North Carolina-Chapel Hill, NC

Context: It is widely believed that organizing children on youth football teams by both age and size (weight) creates a safer playing environment. However, opponents of this concept charge that removing children from their peer groups diminishes the integrity of the game and ultimately reduces participation. To date, no studies have comprehensively evaluated the injury risks associated with these two playing standards in youth football. **Objective:** To compare the risk of injury between the Age-Only (AO) and Age-Weight (AW) playing standards in youth football. **Design:** Cohort. **Setting:** Youth football practice and game fields in 13 unique youth football leagues (ages 5 to 14 years) across 6 states over 2 seasons. Athletic Trainers (AT) used an online Injury Surveillance Tool (IST) to report demographic, injury and exposure information. **Patients or Other Participants:** There were a total 3102 players with 1534 in the AO (mean age = 10.50 ± 1.84 years; height = 145.62 ± 16.26 cm; weight = 44.25 ± 15.01 kg) and 1568 in the AW (mean age = 10.90 ± 2.06 years; height = 146.79 ± 14.28 cm; weight = 42.89 ± 13.14 kg) groups. **Intervention(s):** The independent variables included in this analysis were playing standard (AO or AW) and event type while controlling for other factors like city and state. **Main Outcome Measure(s):** Injuries included any incident requiring assessment by the AT or other healthcare providers and were categorized as time loss or non-time loss injuries. An athlete-exposure (AE) was defined as one athlete

participating in a scheduled team practice or game. Injury risk, risk ratio (RR), injury rates (IR) per 1000 AE, injury rate ratios (IRRs), and proportions of injury by body site, diagnosis, and severity are reported with 95% confidence intervals (CI). A RR or IRR with 95% CIs that do not include 1.0 are significantly different ($\alpha = 0.05$). **Results:** There were a total of 4024 player seasons included in the analyses (AO = 1966; AW = 2058). The AO group reported a total of 581 injuries and 63,145 AE (IR = 9.20; 95% CI: 8.45, 9.95). The AW group reported 851 injuries and 76,206 AE (IR = 11.17; 95% CI: 10.42, 11.92). The 2-season risk of being injured was not statistically different between groups (RR = 1.02; 95% CI: 0.90, 1.15) and was 25.5% with both standards combined. This means 1 in 4 players reported at least one time loss or non-time loss injury over the course of the study. However, the overall, game, and practice IRs were statistically higher in the AW group (overall IRR = 1.21; 95% CI: 1.09, 1.35). **Conclusions:** While the risk of injury (proportion of players sustaining at least one injury) between standards was the same, the incidence or rate (IR) per 1000AE was higher in the AW group. This would indicate that more players in the AW group report multiple injuries during a season. Future analyses of the data will include stratification of injury by age within standard, severity, type and time loss.

Free Communications, Oral Presentations: Youth Wellness

Saturday, June 28, 2014, 12:30PM–1:45PM, Room 243; Moderator: Heather Harvey, MA, ATC

14102DOBI

Influence Of Lower Leg Injuries On Landing Kinematics Of Female Adolescent Athletes

Martinez JC, Boling MC, Nguyen A, Trojian TH, DiStefano LJ: University of Connecticut, Storrs, CT; University of North Florida, Jacksonville, FL; High Point University, High Point, NC

Context: High school sport-related injury rates have been estimated to be as high as 2,000,000 injuries per year. Most of these injuries occur to the lower extremity and females have a higher risk of injury compared to males in similar sports. The greatest risk factor for many injuries is a previous injury. Evaluating possible contributing factors, such as altered landing patterns, to explain this elevated injury risk in the female adolescent athlete may optimize injury prevention efforts. **Objective:** To evaluate if female adolescent athletes with a history of a lower leg injury exhibit different landing kinematics compared to individuals with no history of injury. **Design:** Cross-sectional. **Setting:** High School. **Participants:** Fifty-one healthy, high school female athletes (Age = 15.39 ± 1.40 yrs, Mass = 58.63 ± 7.89 kg, Height = 164.45 ± 6.74 cm) volunteered to participate in the study. **Intervention:** Participants completed a single test session, which included a baseline injury history questionnaire and a jump-landing task. Participants completed three trials of the jump-landing task, which required them to jump forward from a 30-cm high box a distance of half their body height, land on both feet with their dominant foot on a force plate, then immediately jump for maximal height. An electromagnetic motion analysis system synchronized with a non-conductive force plate measured three-dimensional kinematics. **Main Outcome Measure(s):** Three-dimensional hip, knee, and trunk kinematics at initial contact (IC)(Ground Reaction Force (GRF) >10 N) and during the deceleration phase (DEC)(IC-peak

knee flexion) were calculated using the average of the three trials. Participants who reported a history of medial shin pain (MSP), a tibial stress fracture (SF), or an ankle sprain (ANK) that required at least one day removed from sport activity were classified as “injured”. Separate independent t-tests were used to compare kinematic variables between the injured groups (MSP, SF, ANK) and those without history of lower extremity injury (UNI) ($\alpha \leq .05$). **Results:** Twenty-five participants reported previous lower leg injuries (ANK: 15, MSP: 10, SF: 6), while twenty-six participants reported no history of lower leg injury. The MSP group exhibited more hip flexion (MSP: $34.54 \pm 9.42^\circ < \text{UNI}$: $25.79^\circ \pm 11.75^\circ$, $P = 0.03$) and less hip abduction (MSP: $0.11^\circ \pm 8.58^\circ < \text{UNI}$: $4.90^\circ \pm 5.84^\circ$, $P = 0.04$) at IC, as well as more hip flexion (MSP: $74.63^\circ \pm 15.79^\circ < \text{UNI}$: $53.05^\circ \pm 21.30^\circ$, $P = 0.004$) during DEC. The SF group exhibited more hip adduction (SF: $2.10^\circ \pm 8.91^\circ < \text{UNI}$: $-4.77^\circ \pm 5.97^\circ$, $P = 0.02$) at IC. No kinematic differences were observed between the ANK and UNI groups ($P > 0.05$). **Conclusions:** Even after returning to full participation after a lower leg injury, female adolescent athletes continue to exhibit altered neuromuscular control such as landing with more hip flexion and hip adduction. These altered movement patterns may be influencing the high rates of re-injury and need to be evaluated during rehabilitation and return-to-play decisions.

Associations Between Physical Characteristics And Landing Biomechanics In Adolescent Females

Tritsch AJ, Shultz SJ, Schmitz RJ, Wideman L, Rulison KL: University of South Florida, Tampa, FL, and University of North Carolina at Greensboro, Greensboro, NC

Context: Females injure their anterior cruciate ligament (ACL) at a rate of four to six times that of similarly trained males. This greater relative risk emerges around age 12, then peaks at age 15 and remains elevated. As females physically mature, they land in greater knee valgus and extension, with increased reliance on knee extensor muscles. The trend towards higher risk landing strategies in adolescent females occurs during a time of steady growth, when strength, body composition, and fitness levels are disparately changing by sex. Landing biomechanics and injury risk both change following exercise, potentially making this a relevant time to screen for high risk biomechanics. **Objective:** To examine the extent that physical measures of strength, body composition, and fitness are related to knee mechanics during a landing task in adolescent females, before and after an exercise challenge. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Participants:** Fifty (12.7 ± 1.4 yrs, 160.7 ± 7.8 cm, 52.3 ± 10.2 kg) healthy, active, adolescent females aged 11 – 15. **Intervention(s):** Physical characteristics were assessed prior to exercise, while biomechanical data were assessed during 45cm drop jump landings performed before and after an exhaustive 20m shuttle run test. Left limb kinetic (1000 Hz) and kinematic (240 Hz) data were averaged over 3 trials at each time-point. **Main Outcome Measure(s):** Participants completed a Tanner self-assessment of maturation. Body composition (% BF) was assessed via skinfold; strength via standing broad jump (SBJ(cm)); and fitness via

20m shuttle run and other physical variables inputted into an Artificial Neural Network equation (VO₂max). Separate, multiple linear regressions tested the relationships between physical characteristics and knee valgus (initial, peak, excursion), tibial rotation (initial, peak, excursion), and relative energy absorption at the knee prior to and following the shuttle run. In each model, maturation stage was entered first, followed by simultaneous entry of physical characteristics (% BF, SBJ (cm), VO₂ max).

Results: Higher Tanner stage predicted less initial knee valgus following exercise ($R^2 = 0.082$, $p = 0.04$), while greater SBJ distance predicted greater peak internal tibial rotation both before ($\beta = 0.18$, $p = 0.01$) and after exercise ($\beta = 0.17$, $p = 0.03$). There were no associations between physical characteristics and relative energy absorption. Exercise had little to no effect on these associations. **Conclusions:** Weak relationships were observed between both maturation and strength with landing mechanics before and after exercise. Based on the fact that the field measures of strength, body composition, and fitness never accounted for greater than 19% of variance in any of the dependent variables, the landing mechanics that change during adolescence cannot solely be attributed to changes in these physical characteristics. Future longitudinal studies are needed to track physical characteristics in conjunction with biomechanics and injuries over time. These data could determine the maturation factors that promote the higher risk biomechanics and knee injury risk in adolescent females. **Acknowledgements:** Supported by the NATA Research & Education Foundation - Doctoral Research Grant

Pediatric Ankle Range Of Motion: What Is Considered "Normal"?

Boucher LC, Onate JA, Bolte JH:
Ohio State University, Columbus, OH

Context: As the scope of care for Athletic Trainers continues to expand into younger populations it is important to appreciate anatomical and biomechanical differences of this population. The pediatric patient should not be treated as a small adult however the uniqueness of this group is not well understood. **Objective:** To evaluate ankle range of motion (ROM) of 4 – 7 year old children and begin to establish normal values for this population for use in prevention, diagnosis, treatment and rehabilitation. **Design:** Cross-sectional design.

Setting: Biomechanics Laboratory.

Patients or Other Participants:

Twenty-one healthy children between the ages of 4 – 7 years old (age 5.7 ± 1.1 yrs, mass = 21.9 ± 4.5 kg, 9M, 12F) volunteered with informed consent from the parent/ guardian.

Intervention(s): ROM was measured bilaterally with a hand held goniometer by an Athletic Trainer with over ten years of clinical and teaching experience. ROM was measured in active plantar flexion (APF), passive plantar flexion (PPF), active dorsiflexion (ADF), and passive dorsiflexion (PDF) with both an extended (ext) and flexed (flex) knee. ROM was also measured in active inversion (AINV) and passive inversion (PINV), active eversion (AEV) and passive eversion (PEV), as well as in rearfoot INV (RINV) and EV (REV). **Main**

Outcome Measure(s): The means and standard deviations were calculated for both the right and left ankle for each motion. Separate ANOVAs were used to evaluate PF, DF, INV, EV for the effect of sex (female, male), side (right, left), and type (active, passive, extended knee, flexed knee). The level of

significance was set a priori at $p < 0.05$.

Results: Average ROM values include APF(ext) = $68.4^\circ \pm 6.9^\circ$, PPF(ext) = $73.4^\circ \pm 6.7^\circ$, APF(flex) = $71.9^\circ \pm 6.8^\circ$, PPF(flex) = $76.5^\circ \pm 6.7^\circ$, ADF(ext) = $12.1^\circ \pm 6.3^\circ$, PDF (ext) = $18.2^\circ \pm 6.9^\circ$, ADF (flex) = $20.5^\circ \pm 6.1^\circ$, PDF (flex) = $27.2^\circ \pm 6.6^\circ$, AINV = $36.5^\circ \pm 7.8^\circ$, PINV = $44.8^\circ \pm 9.3^\circ$, AEV = $15.9^\circ \pm 6.0^\circ$, PEV = $21.9^\circ \pm 6.7^\circ$, RINV = $13.3^\circ \pm 4.9^\circ$, REV = $6.5^\circ \pm 3.0^\circ$. Significant interactions were found in PF ($F = 8.53$, 5,162, $p < .001$). Pairwise comparisons show APF (ext) was less than APF (flex) ($p = .016$). PPF (flex) was also greater than APF (flex) ($p = .002$). Interestingly, PPF (ext) was not significantly different than APF (flex) ($p = .258$). DF also had significant interactions ($F = 38.955$, 162, $p < .001$). Pairwise comparisons reveal females had greater DF than males ($p = .009$). ADF (ext) ($p < .001$) and PDF (ext) ($p < .001$) were significantly less than ADF (flex). PDF (flex) had significantly greater motion ($p < .001$) when compared to ADF (flex). INV and EV had significant interactions ($F = 6.513$, 80, $p < 0.001$; $F = 6.103$, 80, $p = .001$). PINV and PEV were greater than AINV and AEV ($p < .001$; $p < .001$). No right-to-left side differences were observed in any motion. **Conclusions:** Sex differences were present in ankle PF and DF, with females exhibiting greater motion than their male counterparts. PROM was also greater than AROM all directions. Establishing more comprehensive clinical ROM norms is an important step in understanding anthropometric differences between skeletally mature and immature patients, which may aid in diagnosis, rehabilitation, treatment, and return to activity decisions.

Single-Item Patient-Rated Outcome Measures Improve During Recovery In Adolescent Athletes Following Musculoskeletal Injury: A Report From The Athletic Training Practice-Based Research Network

Snyder Valier AR, Bay RC, Welch CE, Sauers EL, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Single-item patient-rated outcome measures (SI-PROMs), including the numeric pain rating scale (NPRS) and global ratings of function (GROF), disability (GROD) and change (GROC), are efficient ways to evaluate changes in health status from the patient perspective during recovery. Studies measuring changes in health status in adolescent athletes suffering from musculoskeletal injuries using SI-PROMs are limited. **Objective:** To determine patient-perceived recovery of pain, function, disability and change over time following musculoskeletal injury in adolescent athletes using SI-PROMs and to examine floor and ceiling effects of these measures in this unique patient population. **Design:** Repeated Measures. **Setting:** Secondary school athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** 90 athletes (n = 40 males, n = 50 females; age = 17.8 ± 2.3; height = 169.9 ± 9.4; mass = 66.6 ± 13.4) participating in interscholastic athletics who suffered a musculoskeletal injury documented by an athletic trainer within the AT-PBRN were included. **Intervention(s):** Patients completed the NPRS (range = 0 – 10; 0 = no pain, 10 = extreme pain), GROF (range = 0 – 100%; 0% = no use, 100% = full use), GROD (7-point Likert; 1 = no difficulty, 7 = cannot perform daily activities), and GROC (15 point Likert scale; 1 = a very great deal worse; 15 = a very great deal better) at athletic training

visits during weeks 1 (W1: mean = 2 ± 1.3 days), 2 (W2: mean = 11.4 ± 1.6 days), and 3 (W3: mean = 21.4 ± 1.6 days) post-injury. **Main Outcome Measure(s):** Dependent variables included scores on the NPRS, GROF, GROD, and GROC at three post-injury visits. Repeated measures analyses of variance were used to examine trends in patient response across the three visits, with pairwise differences assessed using Bonferroni-correction ($P < .05$). Frequency tables were examined for ceiling and floor effects, which were observed when a substantial percentage of respondents reported the best or worst score, respectively. Means and standard deviations are reported for all variables. **Results:** NPRS scores significantly improved ($P < .001$) across the three visits (W1: 4.6 ± 1.9; W2: 3.0 ± 1.8; and W3: 2.1 ± 1.9). Similarly, GROF scores improved ($P < .001$) across the three visits (W1: 59.8 ± 23.1; W2: 75.2 ± 16.2; and W3: 81.1 ± 15.4). Scores for the GROD improved across the three visits (W1: 3.0 ± 1.3; W2: 2.0 ± 1.0; and W3: 1.8 ± 1.0), with W1-W2, $P < .001$ and W2-W3, $P = .029$. Ratings of perceived change (GROC) improved ($P < .001$) between W1 (9.7 ± 1.9) and W2 (11.2 ± 2.4) but not ($P = .517$) between W2 and W3 (11.5 ± 2.6). Ceiling effects were noted for GROD at all three visits (W1: 19.3%; W2: 38.6%; W3: 39.7%), with no ceiling or floor effects observed for the other SI-PROMs. **Conclusions:** Our results suggest that, as adolescent athlete patients recover from musculoskeletal injury, SI-PROMs are able to efficiently identify measureable, linear improvements in pain, function, disability, and overall health status. Ratings of disability using SI-PROMs may be less useful for adolescent athlete patients due to the ceiling effects noted. Clinically, SI-PROMs should be considered to obtain rapid assessments of patient health status. Funded by the National Athletic Trainers' Association Research and Education Foundation.

The Influence Of Age And Sex On Jump-Landing Patterns: A Clinical Evaluation

King CE, Kulow SM, Valovich McLeod TC, Lam KC: A.T. Still University, Mesa, AZ

Context: The evaluation of movement patterns is an essential component of injury prevention. The Landing Error Scoring System (LESS) is a screening tool used to identify individuals who may be at-risk for lower extremity injuries. Previous investigations using the LESS have identified sex differences in jump-landing patterns but little is known if age group differences exist. **Objective:** To identify age and sex differences in jump-landing patterns in high school (HS) and college (COL) athletes using the LESS. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of 100 HS (female = 56, male = 44; age = 15.5 ± 1.3 years, height = 173.6 ± 12.0 cm, mass = 66.3 ± 13.4 kg) and 95 COL (female = 61, male = 34; age = 19.2 ± 1.4 years, height = 173 ± 3 kg, mass = 68.1 ± 10.0 kg) athletes participating in basketball, soccer, or volleyball without restrictions. **Intervention(s):** Independent variables included age group (HS, COL) and sex. Participants were videotaped performing three trials of a standardized jump-landing task. Videos were later scored using the LESS, a 17-item scoring system that counts the number of errors committed at initial ground contact (IGC) and maximum knee flexion (MKF). The mean of all trial scores represents an overall score (OS), with higher scores indicating poorer jump-landing patterns. Errors for each scoring item were summed across trials for an item score. **Main Outcome Measure(s):** Dependent variables were the OS and 17 item scores. A two-way analysis of variance with two factors (age group, sex) was used to identify interaction and main effects. Post-hoc analyses were conducted

using Tukey HSD. **Results:** Female HS athletes demonstrated higher OS ($p = .035$; HS-female: 7.13 ± 2.04 , HS-male: 4.95 ± 2.10 ; COL-female: 6.31 ± 2.28 , COL-male: 5.56 ± 2.81) and more errors for limited trunk flexion ($p = .006$; HS-female: 1.63 ± 1.37 , HS-male: 0.86 ± 1.25 ; COL-female: 0.67 ± 1.12 ; COL-male: 0.94 ± 1.32), while male HS athletes demonstrated more errors for lateral trunk flexion ($p = .004$; HS-female: 0.00 ± 0.00 , HS-male: 0.16 ± 0.48 ; COL-female: 0.13 ± 0.34 , COL-male: 0.03 ± 0.17). Male COL athletes displayed more errors for landing heel-to-toe ($p = .008$; HS-female: 0.18 ± 0.69 , HS-male: 0.16 ± 0.53 ; COL-female: 0.48 ± 0.89 , COL-male: 1.12 ± 1.25) and limited knee flexion at IGC ($p = .004$; HS-female: 0.13 ± 0.47 , HS-male: 0.02 ± 0.15 ; COL-female: 0.07 ± 0.31 , COL-male: 0.32 ± 0.68). HS athletes demonstrated more errors for knee valgus at IGC ($p = .047$; HS: 1.40 ± 1.33 , COL: 1.06 ± 1.05), knee valgus at MKF ($p < .001$; HS: 1.99 ± 1.10 , COL: 1.41 ± 1.13), and narrow landing stance ($p < .001$; HS: 2.76 ± 1.01 , COL: 2.12 ± 1.04). COL athletes committed more errors landing with foot asymmetry ($p = .003$; HS: 0.31 ± 0.88 , COL: 0.71 ± 0.91), toes out ($p = .003$; HS: 0.45 ± 1.09 , COL: 0.92 ± 1.12), and limited hip flexion ($p < .001$; HS: 0.20 ± 1.01 , COL: 0.96 ± 1.04). Females committed more errors for knee valgus at IGC ($p < .001$; female: 1.80 ± 1.17 , male: 0.66 ± 1.17), knee valgus at MKF ($p < .001$; female: 2.33 ± 1.09 , male: 1.06 ± 1.10), and limited knee flexion at MKF ($p = .024$; female: 1.58 ± 1.27 , male: 1.15 ± 1.28). **Conclusions:** Jump-landing patterns appear to be impacted by both age and sex. High school athletes generally demonstrated poorer jump-landing patterns, and findings related to sex differences corroborate previous studies. Our results suggest that injury prevention programs should be implemented before college and targeted for female athletes. Future studies should determine

the clinical meaningfulness of these movement pattern differences and their impact on injury prevention strategies.

Low Level Laser Therapy: Translating Evidence Based Science into Clinical Practice

Thursday, June 26, 2014, 8:00AM-9:00AM, Room 244; Discussants: Douglas Johnson, ATC, EES, CLS; Timothy Demchak, PhD, ATC; Moderator: Paul Borsa, PhD, ATC

Free Communications, Oral Presentations: Emerging Interventions for Thermal and Iontophoresis Treatment

Thursday, June 26, 2014, 9:30AM-10:30AM, Room 244; Moderator: Jody Brucker, PhD, ATC
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Collegiate Athletic Trainers' Perceived And Actual Knowledge Of Therapeutic Ultrasound Concepts

Schellhase KC, Plant J, Rothschild C: University of Central Florida, Orlando, FL

Context: Therapeutic ultrasound is a widely used therapeutic modality; however, little is known about the knowledge level of athletic trainers. As the athletic training profession increases emphasis on evidence-based practice, it will be important for athletic trainers to understand therapeutic ultrasound concepts and for preceptors to teach students evidence-based therapeutic ultrasound. **Objective:** The purpose of the study was to examine athletic trainers' perceived and actual knowledge of therapeutic ultrasound concepts. Sub-objectives were to understand how perceived and actual knowledge differs between practice setting, age, and number of therapeutic modalities courses taken. **Design:** Cross sectional survey. **Setting:** Participants completed a web-based survey. **Patients or Other Participants:** Responses from 111 (11.3%) randomly selected athletic trainers (age = 35.55 ± 8.86 years) employed in collegiate settings (clinical/academic/split appointment) were analyzed. **Intervention:** The questionnaire included: Likert scale questions regarding perceived knowledge of the educational competencies related to therapeutic ultrasound; textbook validated knowledge questions; frequency of use questions; and demographic questions. **Main Outcome Measure(s):** Demographic information, perceived and actual knowledge scores were obtained. A Pearson correlation coefficient was calculated between participants' perceived and actual knowledge scores. Three one-way MANOVAs were conducted to determine if there was a difference in perceived or actual knowledge scores that was dependent upon

participants' setting, age, or number of therapeutic modalities courses taken.

Results: Athletic trainers in collegiate settings reported fairly high confidence in their knowledge of therapeutic ultrasound concepts ($= 3.31 \pm 0.52$ out of 4); however, only a weak/moderate correlation ($r(109) = .274$, $P < .001$) was found between perceived and actual knowledge. MANOVAs revealed significant main effects for setting ($\Lambda = .857$, $F_{4,214} = 4.285$, $P = .002$, $\eta^2 = .074$), age ($\Lambda = .771$, $F_{6,210} = 4.868$, $P \leq .001$, $\eta^2 = .122$) and number of courses taken ($\Lambda = .790$, $F_{8,208} = 3.260$, $P = .002$, $\eta^2 = .111$). Follow-up ANOVAs revealed significant main effects for actual knowledge based on setting ($F_{2,59} = 7.606$, $P < .001$, $\eta^2 = .123$); perceived and actual knowledge based on age ($F_{3,73} = 3.581$, $P = .016$, $\eta^2 = .092$; $F_{3,59} = 8.074$, $P < .001$, $\eta^2 = .186$); and perceived and actual knowledge based on number of courses taken ($F_{4,72} = 3.569$, $P = .009$, $\eta^2 = .120$; $F_{4,35} = 4.523$, $P = .002$, $\eta^2 = .147$). College/academic participants demonstrated higher actual knowledge scores than college/clinical ($= 74\%$ vs. $= 65\%$) participants. Perceived knowledge was highest in the 40 – 49 year old group and lowest in the 20 – 29 year old group. Actual knowledge was highest in the 40 – 49 year old group ($= 81\%$) and lowest in the 50 – 59 year old group ($= 64\%$). Athletic trainers in all collegiate settings demonstrated higher perceived and actual knowledge if they completed additional therapeutic modalities courses (up to three). **Conclusions:** Collegiate athletic trainers do not have an accurate perception of their actual knowledge of therapeutic ultrasound concepts. Actual knowledge of therapeutic ultrasound concepts was generally poor, highly variable, and erred toward using inadequate intensities. Those who worked in the college/academic setting, were in the 40 – 49 year old group, and had taken three courses, tended to have higher actual knowledge scores.

Pulsed Short Wave Diathermy And Moist Heat Packs On Passive Ankle Plantarflexor Mechanical Properties

Akehi K, Long BC, Cody AD, Goad CL: Oklahoma State University, Stillwater, OK; Central Michigan University, Mt Pleasant, MI; Lamar University, Beaumont, TX

Context: Thermotherapy is often used prior to rehabilitation. Its influence on passive biomechanical properties is not conclusive. **Objective:** The purpose of the study was to determine if a pulsed short-wave diathermy (PSWD) or moist heat pack application to the plantarflexor muscles influenced tissue mechanical properties. **Design:** Randomized controlled study. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Thirty-two college-aged participants (male: $n = 17$, age = 19.79 ± 1.15 yrs, ht = 177.36 ± 4.58 cm, mass = 92.76 ± 20.71 kg; female $n = 15$, age = 20.35 ± 1.37 yrs, ht = 165.58 ± 9.08 cm, mass = 73.98 ± 17.76 kg) volunteered to participate. Each subject completed a health history questionnaire to ensure they met an inclusion criteria. **Intervention(s):** A $2 \times 3 \times 3 \times 4$ cross-over measure was conducted. Independent variables were sex (male and female), treatment (moist heat pack, PSWD, and nothing), day (1st, 2nd, and 3rd) and time (pre-treatment, immediate post, 10, and 20 minutes post-treatment). Subjects were randomly assigned to a treatment order after signing the IRB approved informed consent document. On the first day, we obtained subject demographic information and took each subject through a familiarization session. For testing, subjects warmed up on a stationary cycle ergometer for 5 minutes. Subjects were then positioned on an isokinetic dynamometer for passive ankle dorsiflexion ROM, plantarflexor torque, and surface electromyography. These measures were taken twice at $5^\circ/\text{s}$, starting at 20° of plantarflexion.

A treatment was then administered for 20 minutes. For the control day, subjects rested on the dynamometer chair where measures were taken at the same time intervals as the heat treatments. Post-treatment measures were taken immediately and at 10 and 20 minutes after each treatment. We also measured surface temperature during data collection. **Main Outcome Measure(s):** We assessed maximum passive ankle dorsiflexion ROM, maximum passive plantarflexor torque, and passive musculotendinous stiffness (MTS) at 4 common joint angles (1 – 4). **Results:** Both heat modalities increased passive ankle dorsiflexion ROM in males immediately following the treatment (males, moist heat; Pre: 33.04 ± 8.69 ; Post: 35.29 ± 10.11 ; PSWD; Pre: 31.64 ± 9.29 ; Post: 34.33 ± 9.55 ; $P = .002$) but not females (moist heat; Pre: 28.33 ± 7.48 ; Post: 29.38 ± 9.08 ; PSWD; Pre: 29.15 ± 10.08 ; Post: 30.96 ± 10.96 ; $P > .05$). PSWD decreased passive MTS at three of the four joint angles for male (Tukey-Kramer, $P < .05$) but not in females (Tukey-Kramer, $P > .05$). Passive MTS for the control group increased during the post-treatment measures in both sexes (Tukey-Kramer, $P < .05$). Regardless of the treatment, males had higher maximum passive ROM, maximum torque, and MTS (Tukey-Kramer, $P < .05$, respectfully). Both heat modalities increased skin surface temperature immediately following the application (Tukey-Kramer, $P < .01$). **Conclusions:** A 20-minute superficial and deep heating modality applications influenced lower leg tissue mechanical properties but responses to these treatments were sex specific.

The Time Course Of Dexamethasone Sodium Phosphate Delivered Via Iontophoresis Through Human Skin

Rigby JH, Mack GW, Johnson AW, Myrer JW, Bylund RS, Draper DO: Brigham Young University, Provo, UT

Context: The efficacy of iontophoresis at delivering dexamethasone sodium phosphate (DEX-P) through the skin is unknown in humans because of the lack of minimally invasive measurement techniques. **Objective:** To determine the time course of DEX-P iontophoresis delivery to underlying tissues 1 and 4mm beneath the skin using microdialysis. **Design:** Controlled laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Fifty-six healthy male participants (age = 24.4 ± 3.3 yrs, height = 71.8 ± 2.5 in, weight = 181.8 ± 26.1 lbs) **Intervention(s):** Participants were randomly assigned into one of five groups: (1) 1 mA current, probes depth of 1 mm; (2) 1 mA current, probes depth of 4 mm; (3) 2 mA current, probes depth of 1 mm; (4) 2 mA current, probes depth of 4 mm and (5) skin perfusion. Treatment groups. Groups 1 – 4 received 120 mAmin iontophoresis of 4 mg/ml DEX-P. Three hollow fiber (18 KD MWCO) microdialysis probes perfused at 1.2 μ L/min with saline were used to assess DEX-P, dexamethasone (DEX) and its metabolite (DEX-MET) in dialysate from probes placed at the desired depth below the calf's skin surface. Dialysate was collected at 15 minute intervals throughout the treatment. Skin perfusion group. Participants were randomly assigned to receive 120 mAmin iontophoresis of 4 mg/mL DEX-P using either 1 or 2 mA current intensities. Skin perfusion was measured using laser Doppler flowmetry placed within the drug chamber. **Main Outcome Measure(s):** From the

collected dialysate, DEX-TOTAL was calculated as the sum of the three analytes and the in vivo concentration was calculated using high performance liquid chromatography (HPLC) standard curves. A 4 x 5 (group x dose) repeated measures ANOVA was used to determine significant differences between treatment groups. Skin perfusion was calculated as a percentage of baseline. A 2 x 13 (intensity x dose) repeated measures ANOVA was used to determine significant differences between current intensities. **Results:** There was no difference of DEX-TOTAL between current intensities ($P = 0.99$) but a greater amount of DEX-TOTAL was recovered at 1 mm ($F_{12,112} = 5.21$, $P < .001$). Peak means for the 1 and 2 mA at 1 mm were 10.8 ± 8.1 and 7.7 ± 5.5 μ g/ml and at 4mm being 2.0 ± 0.8 and 1.3 ± 0.9 μ g/ml, respectively. Skin perfusion rapidly increased during both iontophoresis intensities, however, perfusion significantly decreased 80 minutes before the conclusion of the 1 mA treatment ($F_{12,264} = 23.17$, $P < .001$). Peak skin perfusion was $741.4 \pm 408.7\%$ and $711.6 \pm 260.8\%$ baseline for 1 and 2 mA intensities, respectively. **Conclusions:** Significant concentrations of DEX-TOTAL were found in vivo through human skin regardless of current intensity. Though current induced vasodilation occurred, it did not significantly affect the tissue accumulation of DEX-TOTAL.

Clinical Applications Of Therapeutic Modalities Among Collegiate Athletic Trainers And Sports Physical Therapists

Hawkins JR, Hawkins SW: Illinois State University, Normal, IL; Colorado Mesa University, Grand Junction, CO; Uintah Basin Medical Center, Roosevelt, UT

Context: Therapeutic modalities are widely used by athletic trainers (ATs) and physical therapists (PTs), but their use may not be guided by current therapeutic modality (TM) research. **Objective:** To determine via two descriptive surveys whether the clinical application of cryotherapy and thermotherapy among collegiate ATs and Sports PTs reflects current TM research. **Design:** Cross-sectional survey. **Setting:** Web-based. **Patients or Other Participants:** The NATA Research Survey Service selected two samples (one for each survey) of 2,500 collegiate ATs (response rate = 13.6%/341 and 16.1%/402 for the cryotherapy and thermotherapy surveys respectively). All districts and divisions of NCAA athletics were represented. All members (7283) of the Sports Physical Therapy Section of the APTA were recruited (response rate = 6.9%/503 and 6.8%/496 for the cryotherapy and thermotherapy surveys respectively). North Dakota was the only state that did not have at least one response for either survey. **Intervention(s):** Two surveys using scenarios to present injury conditions were developed based on current TM research. Cryotherapy scenarios focused on acute and sub-acute injury management. Thermotherapy scenarios focused on pre-participation management of acute, sub-acute, and chronic injuries. Respondents were asked to select a treatment approach based upon options provided (eg, RICES, cryokinetics, and Game Ready or hydrocollator packs, whirlpool, and ultrasound). Follow-up questions were also asked. The survey

was pre-tested by five ATs and five PTs who provided input concerning the scenarios, the treatment options, and the specifics of each treatment. This pre-test provided content validity. Reliability was determined via internal consistency between similar questions. A Select Survey link was distributed via email to participants. The survey was available for two weeks with a follow-up email sent after one week. **Main Outcome Measure(s):** Answers to the scenario based questions. **Results:** Reliability: Cronbach's alpha = > 0.9. Agreement between treatment approaches and current TM research was more common with thermotherapy than cryotherapy. Both ATs and PTs selected a hydrocollator pack to treat low back spasms (ATs: 221/73%, PTs: 188/61%), active exercise for a 1 week old quadriceps strain (ATs:133/44%, PTs:214/61%), and no heat for an acute stinger (ATs: 199/67%, PTs: 196/57%). ATs and PTs managed tendinitis differently, ATs selected ultrasound (157/50%) and PTs selected active exercise (240/65%). All modalities selected were applied according to current TM research. ATs and PTs treated an acute AC sprain with an ice pack (ATs:160/60%, PTs:194/62%), but differed in treatment time (ATs:16-20min, PTs:11-15min) and the use of a barrier (ATs:No, PTs:Yes). Different approaches were chosen for the acute and sub-acute management of a grade II lateral ankle sprain. **Conclusions:** ATs and PTs applied thermotherapy according to current TM research. Cryotherapy was applied with greater variability, with applications seemingly guided more by preference/experience than research. Continuing education, application of current research, and additional outcomes based research needs to remain a focus.

Free Communications, Oral Presentations: Current Perspective of Cryotherapy

Thursday, June 26, 2014, 10:45AM-12:00PM, Room 244; Moderator: Cynthia Trowbridge, PhD, ATC, LAT

14234FOTH

Comparing Surface, Subcutaneous And Intramuscular Temperature Effects Of Gebauer Painease® And Ethyl Chloride Topical Vapocoolant Products In Human Subjects

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Context: Vapocoolant Sprays rapidly cool the skin, providing brief local anesthesia for injections and intravenous cannulation as well as management of minor sports injuries and spray & stretch. Ethyl chloride (EC) is a topical vapocoolant whose flammability limits potential clinical usage. PainEase® (PE) vapocoolant spray has been offered as an alternative with similar cooling properties. **Objective:** To compare the temperature effects of EC and PE vapocoolant products in normal humans during typical application. **Design:** Crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** 20 healthy college-age subjects without a history of cold sensitivity, prior forearm injury or any other exclusionary criteria consented to participate in this study. **Intervention(s):** Eight testing conditions for each vapocoolant product from three independent variables; nozzle (mist & stream), distance (near & far), and duration (short & long) determined using a 2 x 2 x 2 factorial. Treatment order was determined using a balanced Latin square. **Main Outcome Measure(s):** Temperature measurements made using type-T thermocouples at three tissue depths (skin-thermocouple interface, SubQ and 1cm IM). In the first arm of the study PE was applied to the forearm of each subject according to the parameters of each of the eight testing conditions. In the second arm of the study, EC was applied in the same manner. Thermocouples were interfaced to a computer and temperatures were recorded at 1 second intervals for 500 seconds. Dependent measure was

lowest temperature recorded. Data were analyzed using a repeated measures MANOVA with $\alpha = 0.05$. **Results:** Across conditions, skin-interface temperatures declined well below freezing for both PE ($-11.4 \pm 0.36^{\circ}\text{C}$) and EC ($-8.9 \pm 0.55^{\circ}\text{C}$), and rewarmed within 4-5 minutes. SubQ temperature change was small (PE $27.9 \pm 0.35^{\circ}\text{C}$, EC $30.7 \pm 0.47^{\circ}\text{C}$). Almost no temperature change was recorded IM (PE $33.1 \pm 0.24^{\circ}\text{C}$, EC $32.3 \pm 0.29^{\circ}\text{C}$). Main effects occurred between the two products for skin-interface temperature ($p = 0.001$) and SubQ temperature ($p < 0.001$); no difference for IM temperature. An interaction effect was observed for vapocoolant product (PE) by nozzle (mist) by distance (close) by duration (long) ($p = 0.044$) at the skin-thermocouple interface. **Conclusion:** We conclude that both PE and EC products produce cooling effects in superficial human tissue. Human tissue can be cooled to below freezing without causing injury. PE produces lower temperatures at skin-interface and SubQ depths than EC, but actual differences may be too small to be clinically relevant. PE with the mist nozzle from close distance for long duration produces the coldest temperatures at the skin-thermocouple interface.

14159DOTH

Effects Of Focal Ankle Joint Cooling On Sural Nerve Conduction In Healthy And Sprained Ankle Joints

Pritchard KA, Hart JM, Park J, Hertel J, Saliba S: University of Virginia, Charlottesville, VA, and Shenandoah University, Winchester, VA

Context: Cryotherapy is part of the standard of care for musculoskeletal injuries, but the physiological effects of cryotherapy are not well understood. Current research often examines healthy non-painful participants, so results cannot be generalized to an injured population. **Objective:** To compare the effects of focal ankle joint cooling on sural nerve conduction in healthy and subacute lateral ankle sprain participants. We hypothesized that ankle sprain patients would have worse sural nerve transmission compared to healthy participants and that joint cooling would result in similar conduction between groups. **Design:** Controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 33 participants (22 healthy controls: 8M, 14F; age = 20.6 ± 2.5 years; height = 168.0 ± 12.0 cm; mass = 77.7 ± 13.3 kg; FAAM-ADL = $99.1 \pm 2.7\%$; 11 subacute lateral ankle sprains: 7M, 4F; age = 21.0 ± 1.8 years; height = 177.8 ± 8.6 cm; mass = 86.5 ± 10.2 kg; FAAM-ADL = $62.1 \pm 22.6\%$; days since injury = 10.4 ± 2.7) participated. Ankle sprain participants reported a minimum pain rating of 30mm on a 100mm visual analog scale to qualify. **Intervention(s):** Independent variables were group (healthy, injured) and time (baseline, post-cryotherapy). Focal ankle joint cooling using 2-0.5 L crushed ice bags with compression for 15 minutes was applied to all participants. **Main Outcome Measure(s):** Sensory nerve action potential measures of the sural nerve (onset latency, peak latency, amplitude, and nerve conduction velocity) and self-reported pain at baseline

and post-intervention were assessed. Sural nerve data were non-normally distributed, so Mann-Whitney U and Wilcoxon signed ranks tests were used to assess for differences, and results are presented as median (interquartile range [IQR]). A 2 x 2 (group x time) ANOVA was used to assess for changes in pain. Descriptive statistics are presented as mean \pm SD. **Results:** There were no significant group differences in onset latency or peak latency. At baseline, the injured group had significantly worse amplitude than the healthy group (injured: 17.7 μ V [11.3, 21.0], healthy: 22.7 μ V [18.0, 27.3], $P = .031$); but after joint cooling, there were no differences between groups (injured: 24.3 μ V [17.2, 37.6], healthy: 31.3 μ V [23.0, 39.7], $P = .204$). Similarly, the injured group had significantly worse conduction velocity at baseline (injured: 41.7m/s [36.6, 46.7], healthy: 46.5m/s [44.6, 48.3], $P = .026$), but after joint cooling, there were no differences between groups (injured: 27.0m/s [22.7, 34.2], healthy: 28.3m/s [25.6, 30.6], $P = .694$). Within the injured group, focal joint cooling significantly increased amplitude ($P = .024$) and decreased conduction velocity ($P < .001$). The injured group had significantly greater pain at baseline (injured: 5.4 \pm 2.1, healthy: 0.04 \pm 0.13, $P < .001$) which was significantly decreased by joint cooling (injured: 3.8 \pm 2.8, healthy: 0.03 \pm 0.16, $P = .001$). **Conclusions:** Patients who were experiencing mild pain due to lateral ankle sprains had lower amplitude and slower conduction velocity at baseline compared to healthy participants, potentially signifying sural nerve dysfunction. Focal ankle joint cooling altered these portions of sensory nerve action potential measurements, but did not cause any differences between groups. Applying focal cooling to an injured joint may cause sensory nerve function surrounding that joint to appear normal.

Focal Joint Cooling Improves Clinical Impairments In Patients With Ankle Sprains

Bottinick A, Pritchard KA, Hertel J, Saliba S: University of Virginia, Charlottesville, VA

Context: Cryotherapy is a common intervention after musculoskeletal injuries, yet the majority of research investigates the effect of cold on healthy joints. Understanding the effects of focal joint cooling on acute injuries may help clinicians prescribe more effective rehabilitation programs. **Objective:** To examine the effects of a single focal joint cooling treatment on pain, joint effusion, range of motion (ROM), isometric strength, and dynamic balance in individuals with subacute lateral ankle sprains. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** 10 patients with lateral ankle sprains in the previous 5 to 14 days volunteered to participate (5 males, 5 females; age = 20.6 \pm 2.2 years; height = 172.5 \pm 11.5cm; mass = 69.9 \pm 14.1kg; FAAM-ADL = 68.4 \pm 8.7%; FAAM-Sport = 45.3 \pm 27.2%). **Intervention(s):** All measurements were completed on the injured and contralateral limb in a random order at baseline and repeated prior to ice application to determine any effect of repeated measurements. The focal joint cooling intervention consisted of two 0.5L crushed ice bags applied with an elastic wrap for 15 minutes to the ankle joint. Measurements were taken again post-cryotherapy. **Main Outcome Measure(s):** Dependent variables included pain measured on a Visual Analog Scale during the Star Excursion Balance Test (SEBT), figure-8 joint circumference, active ROM (dorsiflexion, plantarflexion, inversion, eversion), isometric strength (dorsiflexion, plantar flexion, inversion, eversion), and normalized dynamic balance reach distance on the SEBT (anterior, posteromedial, and

posterolateral directions). Separate dependent t-tests were used to examine differences in the injured and contralateral limbs at baseline and then pre- to post-cryotherapy on the injured limb only. **Results:** There were no significant differences in any measures between baseline and prior to ice application, so the average value was used in statistical analysis. Comparing the injured to contralateral limb, before focal joint cooling, the injured ankles had significantly greater pain (34.1 \pm 8.0mm vs. 0.0 \pm 0.0mm, $P < .001$) and joint circumference (51.9 \pm 3.3cm vs. 51.0 \pm 3.2cm, $P = .02$), less ROM (dorsiflexion: 15.3 \pm 6.8° vs. 26.2 \pm 11.0°, $P < .001$; eversion: 4.8 \pm 1.8° vs. 6.2 \pm 2.2°, $P = .003$), isometric strength (dorsiflexion: 145.9 \pm 17.6N vs. 191.9 \pm 26.0N, $P = .001$; plantarflexion: 182.1 \pm 22.8N vs. 228.2 \pm 42.0N, $P = .001$; inversion: 116.1 \pm 31.3N vs. 147.9 \pm 21.1N, $P = .02$; eversion: 108.3 \pm 24.6N vs. 143.2 \pm 29.0N, $P = .001$), and dynamic balance (anterior: 0.62 \pm 0.1 vs. 0.69 \pm 0.1, $P = .003$; posteromedial: 0.66 \pm 0.1 vs. 0.81 \pm .1, $P = .001$) than the contralateral ankle. After ice, there was improved dorsiflexion ROM (presented as baseline vs. post-cryotherapy) 15.3 \pm 6.8° vs. 18.7 \pm 5.9°, $P = .01$; isometric strength (dorsiflexion: 145.9 \pm 17.6N vs. 156.7 \pm 21.9N, $P = .05$; plantarflexion: 182.1 \pm 22.8N vs. 201.2 \pm 43.5N, $P = .05$; eversion: 108.3 \pm 24.6N vs. 119.3 \pm 24.4N, $P = .02$), and dynamic balance (posterolateral: 0.73 \pm 0.1 vs. 0.77 \pm 0.1, $P = .01$; posteromedial: 0.66 \pm 0.1 vs. 0.77 \pm .1, $P = .001$) but cold did not significantly affect pain nor joint effusion. **Conclusions:** Patients with acute ankle sprains show deficits in various clinical impairments, and a 15-minute focal joint cooling intervention was able to immediately improve some of those deficits. Taking advantage of these improvements during rehabilitation might allow patients to better perform therapeutic exercises, which may impact recovery.

Effects Of Focal Joint Cooling On Sensory Nerve Action Potentials In Patients With Chronic Ankle Instability

Kosik KB, Pritchard KA, Hertel J, Saliba S: University of Virginia, Charlottesville, VA

Context: Repetitive damage to the lateral ankle may alter afferent nerve transmission and may contribute to the paradigm of joint dysfunction. Cryotherapy influences sensory nerve transmission in acute injuries, but the effect of ice has not been evaluated in patients with chronic ankle instability (CAI). **Objective:** To determine if sensory nerve action potential (SNAP) measurements differ between healthy and CAI participants before and after joint cooling. **Design:** Controlled laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** 11 patients with self-reported CAI (age = 23 ± 4.47 years, height = 174.78 ± 11.35 cm, mass = 79.18 ± 17.20 kg, FAAM-ADL = $91.0 \pm 4.2\%$, FAAM-Sport = $75 \pm 2.5\%$) and 16 healthy individuals (age = 22 ± 3.35 years, height = 170.09 ± 11.47 cm, mass = 67.19 ± 22.93 kg, FAAM-ADL = $100 \pm 0\%$, FAAM-Sport = $100 \pm 0\%$) volunteered to participate. **Intervention(s):** Independent variables were group (healthy, CAI) and time (pre-intervention, post-intervention). All measurements were taken on the self-reported worst ankle in the CAI group, and on a randomly selected ankle in the healthy group. Two 0.5L ice bags were wrapped on the ankle with an elastic bandage for 15 minutes. **Main Outcome Measure(s):** SNAP measurements (onset latency, peak latency, amplitude, conduction velocity, duration) were taken for the sural, saphenous, and superficial peroneal nerves before and after cryotherapy. Data were non-normally distributed, therefore Mann-Whitney U and Wilcoxon signed ranks tests were used to assess for differences; results are presented as median

(interquartile range [IQR]). **Results:** At baseline, the only group difference was in the superficial peroneal nerve amplitude, with significantly lower values in the CAI group ($6.9\mu\text{V}$ [3.4, 17.6]) compared to the healthy group ($13.6\mu\text{V}$ [5.4, 37.4], $P = 0.026$). Following cryotherapy, the sural nerve in the healthy group had increased onset latency (pre = 3.1ms [1.4, 9.1]; post = 5.1ms [2.7, 12.8], $P = 0.026$), peak latency (pre = 3.8ms [2.0, 11.4]; post = 7.1ms [4.2, 11.1], $P = 0.16$), and a decrease in conduction velocity (pre = 39.9m/sec [12.1, 71.2]; post = 25.4m/sec [9.7, 40.8], $P = 0.011$) and duration (pre = 12.9msec [5.3, 19.1]; post = 10.9msec [7.2, 14.9], $P = 0.026$); while there were no sural nerve changes due to ice in the CAI group. In the superficial peroneal nerve of the healthy group, ice increased onset latency (pre = 2.3ms [1.9, 7.1]; post = 3.1ms [2.5, 8.4], $P = 0.006$) and peak latency (pre = 3.0ms [2.5, 9.6]; post = 3.9ms [3.2, 9.9], $P = 0.08$); similarly, the CAI group increased in onset latency (pre = 2.3ms [1.5, 8.3]; post = 3.0ms [2.4, 8.1], $P = 0.008$) and peak latency (pre = 3.0ms [2.1, 9.2], post = 3.7ms [3.2, 10.4], $P = 0.004$) and decreased in conduction velocity (pre = 47.5m/sec [18.4, 70.3]; 39.6m/sec [10.5, 47.0], $P = 0.003$) pre to post. The only significant finding for the saphenous nerve was an increase in amplitude (pre = $5.64\mu\text{V}$ [1.3, 22.0]; post = $7.8\mu\text{V}$ [2.7, 13.5], $P = 0.031$) for the healthy group pre to post. **Conclusions:** There were differences in SNAP measures between healthy and CAI groups in the superficial peroneal nerve, indicating dysfunction of the nerve. Joint cooling resulted in similar changes in superficial peroneal nerve of CAI and healthy groups, while ice only affected the function of the sural and saphenous nerves in healthy individuals.

A Comparison Of Game Ready® And Cold Whirlpool For Acute Edema Removal

Powers ME: Marist College, Poughkeepsie, NY

Context: While many modalities have been incorporated to reduce pain and edema during the management of musculoskeletal trauma, cryotherapy has long been recognized as beneficial. Both active exercise and intermittent compression are commonly combined with cryotherapy to enhance lymphatic function and further remove edema. Unfortunately, their efficacy has only been scarcely investigated, with conflicting results reported. Thus, an optimal treatment for edema removal has yet to be identified. **Objective:** To determine whether a single treatment with the Game Ready® compression system (GR) or cold whirlpool with active exercise (CWP) is more effective for removing subacute edema. **Design:** A randomized and counterbalanced single blind design. **Setting:** An athletic training facility. **Participants:** Fourteen male and female varsity and club athletes (age = 20.1 ± 1.1 y, height = 178.6 ± 12.1 cm, mass = 71.8 ± 14.3 kg) who suffered a grade I or II ankle sprain within 48 hours volunteered to participate. To be included, the injury must have required removal from participation and acute injury management. Potential subjects were excluded from participation if cryotherapy or intermittent compression was contraindicated. **Intervention(s):** Subjects were randomly assigned to one of two treatment groups, GR and CWP. During the GR condition, subjects were placed supine on a treatment table with the injured leg elevated 75° while receiving a GR treatment for 30 minutes. A standard ankle wrap was applied using manufacturer's instructions and connected to a GR Pro 2.1 Control Unit. The water initially placed in the unit was standardized at 4.44°C with the coldest temperature

and the highest pressure settings used. During the CWP condition, subjects were seated at a whirlpool with the knee flexed to 90° and the distal two-thirds of the lower leg submerged in the water approximately 91.4 cm from the turbine. With the water maintained at 10°C and the turbine facing the ankle, subjects performed a single repetition of full pain free range dorsiflexion and plantar flexion every 20 seconds over a 30 minute treatment period. **Main Outcome Measure(s):** Lower extremity edema was assessed immediately prior to and following treatment using a standard volumetric tank and volumetric measurement. **Results:** A 2 x 2 analysis of variance with repeated measures revealed that neither treatment was beneficial for removing edema ($F_{1,12} = .732$, $p = .409$) as no significant differences were noted when comparing limb volumes before ($1.33 \pm .27L$) and after ($1.33 \pm .26L$) CWP and before ($1.42 \pm .33 L$) and after ($1.37 \pm .33 L$) GR. Likewise, no differences were observed ($T_{12} = 1.53$, $p = .151$) when comparing the percent change during CWP ($.67 \pm 3.94 \%$) and GR ($3.16 \pm 2.55 \%$) treatments. **Conclusions:** Although there was a non-significant trend for an improvement following GR application, the results suggest that neither treatment is beneficial for subacute edema removal. Future research should focus on varying parameters of these treatments to possibly identify an optimal treatment.

Free Communications, Oral Presentations: Infectious Disease Case Studies

Thursday, June 26, 2014, 12:15PM-1:30PM, Room 244; Moderator: John Baldea, MD, CAQSM

14018MC

The Forgotten Disease: A Rare Case Of Lemierre's Syndrome In A Male Division I Collegiate Football Player

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Fargo, ND

Background: A healthy 19 year old Division I linebacker (body mass=104 kg; height=189 cm) attended football camp during the summer and developed signs and symptoms rapidly. Initially the athlete experienced severe throat pain. Over the next few days, the athlete reported having night sweats, fever, nausea, vomiting, shortness of breath, and generalized body weakness. Additionally during the football camp, the athlete received a direct blow from a helmet to his left arm causing swelling and a hematoma. On the fifth day, symptoms were so severe that a family member took him directly to the hospital. **Differential Diagnosis:** Infectious Mononucleosis, Meningitis, and Streptococcus Pharyngitis. **Treatment:** Upon arrival at the hospital, vitals were taken and the athlete had increased blood pressure, heart rate, and body temperature. The physician ordered a monospot test to check for mononucleosis and lumbar puncture to check for meningitis. Due to the left arm hematoma, blood draws were taken from numerous sites on the right arm. The first physician couldn't determine the diagnosis. The second physician recognized the symptoms based on a previous case and ordered additional blood tests to determine if the athlete had Lemierre's Syndrome. Evaluation of the throat revealed a peritonsillar abscess that required surgical removal. The athlete was taken into surgery where he underwent a left peritonsillar abscess removal for quinsy and was placed on antibiotics. The patient was then transferred emergently to the ICU of a more advanced hospital to be treated for severe odynophagia and Internal Jugular Vein Thrombosis. Vitals were declared

stable after the transfer. Computed tomography (CT) scans of the neck were positive for thrombosis in the left tonsillar abscess and extended into the left Internal Jugular Vein. Nodular opacities were also found in the air spaces during the neck CT indicating pneumonia or septic emboli. The blood culture showed thrombocytopenia, abnormal liver tests and renal functions. The blood culture was also positive for bacteremia caused by the gram-negative anaerobic bacillus, *Fusobacterium necrophorum*, which confirmed the diagnosis of Lemierre's Syndrome. CT scans of the chest showed bibasilar airspace disease confirming pneumonia. CT scans of the abdomen were normal. EKG of the heart showed an incomplete right bundle branch block. The athlete's left arm remained swollen and was monitored until healed. Thoracentesis was performed for the pleural effusion and yellow fluid was removed. The patient was monitored closely and kept under antibiotics and incentive spirometry. He was given anticoagulation medications and was eventually released from the hospital. The athlete was cleared two months later for Division I football without complications. **Uniqueness:** Lemierre's syndrome was once called the Forgotten disease because of its rarity. Diagnosis is often delayed because of physician's lack of awareness of symptoms and knowledge of the syndrome. No case reports on athletes have been documented in the literature. Lemierre's is so uncommon that only a few prospective studies have been conducted to determine the epidemiology. This research shows that Lemierre's syndrome occurs in young, healthy adults, but researchers haven't determined why this population is most affected. **Conclusion:** Although Lemierre's syndrome is rare, the athletic trainer is the first person to evaluate and diagnose an athlete who presents with a rapid onset of symptoms. Since this forgotten disease is seen in healthy, young adults, athletic trainers should be aware

and recognize the signs and symptoms to prevent the life-threatening complications of Lemierre's Syndrome.

Unexplained Chronic Leg Pain In A Female Collegiate Soccer Player: A Case Report

Fleming R, Doherty-Restrepo JL:
Florida International University,
Miami, FL, and Broward Hospital,
Ft Lauderdale, FL

Background: A 21-year-old Caucasian female collegiate soccer player presented in the athletic training room with unexplained, chronic low leg numbness following exertional sport-specific activity. Initially, the athlete reported recurrent episodes of bilateral numbness and tingling below the knees and into the feet (dorsal and pedal) occurring 45 minutes into activity. The condition then progressed to earlier onset, starting during warm-up. The symptoms were recreated with continuous exercise and running for long distances. They occurred more frequently during the preseason and diminished as the season advanced. The athlete did not display any strength or proprioception deficits. After the season the athlete's symptoms subsided; however, during the subsequent season, the athlete presented with additional symptoms, including butterfly rash on the face and erythema of the skin in the lower extremities. She also reported symptoms of Raynaud's Phenomenon in her hands in the mornings and during exercise in very cold weather. The athlete had previous lower extremity injuries, including iliotibial band friction syndrome and a Grade I lateral ankle sprain, and had a history of recurrent rashes since the age of seven that had been treated with Zyrtec. Medications taken under the advisement of the team physician included vitamins D-3, B-6, fish oil and Folic Acid. Her family's medical history revealed that her biological father passed way from complications of cancer, specifically Non-Hodgkin's B-cell lymphoma. **Differential Diagnosis:** Exercise-induced compartment syndrome, chronic exertional compartment

syndrome, anterior compartment syndrome, stress fracture, systemic lupus erythematosus (a chronic inflammatory disease that causes the body's immune system to attack its own tissues and organs), Sjogren's syndrome (a chronic systemic autoimmune disease influenced by environmental conditions and genetic susceptibility factors). **Treatment:** The athletic trainer involved in this case study treated the athlete over the course of two years during the in-season. Initially, the athlete was treated conservatively with rest, elevation of the legs, and ice massage. When the athlete's symptoms did not resolve with conservative treatment she was seen by one of the team physicians, a practicing rheumatologist. The team physician ordered laboratory tests which revealed that polymorphonucleocytes were attacking her white blood cells. This is indicative of an autoimmune disorder. The laboratory results revealed that the athlete's anti-double stranded DNA was normal thereby ruling out a diagnosis of systemic lupus erythematosus. A diagnosis of Sjogren's syndrome was also ruled out due to the presence of Sjogren's anti-SSA and anti-SS-B antibodies in the laboratory results. After ruling out systemic lupus erythematosus and Sjogren's syndrome, the athlete was diagnosed with an undifferentiated autoimmune connective tissue disorder. At the time of the study the athlete was under the care of the team physician who placed her on a drug regimen consisting of Plaquenil and a variety of vitamins. **Uniqueness:** Autoimmune diseases are chronic systemic conditions that present with a broad variety of clinical manifestations which may have overlapping symptoms indicative of common musculoskeletal pathologies of the lower extremity. Autoimmune markers may never develop into a distinctive disorder or may disappear; therefore, it is very difficult to quickly diagnose these conditions. **Conclusions:** There are very few cases

of autoimmune disease in current athletic training literature. It is difficult to diagnose an autoimmune disease because of the diverse clinical manifestations, ill-defined diagnosing criteria, and unknown etiology.

Septic Sacroiliitis In Division III Cross Country Runner

Klein SP, Dunham J, Linens SW:
Georgia State University, Atlanta,
GA, and Emory University, Atlanta,
GA

Background: A 19-year old male, member of a Division III cross country team, complained of low back pain that started four days prior to initial evaluation after a long run. History of low back pain during previous summer that resolved on its own, also denied any specific mechanism of injury. However, he reported an increase in mileage over the last few weeks prior to injury. He also logged over 1500 miles on his current shoes. Upon initial evaluation he presented with pain when running and discomfort while walking. Pain on palpation over the right sacroiliac joint, right gluteal region, and presented with spasm of his right lumbar paraspinals. Key physical exam findings: limited hip internal rotation with pain, limited trunk flexion with pain, and normal trunk extension with pain. Upon manual muscle testing he presented with 4/5 for his right Gluteus Medius, 4/5 right Gluteus Minimus, 4/5 right Tensor Fasciae Latae, 4+/5 Gluteus Maximus, 4+/5 Hip Flexors, 3/5 Erector Spinae, and 3/5 Lower abdominals. The previous manual muscles tests all produced pain upon testing. Gillets Test and 90/90 tests were positive. **Differential Diagnosis:** Right Sacroiliac dysfunction. **Treatment:** Initial evaluation from team physician occurred on the same day as initial evaluation by athletic trainer, and was assessed with right sacroiliac dysfunction. He began conservative rehabilitation that same day. Patient was then seen by team chiropractor two days later for adjustment. Patient initially felt better after chiropractic adjustments and rehabilitation. Over the next two days the pain worsened to the point the patient went to the emergency room on his own. There he received an

x-ray of his hip: findings were normal. Emergency room physician prescribed oral Vicodin (5 mg-300 mg). Team physician advised patient to discontinue Vicodin, and was prescribed Medrol Dose Pak (4 mg oral tablet). The following day his symptoms worsened, he had trouble sleeping and most activities of daily living were painful. Patient was placed on crutches and prescribed 5 mg of Flexeril. The following day, the patient's symptoms still had not improved. The patient was then sent for a MRI of the lumbar spine without contrast; initial report was asymmetric right sacroiliac joint edema/inflammation with adjacent edema within the posterior fibers of the right psoas muscle and right lower lumbar paraspinal musculature. The findings were nonspecific, but with findings of asymmetric and unilateral sacroiliitis. He then underwent another MRI without contrast of the pelvis, which showed findings most consistent with septic sacroiliitis. With these findings the patient was admitted to campus hospital for further evaluation and treatment. Once admitted into hospital patient underwent numerous blood and urine analysis tests. He was prescribed Naproxen 500 mg, Piperacillin-Tazobactam 3.375 gm IVPB, Potassium Chloride 40 mEq, and Vancomycin 1 gm IVPB. Blood work showed an elevated white blood cell count of 12.7 (normal range 4.2 – 9.1). Blood cultures found Methicillin-Sensitive Staphylococcus Aureus (MSSA) bacteremia. Once the blood cultures were identified the patient's antibiotic was changed from Vancomycin to Nafcillin. The patient was then dismissed from the hospital and continued antibiotic treatment for four weeks. Patient took semester off and returned home. **Uniqueness:** This type of infection is uncommon and has very low occurrence rates. This case is unique because of initial signs and symptoms were consistent with sacroiliac dysfunction, but the athlete's symptoms rapidly increased over the

next week. **Conclusions:** This case is important because of its initial presentation as sacroiliac dysfunction. The important lesson from this case is that injuries may seem to present as one injury, but certified athletic trainers should not forget about their differential diagnosis and therefore we should be persistent with our follow-up appointments.

140370C

Toxic Shock Syndrome Associated With MSSA Infection And Possible Co-Infection In A High School Football Athlete

Schrade CR: Cleveland Clinic, Wickliffe, OH

Background: This report deals with the development, diagnosis and treatment of an athlete with toxic shock syndrome. The subject was a 17 YO, male high school football player. The subject initially experienced flu like symptoms for 2 days. He had general malaise, mild cough and sore throat. He missed the first half of school on Friday but came in for the remainder to compete in the football game. He reported to the athletic trainer for pre-game preparation and played in the game that evening. He later reported not showering after the game and going straight to bed. The subject began having diarrhea and vomiting Saturday morning. The athlete also experienced minimal urine output. The athlete developed a fever of 104 and experienced dyspnea. On Sunday, the athlete experienced 2 episodes of syncope when walking to the bathroom. On Monday his parents called his primary care physician who diagnosed him with a viral illness and suggested to go to the emergency room if symptoms worsened. The subject maintained the 104 fever as well as syncope, dizziness, and developed back pain, at which point his parents took him to the emergency room. **Differential Diagnosis:** Possible differential diagnoses included viral illness, Lemierre's Syndrome, acute renal failure, toxic shock syndrome, and MRSA/MSSA. **Treatment:** Upon arrival at the hospital the subject was given lab tests and IV fluids. His blood pressure began to drop below 70/40 mmHg and he was tachycardia, and febrile. The lab results showed evidence of renal failure. The subject was then transferred to the ICU at Cleveland Clinic Main Campus. Upon arrival at the ICU he maintained hypotension, tachycardia, remained febrile and

showed low platelet count and creatinine abnormalities. The subject also had a chest X-ray taken, with results showing no abnormalities. A renal ultrasound was performed and showed an enlarged kidney. The subject was thought to be experiencing septic shock. Labs were drawn to rule out Lemierre's Syndrome as well as to identify the organism causing his illness such as staph, strep, meningococcus, or pneumococcus. The subject was put on respiratory support and pressor support with continued low urine output. He was taken off of respiratory support after 3 days but remained on pressor support for one more day, at which point he was able to maintain normal blood pressure on his own. The subject's creatinine levels continued to rise and he was considered for dialysis. Cultures were taken of skin wounds which showed MSSA was present. At this point the patient was improving greatly aside of renal failure. After 2 more days, creatinine levels stabilized and fluid balances began to normalize. At that point, the subject began eating small amounts of food and had more energy throughout the day. The subject was discharged from the ICU on day 10 and was instructed on a strict diet as well as given cleanser and ointment for his cuts and wounds. The subject was seen 1 week after being discharged and showed unremarkable resolution of his symptoms. He was placed on a low sodium diet and was counseled about symptoms of hypertension. He was seen 6 months later at which point his creatinine levels were within normal limits and was asked to be seen only if any future problems occur. **Uniqueness:** Possible co-infection occurrence with viral infection and MSSA infection. Dealing with a staph infection severe enough to result in multiple organ failure and toxic shock syndrome, is rare in the athletic population. **Conclusions:** Monitoring overall athlete health status as well as wound care is paramount to overall care of athletes.

14008FC

Unexplained Knee Effusion In A Recreational Exerciser

Winterstein AP, Field AA, Kerwin RE: University of Wisconsin, Madison, WI

Background: A 19-year old recreational exerciser reported to the University Health Services athletic training clinic early in the fall semester with persistent knee pain and swelling of unknown origin. He reported six weeks of gradual onset bilateral knee pain (right > left) with stiffness upon waking, pain with activities of daily living, and at extremes of joint motion. No acute mechanism of injury or change in his weight lifting or exercise routine was reported. He worked as a greens keeper at a golf course during the summer months. The patient was examined by two licensed athletic trainers six days apart at a walk-in clinic and during a scheduled appointment. Primary concern was right knee pain (anterolateral and medial) and swelling. Clinical exam revealed limited right knee flexion (105 degrees), joint effusion, normal ligamentous exam, lateral joint line tenderness, soft tissue tightness in the IT band, good quadriceps muscle activation and tone, and normal neurovascular findings. The patient also described intermittent stiffness and swelling in his left knee. He denied history of autoimmune disorder, joint diseases, systemic illness, infection, skin rash, or insect bites. The athletic trainer referred the patient to the physician for further evaluation. **Differential Diagnosis:** The differential diagnosis included overuse injury, chronic meniscal tear, osteoarthritis, articular cartilage defect, infection (gonorrhea, Lyme disease, tuberculosis, brucellosis), polyarthrititis (rheumatoid arthritis, Reiter's syndrome), gout, pseudogout, and tumor (e.g. benign cyst, synovial sarcoma). **Treatment:** Upon referral to the physician clinical exam confirmed presence of effusion with no structural

deficiencies. Radiographs of the right knee revealed a focal periosteal reaction along the posterior aspect of the distal femur and a moderate joint effusion. Given the lack of trauma and the presence of effusion, an MRI, lab tests examining inflammatory markers, and Lyme titers were recommended. The patient refused the MRI due to cost obstacles; however an enzyme immunoassay (EIA) was confirmed with a Western Blot for Lyme disease. The physician recommended antibiotic therapy and the patient was placed on a course of doxycycline to which he had a skin reaction. He was then placed on cefuroxime and had an adverse reaction (nausea and malaise). After consultation with an infectious disease specialist he was placed on azithromycin which he tolerated well. The patient has made marked improvement in his swelling but still has intermittent pain in his knees. He will be followed by the infectious disease specialist. **Uniqueness:** This case is unique in that the patient had no recollection of exposure to this tick-borne illness and did not present with the most common (70%) early clinical presentation of erythema migrans or bullseye rash. He also did not exhibit any stiff neck, flu-like symptoms, or swollen lymph nodes which are common to the early localized stage of infection (3 – 30 days). Pain and swelling in large joints (33% of patients) may reflect either early disseminated stage infection (days to weeks) or late disseminated stage infection (months to years). **Conclusions:** Lyme disease is caused by the spirochete *Borrelia burgdorferi* and spread by ixodid ticks (deer and sheep ticks). While Lyme disease is found in all 50 states, 96% of all cases occur in a cluster of 13 states in the Northeast and upper Midwest. Athletic trainers must be aware of the signs and symptoms and prevalence of Lyme disease based on geographic location. Recreational activities, occupations, and travel history may increase a

patient's risk of exposure to tick-borne illness and must be considered when obtaining a thorough history. Lyme disease should be considered as a differential when seeking an explanation for joint pain and swelling in the absence of trauma.

Free Communications, Oral Presentations: Instrument-Assisted Manual Therapy

Friday, June 27, 2014, 8:00AM-8:45AM, Room 244; Moderator: Russell Baker, DAT, ATC

14235FOTH

The Effect Of Instrument-Assisted Manual Therapy Technique On Brachial Hemodynamics And Pain

Boucher T, Gallucci A: Texas A&M University, College Station, TX, and Baylor University, Waco, TX

Context: Instrument-assisted manual techniques are used to break down scar tissue and are purported to increase the rate and blood flow. However, there is no current research that has investigated the effect of instrumented-assisted manual techniques on hemodynamic measures. **Objective:** To investigate the effect of the Graston Technique® versus standard soft tissue mobilization on heart rate (HR), blood pressure (BP), brachial artery blood flow, and subjective pain. **Design:** A repeated-measures crossover design. **Setting:** University Laboratory Setting. **Patients or Other Participants:** Eleven males and nine females (age = 23.4 ± 2.7 years, height = 170.2 ± 8.2 cm, mass = 76.3 ± 18.1 kg) without pathology or cardiovascular impairment completed the study. **Intervention(s):** Participants were randomized to receive either Graston Technique® or manual cross friction/soft tissue mobilization to the extended dominant arm anterior brachial region, medial forearm flexor wad, and distal bicep tendon for 10 minutes in a supine position on two testing sessions separated by 4–7 days. Brachial HR and BP were measured using an automated blood pressure monitor (Ariel BP 2400, Medquip, Bluffton, SC). Brachial artery blood flow velocity (cm/sec) was measured via spectral Doppler ultrasonography (SonoSite M-Turbo, SonoSite, Inc., Bothell, WA). Subjective pain was assessed using a 10cm visual analog scale (VAS). **Main Outcome Measure(s):** HR, BP, and blood flow were measured prior to therapy application, immediately post, and every 5 minutes for 30 minutes. VAS was measured post the testing session. A mixed design repeated measures multivariate

analysis of variance compared HR, BP, and blood velocity between the therapy applications across time. A mixed design repeated measures analysis of variance (ANOVA) compared HR, BP, and blood flow independently between the therapy applications across time. Univariate ANOVA compared VAS between the therapy applications.

Results: No significant difference was shown between therapy applications in multivariate analysis of HR, BP, and blood flow ($P = .74$). No significant difference was found between therapy applications in univariate analysis over time for HR (Graston: 65.5 to 64.5 bpm, Manual: 66.7 to 62.5 bpm, $P = 0.73$), systolic BP (Graston: 115.6 to 117.8 mm Hg, Manual: 114.1 to 117.9 mm Hg, $P = 0.72$), diastolic BP (Graston: 71 to 74.2 mm Hg, Manual: 69.6 to 73.8 mm Hg, $P = 0.98$), or blood flow (Graston: 20.6 to 20.1 cm/sec, Manual: 20.1 to 19.8 cm/sec, $P = 0.32$). There was a significant decrease in HR (66.1 to 63.72 bpm, $P = .001$) relative to time regardless of therapy application and pairwise comparison revealed the significant difference between baseline to immediate post, ten minutes, twenty minutes and twenty-five minutes post. No difference was found for pain between applications (Graston: 3.3, Manual: 3.9, $P = .32$). **Conclusions:** Manual therapy application using Graston Technique® or manual techniques does not differentially influence localized HR, BP, or blood flow. Manual therapy, regardless of technique, does appear to reduce localized HR. Both techniques stimulate equivalent subjective pain.

14157DOTE

Effect Of Graston Technique® As A Treatment For Patients With Chronic Plantar Fasciosis: A Randomized Controlled Trial

Garrett TR, Neibert PJ: University of Northern Iowa, Cedar Falls, IA

Context: Interest and use of instrument-assisted soft tissue massage (IASTM) has increased in athletic training settings for the treatment of chronic pathologies. Randomized control trials are needed to establish the efficacy of IASTM for the treatment of plantar fasciosis. **Objective:** To determine the effectiveness of the Graston Technique (GT) with plantar fascia specific stretching (PFSS) for decreasing pain and increasing foot function in patients with chronic plantar fasciosis. **Design:** Randomized control trial. **Setting:** University research laboratory. **Patients or Other Participants:** A sample of 22 adults (5 males, 17 females) (age = 46.45 ± 12.5 , BMI = 30.48 ± 6.00) from the general population, with a physician diagnosis of chronic plantar fasciosis (length of symptoms 3–144 months). **Intervention(s):** Participants were randomly assigned to one of three groups: Graston Technique® plus plantar fascia specific stretching (GT/PFSS), effleurage therapy plus plantar fascia specific stretching (Eff/PFSS), and control plus plantar fascia specific stretching (Con/PFSS). Participants performed a five minute stationary bike warm up, followed by 8–10 minutes of their assigned treatment. Each session was concluded by having the participants perform PFSS. The stretches were performed ten times for ten seconds in duration. Participants were pre-tested and post-tested using the: (1) Foot Health Status Questionnaire (FHSQ) utilizing three subscales of foot pain, foot function and general foot health, (2) McGill Pain Questionnaire (MPQ) which subjectively measures major psychological dimensions of pain, (3) and Visual Analog Scale (VAS). For the current study, all measures demonstrated

adequate test-retest reliability, with alphas ranging from .71 to .99. **Main Outcome Measure(s):** Between groups ANOVA was used for three FHSQ subscales (foot pain, foot function, and general foot health), MPQ, and VAS. **Results:** Significant improvements were noted in FHSQ foot function for the GT/PFSS group compared to the Eff/PFSS group ($F_{2, 22} = 4.716$, $p = .022$, $R = .58$), as well as general foot health of the GT/PFSS group compared to the Con/PFSS group ($F_{2, 22} = 4.56$, $p = .024$, $R = .57$). VAS had a significant decrease in pain for the GT/PFSS group when compared with the Eff/PFSS group ($F_{2, 22} = 4.41$, $p = .027$, $R = .56$). No significant differences were noted between Eff/PFSS and Con/PFSS groups. **Conclusions:** Participants with chronic plantar fasciosis significantly improved in three of the five variables measured over a six week treatment of Graston Technique®, as compared to effleurage and control groups. IASTM with PFSS is effective in decreasing pain and improving foot function in patients with chronic plantar fasciosis.

The Effect Of Instrument-Assisted Soft Tissue Mobilization On Iliotibial Band Extensibility

Smuts JS, Frank JM, Schrader JW, Docherty CL: Indiana University, Bloomington, IN

Context: Many methods exist for increasing iliotibial band (ITB) extensibility with varying effectiveness. Instrument Assisted Soft Tissue Mobilization (IASTM) is theorized to reduce soft tissue restrictions and allow for an increase in extensibility, however few randomized controlled clinical trials have been conducted on this intervention. **Objective:** To determine if IASTM increases ITB extensibility. **Design:** Randomized Controlled Trial. **Setting:** University Research Laboratory. **Patients and Other Participants:** Forty-five physically active subjects with ITB tightness volunteered to participate in this study. Subjects had an average hip adduction range of motion of $12.45^\circ \pm 1.5$ at baseline. Subjects were randomly assigned to either the IASTM (9 males and 13 females; $19.59 \pm .96$ years; 172.20 ± 11.36 cm; 69.17 ± 13.27 kg) or Control (10 males and 13 females; 19.13 ± 1.01 yrs; 170.85 ± 8.55 cm; 65.76 ± 10.29 kg) groups. **Intervention(s):** Subjects in the IASTM group received the Graston Technique®, which is a form of soft tissue mobilization that uses six patented stainless steel instruments to diagnose and treat soft tissue adhesions and fascial restraints. Subjects in this group received a standardized protocol which included a warm-up, soft tissue mobilization using instruments GT-1, GT-3, and GT-4 (Graston Technique LLC, Indianapolis, IN), and two hip strengthening exercises. Subjects in the control group received a sham microcurrent treatment in which the pads were placed on the ITB but the intensity was not increased. Hip adduction range of motion was obtained by a digital inclinometer (Lafayette Instrument

Company, Lafayette, Indiana) through the Modified Ober's test. Testing occurred at baseline and following the 6 treatment sessions. **Main Outcome Measure(s):** The dependent variable was hip adduction range of motion($^\circ$). A repeated measures ANOVA was completed with one between subject's factor (group at 2 levels) and one within subject's factor (time at 2 levels). A priori alpha level was set at $p < .05$. **Results:** We identified no significant time by group interaction for hip adduction range of motion ($F_{2,86} = 0.2$, $p = .84$, $\eta^2 = .01$, power = .08). From baseline to post test the mean difference was minimal for both groups (IASTM: $2.9 \pm 1.2^\circ$, 95% CI: -5.8 to 0.1° and CON: $2.0 \pm 1.1^\circ$, 95% CI: -4.8 to 0.8°) **Conclusions:** Instrument assisted soft tissue mobilization using the Graston Technique® did not increase ITB extensibility after 6 treatment sessions. Further research is needed to determine how this treatment technique can be used to alter patient reported outcomes related to ITB pathology.

Free Communications, Oral Presentations: Hot Topics in Heat Illness

Friday, June 27, 2014, 9:00AM-10:15AM, Room 244; Moderator: Brendon McDermott, PhD, ATC

14354UOEX

Effects Of Ice Slurry Consumption During A Warm-Weather Road Race

Belval LN, Stearns RL, Huggins RA, Moore JL, Scanlon DM, Attanasio SM, Vandermark LW, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Ice slurry consumption before exercise has been shown to affect temperature responses and performance. However, no study has examined the effects of ice slurry consumption during competitive exercise. **Objective:** To determine the physiological and perceptual responses to consuming ice slurry during intense warm-weather running. **Design:** Cohort field study. **Setting:** 2013 Falmouth Road Race (11.2 km; Falmouth, MA, WBGT: 27.04 ± 1.20 °C). **Patients or Other Participants:** 28 race participants recruited prior to the race. (26 males, 2 females, mean \pm SD; 37 ± 11 years, 74.8 ± 14.3 kg) Subjects were allocated into two groups, ice slurry group (IS; N = 14) and non-ice slurry group (CON; N = 14). **Intervention(s):** During the race individuals in IS were offered 8oz of ice slurry containing carbohydrate and electrolytes (Core Coolsdown Inc.) at 3.2 km, 6.4 km, and 9.6 km. **Main Outcome Measure(s):** Within 40 days of the race, subjects completed VO₂max testing. On race day subjects reported for pre-race measures including gastrointestinal temperature (TGI), body mass and urine specific gravity (USG). Subjects also completed inventories of thirst, thermal sensation and the Environmental Symptoms Questionnaire-14 (ESQ). Both groups were allowed to consume fluids ad libitum during the race. Wet bulb globe temperature (WBGT) was recorded at the finish line. Immediately following the race, measurements of TGI, USG, body mass, thirst, thermal sensation and ESQ were obtained. Finish-time was recorded. Independent sample t-tests were used to compare

physiological and performance measures between groups. Mann-Whitney U tests were completed to compare perceptual responses between groups. **Results:** No differences were observed between groups for VO₂max (IS: 50.38 ± 4.91 ml·kg⁻¹·min⁻¹, CON: 52.86 ± 7.21 ml·kg⁻¹·min⁻¹, $p = 0.339$), speed at VO₂max (IS: 14.6 ± 0.98 km·h⁻¹, CON: 15.3 ± 1.3 km·h⁻¹, $p = 0.112$), body mass (IS: 75.01 ± 16.12 kg, CON: 74.64 ± 12.81 kg, $p = 0.947$) or age (IS: 39 ± 12 years, CON: 35 ± 10 years, $p = 0.365$). IS consumed 6.9 ± 3.4 g/kg ice slurry during the race. No differences were observed for post-race TGI (IS: 39.79 ± 0.73 °C, CON: 39.47 ± 0.72 °C, $p = 0.277$), change in TGI (IS: 2.58 ± 0.99 °C, CON: 2.41 ± 0.73 °C, $p = 0.669$), post-race USG (IS: 1.009, CON: 1.008, $p = 0.801$), or finish time (IS: 55.82 min, CON: 52.53 min, $p = 0.216$). No difference was observed in thermal sensation (median [25th, 75th percentile] IS: 6 [5.5, 6.5], CON: 6 [5, 7], $p = 0.176$). IS reported significantly lower perceptions of thirst (IS: 5 [3, 7], CON: 6 [4, 8], $p = 0.003$) and ESQ scores (IS: 9 [2, 16], CON: 16 [7, 25], $p = 0.010$). **Conclusions:** Ice slurry consumption during exercise did not result in differences for perceived thermal sensation, hydration indices or TGI. However, IS reported lower thirst and fewer symptoms on the ESQ. Therefore, within the context of a summer road race and when race times were similar, runners who consumed ice slurry finished with fewer heat stress symptoms than CON.

Use Of The Discomfort Index (DI) As An Alternative Heat Stress Index (HSI)

Miles JD, Cooper ER, Grundstein AJ, Ferrara MS: University of North Georgia, Dahlonega, GA; University of Georgia, Athens, GA; University of New Hampshire, Durham, NH

Context: For years the Wet Bulb Globe Temperature (WBGT) has been accepted as the “gold standard” for use in Heat Stress Indices (HSI). Currently, use of the WBGT in HSI’s is recommended by organizations such as the National Athletic Trainers’ Association (NATA), American College of Sports Medicine (ACSM), Department of Defense (DOD), and some local and state organizations. The discomfort index (DI) is currently used in other countries to develop HSI’s, most notably in Israel. DI is calculated by using the equation $0.5 \text{ dry bulb (DB)} + 0.5 \text{ wet bulb (WB)}$. This measurement may be an alternative to WBGT. **Objective:** To determine strength of relationship of the DI with WBGT and to propose a scale based on DI. **Design:** Prospective epidemiological design. **Setting:** Interscholastic institutions from five geographic regions in the state of Georgia (North, Metro Atlanta, Central, Southeast, Southwest). **Patients or Other Participants:** Interscholastic football athletes from 23 schools in the state of Georgia for August, 2009–2011 seasons. **Intervention(s):** An ATC was identified at each school and recorded all athlete-exposure (AE), Exertional Heat Illness (EHI), and environmental conditions. EHI types were identified as heat cramps (HC), heat exhaustion (HE), heat syncope (HS), and heat stroke (STR) as defined by the NATA Position Statement. Due to the low number of HS’s, HS and HE were combined to form one variable (HS/HE). **Main Outcome Measure(s):** Injury Rates (IR’s) were calculated for all injuries for which environmental data were

available. IR's were calculated using the equation $\# \text{ of EHI's} / \text{AE} \times 1000$. DI's were calculated using raw environmental data and the previously mentioned equation. Pearson Correlation was used to determine the strength of relationship between DI and WBGT. IR's were plotted in 1° Fahrenheit (F) increments to determine possible cut points for the development of an HSI scale. **Results:** There were 460 EHI's for which environmental data were available. Of those, 349 were HC's and 111 were HS/HE. The R^2 between WBGT and DI was 0.917. Major cut points using HS/HE IR were noted at a DI of 79, 82, 88, and 91 degrees F. We defined cut points as those temps where IR increased by a factor of at least 2. **Conclusions:** These data demonstrated a strong relationship between WBGT and DI, suggesting implementation of a HSI using DI a good alternative. This study confirms previous data collected by the DOD, but is specific to an athletic setting. Use of a HSI using DI may be favorable, as it is a simpler scale and a value that could be easily reported by organizations such as the National Weather Service and the National Oceanic and Atmospheric Administration-ultimately more easily accessible to the general public. Further studies are needed to determine best practice with DI. This project was funded by the NATA Research & Education Foundation.

Effect Of Educational Intervention On Hydration Behaviors, Status, And Knowledge In High School Football Players

Kanemura K, McDermott BP, Adams JD, Ridings CB, Kavouras SA: University of Arkansas, Fayetteville, AR

Context: Hypohydration can negatively affect athletes, declining athletic performance and increasing heat-illness risk. Hydration education could enhance athletes' behavior in maintaining proper hydration, but effects remain unclear. **Objective:** To assess the short- and long-term effect of a one-time educational intervention on hydration behaviors, status, and knowledge in high school football players. **Design:** Randomized controlled trial. **Setting:** In-season American football. **Patients or Other Participants:** Forty-one high school football players (15.9 ± 0.9 y, 176.0 ± 7.5 cm, 87.5 ± 25.1 kg, 15.9 ± 7.5 % body fat) voluntarily participated. **Intervention(s):** Participants were randomly assigned to an educational intervention (EI) or control group (NI). The EI consisted of a 5-minute presentation on the importance of hydration, quick self-assessment techniques, and hydration status feedback from baseline data. Participants in EI group were provided a personal water bottle. A baseline data collection consisted of 48-hour fluid intake logs, urinalysis and questionnaires. The EI occurred 4 days post-baseline and data collection was repeated 3 days and 3.5 weeks post-EI on the same day of the week. **Main Outcome Measure(s):** Participants provided a small urine sample prior to practice for urine color (Ucol) and urine specific gravity (USG). Participants recorded their fluid intake for 48-hour prior to data collection using fluid intake logs. Twenty-four-hr averages for total fluid consumed (FC) and water consumed (WC) were calculated. Written questionnaires quantified hydration

knowledge and habits. **Results:** The EI and NI groups were not significantly different at baseline for Ucol, USG, FC, WC, hydration knowledge or habits ($P > 0.05$). There was a significant group \times time interaction for Ucol ($P < .001$) and USG ($P < .001$). USG at baseline (EI: $1.026 \pm .006$; NI: $1.022 \pm .009$), data collection 2 (EI: $1.018 \pm .010$; NI: 1.026 ± 0.007) and data collection 3 (EI: $1.022 \pm .009$; NI: $1.025 \pm .007$) demonstrated our responses. A similar interaction was seen with FC ($P = .05$) and WC ($P < .001$). Compared to NI, EI participants increased WC from baseline (EI: 1289.5 ± 768.8 mL; NI: 1109.8 ± 651.8 mL) to data collection 2 (EI: 2173.9 ± 893.9 mL; NI: 1229.0 ± 665.3 mL), but were similar to baseline by data collection 3 (EI: 1560.8 ± 881.0 mL; NI: 1075.6 ± 580.3 mL). Overall, between baseline and data collection 2, EI increased 19% in FC, while NI showed a 6% FC decrease. Our surveys demonstrated no significant differences over time or between groups ($P > .05$). **Conclusions:** A 1-time EI in high school football players improved hydration status and behaviors temporarily despite no increases in hydration knowledge. Our results demonstrated that EI participants increased FC by drinking more water, and this led to improved hydration status. The benefits of our EI did not persist and were not present roughly 3 weeks following EI.

The Influence Of Intermittent Hand Cooling On Core Body Temperature And Performance In The Heat While Wearing An American Football Uniform

Sundeen MW, Huggins RA, Adams WM, Vandermark LW, Dempsey DM, Adams JE, Murray KP, Stearns RL, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Fluid replacement and cooling during exercise have been shown to improve the ability to thermoregulate during exercise in the heat. Wearing an American football uniform increases heat storage and presents a challenge to optimal cooling. New modalities such as peripheral cooling may reduce core body temperature and improve performance in the areas of power, speed, agility, reaction time, and balance.

Objective: To determine the effect of intermittent hand cooling with and without fluid replacement on sport-specific performance measures. **Design:** Randomized crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** Thirteen males (age: 24 ± 3 yrs, height: 179 ± 5 cm, body mass: 82.6 ± 9.8 kg) performed three separate 90-minute treadmill exercise bouts in a hot environment (39°C , $40\%\text{RH}$) while wearing an American football uniform.

Intervention: Participants were randomly allocated to hand cooling (HC), HC with fluid replacement (HCF), and no cooling (CON) in a counterbalanced order. Participants performed HC treatment using a negative pressure device ($\sim 140\text{mmHg}$) on 1 hand every 12th minute of exercise for 3 minutes. **Main Outcome Measure(s):** Participants completed sprint speed on a non-motorized treadmill (Sprint), foot speed count (Count), counter movement vertical jump (VJ), reaction time (React), and modified balance error scoring system (BESS) performance battery before

(PRE) and after (POST) exercise. TRE was measured PRE and POST exercise. A repeated measure ANOVA for condition by time with post-hoc Bonferroni tests set at ($\alpha \leq 0.05$) were utilized to compare differences. Mean differences with 95% confidence intervals, effect sizes (MD, 95% CI, ES) and percent change in performance measures (% Δ) PRE to POST (% Δ , 95% CI, ES) were used to compare performance across conditions. **Results:** POST TRE for HCF ($38.64 \pm 0.39^{\circ}\text{C}$) was significantly different than CON ($39.24 \pm 0.49^{\circ}\text{C}$; $p = 0.005$, $\text{ES} = 0.61$) but not HC ($38.86 \pm 0.45^{\circ}\text{C}$; $p = 0.66$, $\text{ES} = 0.25$). POST TRE for HC was not different than CON ($p = 0.111$, $\text{ES} = 0.41$). Sprint % Δ [HCF-CON] was 4.99%, (95% CI = -0.05 to 10.04), $\text{ES} = 0.73$, [HCF-HC] was 2.12%, (95% CI = -2.93 to 7.17), $\text{ES} = 0.20$, and [HC-CON] was 2.88%, (95% CI = -2.17 to 7.92), $\text{ES} = 0.26$. Count % Δ [HCF-CON] was 3.77%, (95% CI = -2.77 to 10.31), $\text{ES} = 0.31$, [HCF-HC] was 2.06%, (95% CI = -8.59 to 4.48), $\text{ES} = 0.25$, and [HC-CON] was 5.83%, (95% CI = -0.71 to 12.37), $\text{ES} = 0.44$. React % Δ for [HCF-CON] was -5.96%, (95% CI = -14.10 to 2.17), $\text{ES} = 0.51$, [HCF-HC] was -7.10%, (95% CI = -15.23 to 1.03), $\text{ES} = 0.46$, and [HC-CON] was 1.14%, (95% CI = -6.99 to 9.27), $\text{ES} = 0.08$. BESS Δ score [HCF-HC] was -21%, (95% CI = -53 to 12), $\text{ES} = 0.46$, [HC-CON] was -17%, (95% CI = -49 to 16), $\text{ES} = 0.27$, and [HCF-CON] was -37%, (95% CI = -70 to -5), $\text{ES} = 0.53$. **Conclusions:** HCF significantly reduced TREC POST. Furthermore, HCF resulted in improvements in % Δ for Sprint and React compared to CON. Reduced thermal strain in the HCF condition may have allowed for a greater effort during performance tasks POST.

The CoolShirt System™ Aids Thermoregulation During Exertion In A Hot Environment

Stamatis P, Powers ME: Marist College, Poughkeepsie, NY, and Orthopedic Associates of Dutchess County, Poughkeepsie, NY

Context: The incidence of heat illness is greatest in athletes who begin training in late summer when ambient temperature and relative humidity are at their highest. The risk of heat illness is even greater in football, as the clothing and equipment present a significant challenge to thermoregulation. Manufacturers of the CoolShirt System™ claim it can help manage thermoregulation in extreme environments and prevent heat-related illnesses. However, research regarding the efficacy of this system is very limited. **Objective:** The purpose of this study is to determine if the CoolShirt System™ will aid thermoregulation during exercise in a warm environment.

Design: Randomized crossover design. **Setting:** Data was collected in a temperature controlled research laboratory.

Patients or Other Participants: Nine healthy male varsity and recreational athletes (age = 22.00 ± 3.32 y, mass = 83.27 ± 9.26 kg, height = 179.49 ± 5.54 cm) who were acclimated to a warm environment volunteered to participate.

Intervention(s): Each subject was assessed for body mass (BM), heart rate (HR) and core temperature (T_{core}) during a bout of exercise in a warm environment while wearing football equipment and clothing under two conditions, CoolShirt System™ (Cshirt) and cotton T-shirt (Tshirt), separated by a period of one week. The exercise protocol consisted of three sets of ten maximal effort 10-second sprints with 30-second of active recovery on a Monark 834E cycle ergometer in a room maintained at 35°C . The three sets were separated by 5-minute of passive recovery in the same warm environment. **Main Outcome Measure(s):**

Tcore was measured prior to and during exercise using a CorTemp Disposable Temperature Sensor and a CT2000 Miniaturized Ambulatory Recorder (HTI Technologies, Inc, Palmetto, FL). Sweat loss was determined as the change in BM from pre-exercise to immediate post exercise measured using a standard electronic scale. HR was monitored using a Polar T34 chest transmitter (Polar Electro, Inc, Lake Success, NY) which wirelessly transmits the heart rate data to a Polar WearLink compatible receiver. **Results:** ANOVA with repeated measures revealed a significant Time main effect ($F_{6,48} = 63.51$, $p = .001$) for Tcore, as a progressive increase was observed throughout the exercise protocol. Cshirt had no effect however, as a significant Condition x Time interaction ($F_{4,48} = 1.40$, $p = .235$) was not observed. A significant Time main effect ($F_{1,11} = 201.97$, $p = .001$) was also observed for BM, as a significant decrease was observed. The Cshirt did effect sweat loss, as a significant Condition x Time interaction ($F_{1,11} = 4.88$, $p = .044$) was observed. Tshirt resulted in a significant decrease in BM from pre (83.4 ± 9.5 kg) to post (82.7 ± 9.4 kg) exercise, while no change was observed when comparing the pre (83.1 ± 9.5 kg) to post (82.8 ± 9.5 kg) Cshirt BM. **Conclusions:** The CoolShirt System™ enabled subjects to maintain a similar Tcore while sweating less. This might aid the body's thermoregulation when exercising in the heat.

Heat Evidence-Based Forum: Heat Acclimatization in Adolescents

Friday, June 27, 2014, 10:30AM-11:30AM, Room 244; Discussants: David Csillan, MS, ATC, LAT; Rebecca Stearns, PhD, ATC, PES; Moderator: Susan Yeargin, PhD, ATC

Free Communications, Oral Presentations: Upper Extremity Muscle Activation

Saturday, June 28, 2014, 8:00AM-9:00AM, Room 244; Moderator: Stephanie Moore-Reed, PhD, ATC

14269MOMU

Lower Trapezius Muscle Thickness And Strength In Patients With And Without Scapular Dyskinesis

VanDeusen A, Eberman LE, Kahanov L, Demchak TJ, Wasik M, Reynolds K, Evanich JJ, Games KE: Indiana State University, Terre Haute, IN

Context: Dyskinesia has been linked to deficits in muscular strength and neuromuscular control of the scapular stabilizers. Often, when treating overhead athletes with pathological shoulders, Athletic Trainers focus on rotator cuff and scapular muscle strength to find resolution, yet the role of the lower trapezius strength in scapular dyskinesia is not well understood. **Objective:** To measure the relationships and identify differences among varying levels of scapular dyskinesia on lower trapezius muscle thickness and strength. **Design:** Ex-post-factor descriptive design **Setting:** Indiana State University Applied Medicine Research Center. **Patients or Other Participants:** Fifty participants (age = 25.18 ± 5.90 y; mass = 71.67 ± 13.15 kg; height = 173.5 ± 10.2 in; males = 23/50, 46%, females = 27/50, 54%; right-handed = 48/50, 96%, left-handed = 2/50, 4%) completed the study. **Intervention(s):** We evaluated scapular dyskinesia using the clinical visualization technique identifying each scapula as normal, with subtle or with obvious dyskinesia. Participants, depending on body mass, lifted a 3lb (mass < 150lb [68kg]) or 5lb (mass > 150lb [68kg]) weight overhead in flexion (5 repetitions) and abduction (5 repetitions), while a trained clinician observed for normal scapulohumeral rhythm, dysrhythmia, or scapular winging. **Main Outcome Measure(s):** We evaluated strength with a hand-held dynamometer (microFET2, Hoggan Scientific, $\pm 1\%$) with a single arm outstretched overhead in a "Y" position. The strength testing was performed at the same time as the diagnostic

ultrasound (GE LOGIQ®e 2008) measurement of muscle thickness. We used separate one way analyses of variance to examine the size and strength of the lower trapezius and compared it over three levels of scapular dyskinesia to identify the differences in the dominant limb (DL) and non-dominant limb (NDL). We used a Spearman rho correlation to determine the relationship between scapular dyskinesia, muscle strength, and muscle thickness in DLs and NDLs. **Results:** We did not identify any significant differences between DL scapular dyskinesia visual inspection categories on the strength ($F_{2,49} = 0.596$, $p = 0.555$, $1-\beta = 0.93$) and thickness variables ($F_{2,48} = 0.714$, $p = 0.495$, $1-\beta = 0.51$). We did not identify any significant difference between NDL scapular dyskinesia visual inspection categories on the strength ($F_{2,49} = 2.382$, $p = 0.103$, $1-\beta = 0.96$) and thickness variables ($F_{2,47} = 0.631$, $p = 0.537$, $1-\beta = 0.54$). We identified no significant correlation between DL or NDL scapular dyskinesia and strength (DL Spearman's $\rho = -0.160$, $p = 0.266$; NDL Spearman's $\rho = -0.106$, $p = 0.466$) or thickness (DL Spearman's $\rho = -0.175$, $p = 0.230$; NDL Spearman's $\rho = -0.091$, $p = 0.537$). We did identify a significant and strong relationship between DL strength and thickness (Spearman's $\rho = 0.706$, $p < 0.001$) and a significant and moderate relationship between NDL strength and thickness (Spearman's $\rho = 0.414$, $p = 0.003$). **Conclusion:** Our findings suggest that lower trapezius strength and thickness have little impact on the presence of scapular dyskinesia. As such, neuromuscular control should be studied to better understand the multifactorial issue of scapular dyskinesia. Our findings also confirmed our hypothesis that muscle strength and thickness are strongly correlated, particularly in the dominant limb.

Activity Comparison Of The Serratus Anterior And Lower Trapezius Muscles During Different Exercise Orientations

Tsuruike M, Ellenbecker TS: Department of Kinesiology, San José State University, San Jose, CA, and Physiotherapy Associates Scottsdale Sport Clinic, Scottsdale, AZ

Context: The serratus anterior (SA) and lower trapezius (LT) muscles have been intensively studied in both asymptomatic and symptomatic shoulders. However, the effect of different exercise intensities on SA and LT muscular activity has not been investigated. **Objective:** To identify SA and LT muscular activity with different intensities during different exercise orientations. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen male active asymptomatic volunteers (19.5 ± 1.2 yrs, 173.1 ± 6.5 cm, 68.8 ± 6.6 kg) were tested. **Intervention:** The EMG signals (root-mean-square) for the SA, LT were collected in two free motion exercises: lawnmower (LM) and robbery (RB). The subjects simultaneously utilized knee, hip, and trunk extension during the LM, whereas no knee and hip extension was utilized during the RB. The EMG values were also compared with the isometric contraction of quadruped shoulder flexion (QSF) at 180° of shoulder flexion. Three different intensities of dumbbells were used and represented 3%, 5% and 7% of body weight (BW) for each exercise. **Main Outcome Measure(s):** A 3X3 repeated measures ANOVA design was used to identify a difference in each of the muscle activities (a percentage of maximum voluntary isometric contraction). **Results:** For QSF, the mean values of SA EMG activity were significantly increased as intensity was increased ($56.3 \pm 20.9\%$, $78.3 \pm 29.1\%$ and $88.1 \pm 33.4\%$ respectively, $p < 0.05$). Also, the mean values of SA EMG activities during QSF were significantly

greater than those of the LM at each of the corresponding intensities ($p < 0.05$). In contrast, no difference in the mean value was observed between QSF and RB at 3% BW whereas significant differences were observed between QSF and RB at 5% and 7% BW ($78.3 \pm 29.1\%$ and $88.1 \pm 33.4\%$ QSF vs. $60.4 \pm 15.7\%$ and $67.0 \pm 18.7\%$ RB respectively, $p < 0.05$). Likewise, the mean values of LT EMG activity during QSF were significantly increased while intensity was increased ($69.4 \pm 17.8\%$, $79.6 \pm 9.6\%$, $86.9 \pm 12.6\%$ respectively, $p < 0.05$). However, for LM no difference in the mean values of LT EMG activities was observed across the different intensities. The mean values at both 5% and 7% BW during LM were significantly smaller than those of RB ($28.4 \pm 15.8\%$ and $28.8 \pm 14.9\%$ LM vs. $43.2 \pm 12.6\%$ and $46.7 \pm 12.5\%$ RB respectively, $p < 0.05$). **Conclusions:** During the QSF exercise, the SA and LT showed the highest EMG activity compared with the other two free motion exercises. For LM it is plausible to speculate that the subjects progressively activated the lower leg, hip and trunk muscles while the intensity was increased, which led to no difference in the LT activity. Free motion exercises with the kinetic chain sequences of force transferred from the lower extremity to upper extremity have been currently recommended for scapular rehabilitation, but still more research is needed to better clarify the effect of joint positions and exercise intensities on target muscle activity in the SA and LT.

Serratus Anterior Activation In Overhead Athletes With Shoulder Impingement During Phases Of The Push-Up

Smith CA, Tucker WS: University of Central Arkansas, Conway, AR

Context: Studies have demonstrated the benefits of using the standard push-up to activate the serratus anterior in patients with and without shoulder impingement. Limitations such as pain and lack of muscle strength may prevent patients from performing a standard push-up. A better understanding of serratus anterior activation during the phases of a push-up may assist clinicians and patients. **Objective:** To compare serratus anterior activation in overhead athletes with and without shoulder impingement during the isometric plank, eccentric and concentric phases of a standard push-up. **Design:** One-between (group), one-within (phase) mixed model. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Twelve overhead sport athletes (9 females: 19.9 ± 1.3 years, 174.6 ± 5.0 cm, 74.2 ± 10.6 kg, 3 males: 24.0 ± 4.6 years, 183.7 ± 3.2 cm, 94.1 ± 11.4 kg) demonstrating symptoms of shoulder impingement (SI) and 12 overhead sport athletes (9 females: 20.1 ± 1.6 years, 170.7 ± 8.4 cm, 71.1 ± 12.4 kg, 3 males: 23.3 ± 8.4 years, 180.3 ± 3.4 cm 83.0 ± 6.9 kg) with no history of shoulder injuries (NI). **Intervention(s):** Clinical signs and symptoms for participants in the SI group were reproduced during an orthopedic assessment that included the Apprehension test, Jobe Relocation test, Neer Impingement test, Cross-over Impingement test and Hawkins-Kennedy test. All participants completed three individual trials of a standard push-up while electromyography of the serratus anterior was sampled at 1000 Hz. Trials consisted of a 1-second isometric plank phase, 1-second eccentric phase and 1-second concentric phase. Trial velocity was

controlled using a metronome. Trunk and shoulder positioning were normalized to the subject's height. There was a one-minute rest period between trials. Mean electromyography data for the serratus anterior were normalized to a maximum voluntary isometric contraction. The independent variables were group (SI and NI) and phase (isometric plank, eccentric and concentric). **Main Outcome Measure(s):** The dependent variable was the normalized mean electromyography of the serratus anterior. The influence of group and phase on serratus anterior activation was compared using a 2x3 factorial ANOVA with repeated measures on the within variable. Alpha level was set a priori at $P \leq 0.05$. **Results:** A main effect for phase ($F_{2,44} = 57.968$; $P < 0.001$) was detected. Pairwise comparisons determined the concentric phase ($71.32 \pm 28.23\%$) was greater than the eccentric ($45.73 \pm 19.58\%$) and isometric plank phases ($38.81 \pm 16.68\%$). The eccentric phase was greater than the isometric plank phase. There was no main effect for group ($F_{1,22} = 2.311$; $P = 0.143$) and no group-by-phase interaction ($F_{2,44} = 0.617$; $P = 0.544$). **Conclusions:** Differences in serratus anterior activation were evident within the three phases. The concentric phase elicited the greatest activation, while the isometric plank phase elicited the least amount of activation. Compared to non-injured individuals, patients with SI elicit similar SA activation during the three phases of a push-up. Future research should investigate other exercises resulting in high levels of SA activation that can be comfortably and successfully performed by patients with SI.

Scapular Muscle Activities During Closed Chain Shoulder Exercises

Porter AC, Nitz AJ, Malone TR, Uhl TL: University of Kentucky, Lexington, KY

Context: Over activation of the upper trapezius (UT) and inhibition of the serratus anterior (SA) and lower trapezius (LT) are reported in patients with shoulder pathologies. Further research is needed to determine exercises that activate the SA and LT while minimally activating the UT. **Objective:** The purpose of the study is to investigate the UT/SA and UT/LT ratios during seven shoulder rehabilitation exercises. **Design:** Cross-sectional study. **Setting:** Clinical laboratory. **Patients or Other Participants:** 13 subjects (age, 33 ± 12 years; height, 1.7 ± 0.10 meters; mass, 82 ± 17 kg) with no history of shoulder injury were recruited from a sample of convenience. **Intervention(s):** The independent variables were the 7 exercises: knee push-up plus, wall push-up plus, incline push-up plus, wall slide, ball roll with depression, inferior glide, and active forward elevation. Surface EMG signal was obtained from the UT, LT and the SA using previously established electrode placements. Three maximal voluntary isometric contractions (MVIC) were recorded for the UT, LT and the SA and averaged to represent MVIC. Subjects then completed the seven exercises based on a predetermined counterbalanced order. Muscle activity was recorded during the concentric performance of each exercise and was normalized to the MVIC value. **Main Outcome Measure(s):** The UT/SA and UT/LT ratios were determined for each exercise from the normalized values. Separate non-parametric repeated measure Friedman's test for each ratio was performed comparing the seven exercises with significance set at ($P \leq .05$). If a significant difference was found a correction for

multiple comparison was performed using a Bonferroni correction. Adjusting for 21 potential comparisons between all exercises altered alpha level to ($P < .0024$). Twenty-one Wilcoxon Signed Rank Tests were performed to compare differences between each exercise with significance set at ($P < .0024$). **Results:** UT/SA ratios were highest for active forward elevation ($1.3 \pm .7$) and for wall push-up plus ($.76 \pm .4$). These ratios were not different from each other ($P = .006$) but were significantly greater than the UT/SA ratios for the inferior glide ($.15 \pm .11$, $P = .001$), ball roll with depression ($.27 \pm .20$, $P = .002$), knee push-up plus ($.29 \pm .14$, $P = .002$), wall slide ($.29 \pm .20$, $P = .002$), and incline push-up plus ($.31 \pm .15$, $P = .002$). UT/LT ratio was greatest for wall push-up plus (4.5 ± 3.1) which was found to be significantly greater than the inferior glide ($.2 \pm .3$, $P = .001$), ball roll with depression ($.4 \pm .37$, $P = .001$), and wall slide ($.6 \pm 1.2$, $P = .001$). **Conclusions:** Wall push-up plus and active forward elevation appear to bias upper trapezius activation relative to the other exercises studied. Clinicians should consider using exercises such as the inferior glide, ball roll with depression, and wall slide first during rehabilitation as they tend to activate the serratus anterior and lower trapezius more while not overly activating the upper trapezius. As patients progress, introducing incline and knee push-up plus exercises would promote a favorable UT/SA and UT/LT ratio. Funding by the National Athletic Trainers Association Research and Education Foundation Masters Grant

Head Evidence-Based Forum: Baseline Versus Normative Values for Concussion

Saturday, June 28, 2014, 9:15AM-10:15AM, Room 244; Discussants: Julianne Schmidt, MA, ATC; Robert Lynall, MS, ATC; Moderator: Janna Fonseca, MEd, ATC

Free Communications, Oral Presentations: Emergency Concussion Assessment Techniques

Saturday, June 28, 2014, 10:45AM-12:00PM, Room 244; Moderator: Richelle Mayfield, MS, ATC
14104DOBI 14148DOSF

Changes in Lower Extremity Stiffness Following Concussion In Collegiate Football Players

DuBose DF, Herman DC, Tillman SM, Moser MW, Pass AN, Jones D, Clugston JR, Farmer KW, Chmielewski TL: University of Florida, Gainesville, FL, and Texas Tech University, Lubbock, TX

Context: It is well documented that neurocognitive function, balance, and gait are altered following concussion, however little is known about the effect of concussion on jump landings. Changes in lower extremity stiffness during jump landings may represent altered mechanisms for joint stabilization and movement control, potentially increasing lower extremity injury risk. **Objective:** To examine changes in stiffness of the entire lower extremity and at each joint during a jump landing in football players following a concussion. **Design:** Pre-test/post-test study. **Setting:** UF Health Orthopaedics and Sports Medicine Institute. **Patients or Other Participants:** Male Division I football players ($n = 13$, age 19.5 ± 0.7 years) who sustained a concussion within 90 days of the post-season. **Intervention(s):** During test pre- and post-season sessions subjects completed a single limb forward land on each side. Subjects jumped from a 25.4 cm step onto a force plate and held their position for 3 seconds. **Main Outcome Measure(s):** Medical records provided concussion data. Right and left limb values were averaged for each variable. Variables included hip, knee, ankle, and leg stiffness. To calculate stiffness at each joint the internal joint extensor moment were normalized to body mass (kg) and plotted against joint flexion angle from initial contact to peak flexion. Regression lines were created and the slopes represented sagittal plane stiffness for the hip, knee, and ankle. Peak vertical reaction force (PVGRF) was normalized to body weight (BW). Leg

stiffness was calculated as the PVGRF/vertical displacement of the lower extremity, determined from the marker placed at the iliac crest, from initial contact to PVGRF. Paired samples t-tests measured differences in pre- and post-season measures. **Results:** Average time from concussion to post-season testing was 49.9 ± 24.2 days. Knee and ankle stiffness decreased significantly (knee: 0.059 ± 0.013 Nm/kgdeg versus 0.047 ± 0.015 Nm/kgdeg, $p = 0.007$; ankle: $0.027 \pm .011$ Nmkg/deg versus 0.021 ± 0.012 Nm/kgdeg, $p = 0.012$), and leg stiffness also decreased significantly from pre- to post-season testing (19.38 ± 4.69 BW/m versus 16.48 ± 3.52 BW/m, $p = 0.008$). Pre- and post-season values for hip stiffness were not statistically different (0.002 ± 0.030 Nmkg/deg versus 0.012 ± 0.034 Nm/ kgdeg, $p = 0.101$). **Conclusions:** Following concussion knee, ankle, and leg stiffness are decreased. Insufficient levels of joint or leg stiffness have been shown to be a potential neuromuscular risk factor for lower extremity injury because altered stiffness may effect joint stabilization. Clinicians may need to include neuromuscular training into concussion rehabilitation protocols to reduce the risk of injury.

Comparing Computer-Derived And Human-Observed BESS Scores

Caccese JB, Kaminski TW: University of Delaware, Newark, DE

Context: Recent guidelines for concussion assessment recommend the use of the Sport Concussion Assessment Tool (SCAT) 3. This compilation of concussion evaluation tools includes the use of the Modified Balance Error Scoring System (BESS). Some research has questioned the objectivity and validity of the BESS test, suggesting that while certain subcategories of the BESS test have sufficient reliability to be used in the evaluation of postural stability, the total BESS score is not reliable, demonstrating limited inter-rater and intra-rater reliability. Recently, a computerized BESS test has been developed to automate the scoring of this concussion assessment tool. **Objective:** The purpose of this investigation was to compare computer-derived BESS scores with those taken from three trained human scorers. **Design:** Inter-rater reliability study. **Setting:** Athletic training room. **Patients or Other Participants:** Seventy-five NCAA Division-I student-athletes (26 male, 49 female, 19 ± 2 years, 173 ± 9 cm, 70 ± 10 kg) volunteered for this study. **Intervention(s):** Subjects were asked to perform the Modified BESS, which includes three stances: single-leg (non-dominant), double-leg, and tandem (non-dominant in back) while standing on the Tekscan (Boston, MA) MobileMat™ BESS. Each stance was maintained for 20 seconds with the hands on hips and eyes closed. Simultaneously, BESS test errors were recorded by three separate examiners. Each trial was scored by counting the errors or deviations from the proper stance using the standardized BESS scoring criteria. Additionally, the MobileMat™ BESS software, guided by an algorithm based off the BESS scoring criteria, displayed an error score

at the end of each trial. **Main Outcome Measure(s):** The number of BESS test errors was computed for the three stances from the software and each of the three human scorers. Interclass correlation coefficients (ICC) were used to compare the errors for each of three stances scored by the MobileMat™ BESS software to each of the three human raters, individually. The ICC values were converted to Fisher's Z-scores, averaged, and converted back into ICC values. Fleiss set guidelines (1981) for inter-rater reliability, where ICC values of <.39 indicates a poor level of agreement, the .40-.59 interval indicates fair agreement, .60-.74 indicates good agreement, and >.75 indicates excellent agreement. **Results:** The double-leg stance resulted in perfect agreement (ICC = 0.999) between MobileMat™ BESS scores and human raters; while, the single-leg (ICC = 0.663) and tandem (ICC = 0.753) stances resulted in good agreement. **Conclusions:** Our results suggest that the MobileMat™ BESS is suitable in identifying BESS errors involving each of the three stances of the Modified BESS protocol. Because the MobileMat™ BESS scores consistently and reliably, this system can be used with confidence by clinicians as an effective alternative in scoring the Modified BESS test. Further study involving the entire BESS protocol as well as total composite scores is warranted.

Systematic Review Of Smartphone Accelerometer Validity And Reliability: Practical Applications For Measuring Concussion Related Balance Deficits

Kasamatsu TM, Cleary MA, Bonilla DJ: Athletic Training Program, Chapman University, Orange, CA

Context: The popularity of smartphones and their capabilities has resulted in the development of many concussion-related smartphone applications for medical and lay communities. The recommendation for baseline, sideline, and post-concussion balance assessment makes smartphone applications ideal due to their portability, time-effectiveness, ease of use, and inexpensive nature. Many smartphone concussion applications use the built-in accelerometer, such as the SwayBalance (SwayMedical LLC., Tulsa, OK) application for the iPhone/iPad (Apple, Inc, Cupertino, CA), but may yield unreliable data for clinical use. To date, no studies currently exist to evaluate concussion-specific smartphone balance applications; however, researchers have investigated the validity and reliability of smartphone accelerometers to measure gait stability, balance training, range of motion, and activity. **Objective:** To systematically review the literature to establish the reliability and validity of smartphone accelerometers and accelerometer-based inclinometers for the application to concussion-related postural stability measurement. **Data Sources:** We searched PubMed/MEDLINE, CINAHL Plus, and SportDiscus with the key words: concussion, smartphone, cell phone, mobile phone, accelerometer, inclinometer, postural stability, balance, gait, and range of motion. Limits included peer-reviewed studies, human subjects, and English language. Reference lists of selected articles were reviewed

for pertinent studies missed during the initial search. **Study Selection:** Article titles, key words, and abstracts were scanned for inclusion. Studies were included if they reported the reliability and/or validity of the use of smartphone accelerometers or inclinometers. Conference proceedings or studies that did not use the accelerometer/inclinometer in smartphones were excluded. **Data Extraction:** We analyzed 18 studies, summarized results, and scored studies according to the Physiotherapy Evidence Database rating (PEDro) scale. **Data Synthesis:** Of the 18 studies analyzing smartphone accelerometers, 5/18 (27.8%) assessed gait or postural stability, 7/17 (38.9%) measured range of motion using a goniometric/inclinometer application, and 6/17 (33.3%) evaluated physical activity. Mean PEDro score was 3.8 ± 1.2 points. Criterion-related validity and intra-tester and inter-tester reliability (Pearson r, intra-class correlations, Bland-Altman, and linear regression analysis) were compared for studies using smartphone accelerometers to assess gait, postural stability, range of motion, and scoliosis curvature. Smartphone validity closely correlated with traditional methods (criterion-related validity, range = 0.83-0.99) and measurements were reproducible by the same clinician (intra-rater reliability, range = 0.80-0.95) and multiple clinicians' (inter-rater reliability, range = 0.70-0.98). **Conclusions:** Smartphone accelerometers are valid and reliable tools for the measurement of gait stability, postural stability, range of motion, and activity. As such, smartphones may be an ideal time and cost-effective tool for concussion-related balance assessment on the sideline or in the athletic training clinic. As smartphone applications continue to be developed, further research is necessary to establish reliability and validity of each application. While smartphone accelerometers have demonstrated moderate to excellent validity and

reliability, clinicians should use caution when implementing smartphone applications into daily clinical practice without sufficient reliability data.

Visuo-Motor Processing Impairments Following Concussion In Athletes

Cripps AE, Livingston SC, Jiang Y, Mattacola CG, Kitzman PH, Van Meter EA, McKeon PO: New Mexico State University, Las Cruces, NM; Wounded Warrior Battalion – East, Camp Lejeune, NC; University of Kentucky, Lexington, KY; Ithaca College, Ithaca, NY

Context: Proper evaluation and diagnosis of a concussion is crucial for athletes' safety. A battery of tools including symptom inventories, balance assessments, and neuropsychological testing is suggested for initial diagnosis and guiding return-to-play (RTP) decisions. The visuo-motor system is an essential component of an athlete's ability to successfully navigate through their environment during sports participation. The effect of an acute sport-related concussion on the visuo-motor system and the athlete's ability to successfully visually 'map their surroundings' have not been investigated. Examining visuo-motor processing following a concussion will provide insight into the underlying pathophysiological processes affecting the athlete's ability to navigate through their environment. Assessing visuo-motor function will also provide a comprehensive examination for clinical recovery following a concussion, allowing the athletic trainer to make a more informed decision regarding RTP. **Objective:** To determine if visuo-motor processing is altered in athletes following a sports-related concussion. **Design:** Longitudinal matched cohort. **Setting:** University research laboratory. **Patients or Other Participants:** Fourteen interscholastic, club, and intercollegiate athletes (8 males, 6 females, 7 concussed subjects [age 17.1 ± 3.0 years, height 174.0 ± 74.2 cm, mass 73.3 ± 23.8 kg], 7 control subjects [age 17.3 ± 3.0 years, height 178.8 ± 11.6 cm, mass 77.9 ± 23.4 kg]) participated.

Concussed subjects (< 48 hours since time of injury) were matched by age, gender, and sport. **Intervention(s):** All subjects completed a simple visuo-motor processing task (SVMP). Each subject completed 120 randomized trials on a modified computer keyboard. Subjects were asked to identify which direction the motion occurred in (left or right). Repeated testing was conducted 10 days following initial testing. **Main Outcome Measure(s):** Reaction time (overall, each grouping of 20 trials, ambiguous and unambiguous trials right/left), number of correct responses, and number of incorrect responses. A repeated measures ANOVA was conducted to determine differences between groups (concussed/control) and sessions (10 days apart). **Results:** A significant day by group interaction was found for overall reaction time ($F_{1,6} = 3.780$, Wilk's $\lambda = 0.759$, $p = 0.076$, $\omega^2 = 0.241$, $1-\beta = 0.577$). Independent pairwise post-hoc analysis revealed concussed athletes had significantly delayed reaction time on test 1 compared to test 2 (test 1 = 496.18 ± 52.85 ms, test 2 = 439.01 ± 20.62 ms), and concussed athletes demonstrated significantly slower reaction time compared between days of testing; to the left direction (test 1 = 484.97 ± 64.60 ms, test 2 = 429.35 ± 34.19 ms), right (test 1 = 474.88 ± 44.44 ms, test 2 = 413.76 ± 28.79 ms), and ambiguous trials (test 1 = 530.62 ± 62.74 ms, test 2 = 472.30 ± 26.98 ms). Concussed athletes also demonstrated significantly slower reaction time on test 1 compared to control subjects (concussed = 530.62 ± 62.74 ms, control = 452.58 ± 81.13 ms). **Conclusions:** Visuo-motor processing is impaired during the initial 10 days following a sports-related concussion. Concussed athletes demonstrate functional differences in SVMP task performance between testing days. An athlete may be placed at greater risk of injury if returned to sports participation with an impaired ability to quickly make

decisions regarding direction of movement. Visuo-motor processing should be a routine component of concussion assessment and RTP decision making.

Concussion Assessment Using The Brain Acoustic Monitor

Acocello S, Broshek DK, Saliba S:
University of Virginia, Charlottesville, VA

Context: Standard assessment of concussion does not typically include measures that directly assess physiological changes, such as cerebral blood flow, that occur following concussion. A device called the Brain Acoustic Monitor (BAM) is purported to detect cerebral blood flow changes through the amplification of sound waves created by cerebral arteries and comparing those characteristics to a reference artery in a peripheral limb. The BAM could provide a physiological measure of concussion with unique diagnostic utility.

Objective: To assess the changes in the BAM measures following sport concussion through return to activity. **Design:** Repeated measures. **Setting:** Sports Medicine Clinic. **Patients or Other**

Participants: Seven concussed athletes (4 males, 3 females; 19.4 ± 2.2 years; 67.4 ± 5.7 kg; 171.7 ± 59.3 cm) were recruited from NCAA Division I athletic teams. Concussion was confirmed by physician diagnosis. **Intervention(s):**

Assessments included readings with the BAM at three time points: 24 to 48 hours post-injury, symptom-free status, and upon clearance for full activity (RTA). BAM assessment involved application of two small sensors at the forehead and one at a digital artery using a finger clip. Approximately 5 readings were used to obtain proper sensor placement after which 3 readings were recorded for analysis. **Main Outcome**

Measure(s): For BAM measurements, two outcomes were collected from each sensor, denoted left and right. The first outcome, ratio, characterized wave erraticism by quantifying the ratio of positive signal excursion to negative signal excursion. The second outcome, divergence, was a comparison of the frequency components of the brain signals

to the reference signal. All outcomes were compared between the three time points using separate repeated measures analysis of variance. Secondary analysis was performed using step-wise linear regression to determine if initial BAM measures were significant predictors of time to RTA. Alpha was set to $P \leq 0.05$. **Results:** No significant differences were found between initial assessment, time of symptom recovery, and day of RTA for left and right ratio and divergence (Left ratio: post-injury = 3.92 ± 0.77 V, symptom-free = 3.37 ± 1.02 V, RTA = 3.30 ± 0.37 V, $F = 1.353$, $P = 0.295$; Right ratio: post-injury = 4.07 ± 1.22 V, symptom-free = 3.13 ± 0.98 V, RTA = 3.90 ± 0.80 V, $F = 2.855$, $P = 0.097$; Left divergence: post-injury = 6.09 ± 5.40 dB, symptom-free = 8.76 ± 4.37 dB, RTA = 9.40 ± 4.77 dB, $F = 2.428$, $P = 0.13$; Right divergence: post-injury = 8.50 ± 6.16 dB, symptom-free = 7.39 ± 5.38 dB, RTA = 9.81 ± 5.83 dB, $F = 0.555$, $P = 0.588$). Additionally, no outcomes were found to be significant predictors of time to RTA (average RTA = 7.7 ± 3.3 days, $R^2 = 0.661$, $P = 0.563$).

Conclusions: BAM measures were not different when athletes returned to full activity compared to assessments at 24-48 hours post-concussion and after initial symptom recovery. BAM measures may not be sufficiently sensitive to detect cerebrovascular differences in a concussed population or may need baseline measurements for post-injury comparison. These findings should be interpreted with caution, however, due to the small sample.

Free Communications, Oral Presentations: Concussion Risk and Assessment

Saturday, June 28, 2014, 12:15PM-1:30PM, Room 244; Moderator: Ashley Littleton, MA, ATC

14345SOSP

Influence Of Age On Baseline Standardized Assessment Of Concussion Concentration Scores

Benson S, Glaviano NR, Saliba S: Saint Anne's-Belfield School, Charlottesville, VA, and University of Virginia, Charlottesville, VA

Context: The Child-SCAT3 was recently released standardized concussion evaluation tool for children under 12 years old. One main difference between previous SCAT battery tests and Child-SCAT3 is an alteration in the concentration subsection within the Standardized Assessment of Concussion (SAC). However, there is little evidence that supports age related variations in the SAC score to substantiate the cutoff for the altered SAC concentration task. **Objective:** To examine the differences in total SAC and subcomponent scores between 12-18 year old student-athletes. **Design:** Cross-Sectional. **Setting:** Single private middle school and high school. **Patients or Other Participants:** 361 student-athletes between 12 and 18 years old (14.6 ± 1.77 years old) with no history of concussion. **Intervention(s):** Subjects completed the SAC test as part of a preseason baseline concussion testing that included neurocognitive assessments. **Main Outcome Measure(s):** Dependent variables were the total SAC test and the four subcomponents (orientation, immediate memory, concentration and delayed recall). Statistical analyses were simple linear regression using age as a predictor on the SAC score and the four-subcomponent scores with an alpha level set a priori at $P < 0.05$. One-way analyses of variance were used to compare total SAC scores and individual subsections by age, separated by whole years between 12 and 18. Tukey's post hoc testing was used to identify differences between the age groups. The percentage of correct answers for the five concentration tasks (3-digit, 4-digit, 5-digit, 6-digit

and months backwards) were also calculated for each single year age group.

Results: Simple linear regression identified age to be a significant predictor for the SAC concentration subcomponent task ($r^2 = 0.187$, $b = 0.447$, $P = 0.001$). Age was not found to be a predictor of the total SAC score ($r^2 = -0.032$, $b = -0.130$, $P = 0.283$) or other subcomponents; Orientation ($r^2 = -0.059$, $b = -0.344$, $P = 0.146$), Immediate Memory ($r^2 = -0.05$, $b = -0.044$, $P = 0.764$), or Delayed Recall ($r^2 = -0.133$, $b = -0.069$, $P = 0.613$). There was a statistical difference in the SAC concentration subscale by age ($P = 0.01$). Post hoc testing identified statistical differences in concentration between 12 and 15 year-olds (3.3 ± 1.1 , 3.9 ± 1.1 , $P = 0.031$) and 12 and 18-year olds (3.3 ± 1.1 , 4.2 ± 1.0 , $p = 0.039$). When comparing the responses for the five concentration tasks, 12 year olds had the lowest percentage of correct responses for the five-digit (46%), six-digit (21%) and month's backward (67%) tasks. **Conclusions:** Age was a good predictor on SAC concentration scores. We also found that 12 year olds had lower concentration scores and an increased difficulty with the advanced SAC concentration tasks compared to the older student-athletes. There were no other differences between any other measures by age. These results provide some evidence that age appropriate concussion baseline testing is important for clinicians to consider.

Computerized Neurocognitive Performance Does Not Reflect Gross Visual-Motor Function During Concussion Baseline Assessments

Bolding BA, Ford KR, Smoliga JM, Nguyen A: High Point University, High Point, NC

Context: Management of sport-related concussions commonly includes the use of computerized neurocognitive assessment methods. Verbal and visual memory, processing speed, and reaction time are assessed through a battery of modules on a personal computer. A potential limitation with this assessment method is that it may not effectively evaluate changes in gross visual-motor function resulting from a sport-related concussion. While an appropriate level of gross visual-motor function is essential in safe return to activity following injury and in the overall management of sport-related concussions, it is unknown if computerized neurocognitive assessment methods are effective in assessing the combination of neurocognitive performance and gross visual-motor function. **Objective:** To examine the relation between baseline performance using a computerized neurocognitive testing method and a gross visual-motor testing method. **Design:** Cross-sectional study. **Setting:** Athletic training clinic and research laboratory. **Patients or Other Participants:** Forty-nine male (20.1 ± 1.4 yrs, 179.9 ± 6.6 cm, 81.5 ± 14.0 kg) and twenty-seven female (19.7 ± 1.1 yrs, 165.0 ± 6.7 cm, 65.0 ± 6.9 kg) Division I lacrosse players participated. **Intervention(s):** All participants completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and Dynavision gross visual-motor tests (D2), as part of a concussion baseline assessment protocol. **Main Outcome Measure(s):** Separate Pearson correlations (r) examined the relation between ImPACT composite scores (visual-motor speed, reaction time, impulse control, verbal memory)

and D2 visual-motor tests (visual-motor speed, right and left reaction score, dual task reaction, dual task memory recall) in males and females. **Results:** In males, the ImPACT composite scores of reaction time (0.617 ± 0.064 s) were correlated ($r = 0.369$, $P = 0.011$) with D2 right limb reaction score (0.490 ± 0.082). ImPACT composite scores of verbal memory (83.8 ± 8.6) were correlated ($r = 0.334$, $P = 0.022$) with D2 dual task memory recall (4.73 ± 1.75). In females, only ImPACT composite scores of verbal memory (82.9 ± 11.9) were correlated ($r = 0.605$, $P = 0.001$) with D2 dual task reaction percentage ($72.8 \pm 18.6\%$). No other significant correlations ($P > 0.05$) were observed between the other ImPACT and D2 measures for males (range = -0.187 – 0.259) and females (range = -0.281 – 0.319). **Conclusions:** Weak to moderate correlations were only observed between baseline reaction performance tests using computerized neurocognitive and gross visual-motor assessment methods. Furthermore, reaction time may be specific to the right limb and not reflect reaction time of the contralateral limb. The lack of observed correlations between other components baseline tests indicates that computerized neurocognitive assessment methods may not be effective in evaluating the combination of neurocognitive and gross visual-motor performance. Based on these findings, the addition of gross visual-motor assessments should be considered in the management of sport-related concussion.

Does ADHD Affect Neurocognitive Performance And Symptoms In Concussed Athletes?

Covassin T, Elbin RJ, McAllister D, Whalen D: Michigan State University, East Lansing, MI; University of Arkansas, Fayetteville, AR; University of Pittsburgh, Pittsburgh, PA

Context: The assessment and management of sport-related concussion can be very challenging given the often-inconsistent injury presentation and variable recovery time associated with this injury. Despite high prevalence rates in adolescent and college-aged athletes, attention deficit hyperactivity disorder (ADHD) has received little empirical attention in the sport-concussion literature. Thus additional data on the effects of ADHD on concussion outcomes is needed. **Objective:** The purpose of this study was to compare changes in neurocognitive performance and symptom reports following sport-related concussion between concussed athletes with and without ADHD. **Design:** Prospective cohort study. **Setting:** This study was performed in a controlled laboratory and field setting. **Patients or Other Participants:** A total of 122 concussed athletes volunteered to participate in the study (61 ADHD: age = 17.6 ± 2.8 years, height = 168.0 ± 46.2 cm, mass = 79.8 ± 30.9 kg, 61 No ADHD: age = 17.6 ± 2.6 years, height = 172.0 ± 33.4 cm, mass = 83.7 ± 24.7 kg). **Intervention(s):** The independent variables were concussion group (ADHD vs No ADHD) and time of assessment (baseline, 2, 7 days post-injury). Participants completed the Immediate Post-concussion Assessment and Cognitive Test (ImPACT), Post-concussion Symptom Scale (PCSS), and self-reported if they had ADHD at baseline; and at 2 and 7 days post-concussion. A series of 2 group (ADHD vs No ADHD) X 3 time (baseline, 2, 7

days) repeated measures ANOVA were performed for each of the four ImPACT composite scores and the four symptom clusters. **Main Outcome Measure(s):** Dependent variables included ImPACT composite scores (verbal/ visual memory, reaction time, processing speed) and symptom clusters (cognitive-migraine-fatigue, somatic, sleep, affective). Separate ANOVAs with Bonferroni correction and post-hoc means comparisons were performed using Tukey's HSD. A bonferroni-corrected p value was set $p = .01$ to control for multiple comparisons. **Results:** There were no group by time significant interactions for verbal memory ([ADHD: No ADHD] $M = 78.3 \pm 14.9$: $M = 81.6 \pm 12.1$ $p = .23$), visual memory ($M = 66.5 \pm 14.7$: $M = 68.5 \pm 14.3$ $p = .59$), motor processing speed ($M = 37.3 \pm 8.7$: $M = 38.4 \pm 8.6$ $p = .45$), and reaction time ($M = .59 \pm .08$: $M = .58 \pm .09$ $p = .22$). There were also no group by time significant interactions for cognitive-migraine-fatigue cluster ($M = 5.4 \pm 7.2$: $M = 3.9 \pm 7.1$ $p = .96$), somatic cluster ($M = .61 \pm 1.6$: $M = .39 \pm 1.3$ $p = .52$), affective cluster ($M = .11 \pm .64$: $M = .10 \pm .45$ $p = .85$), and the sleep cluster ($M = .85 \pm 2.1$: $M = .52 \pm 1.6$ $p = .76$). **Conclusion:** Overall this study suggests that there are no differences on post-concussion neurocognitive performance and symptoms between concussed athletes with and without ADHD. Although clinicians believe that ADHD is a 'moderating' variable in sports-related concussion management, results from our study suggest they have no effect on an athletes' cognitive function following concussive injury. .

The Effect Of Concussion History And Scholastic Age On Visual Performance

Mihalik JP, Lynall RC, Schmidt JD, Register-Mihalik JK: The University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Georgia, Athens, GA; WakeMed Health & Hospitals, Raleigh, NC

Context: The inclusion of visual and oculomotor screenings in multifaceted concussion management protocols is on the rise. Some researchers speculate deficits in visual performance may be a potential concussion risk factor and may also be affected following injury. This clinical research area has not been explored. **Objective:** To determine the effect of concussion history and scholastic age (college or high school—HS) on visual performance in student-athletes. We hypothesized that student-athletes with a concussion history would perform worse than those with no history. No differences were expected for age. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** College ($N = 134$; age = 20.5 ± 2.4 yrs) and HS ($N = 66$; age = 17.1 ± 0.9 yrs) student-athletes. **Intervention(s):** Participants completed a valid and reliable visual performance evaluation (Nike SPARQ Sensory Station) prior to the start of the athletic season. Participants were categorized by concussion history self-report (no history vs. 1+ concussions) and scholastic age (college vs. HS). **Main Outcome Measure(s):** The SPARQ measured visual acuity, contrast sensitivity, depth perception, near-far quickness, target capture, perception span, eye-hand coordination, and go/no-go reaction. We employed a 2 (concussion history) \times 2 (scholastic age) ANOVA for each outcome. **Results:** Visual acuity, measured as Logarithm of Minimum Angle of Resolution (LogMAR; lower value is better), was better ($F_{1,196} = 7.18$; $P = 0.008$) in student-athletes

with no concussion history (LogMAR = -0.23 ± 0.01) compared to those with a concussion history (LogMAR = -0.16 ± 0.02). Student-athletes with a concussion history (1869.6 ± 129.4 ms) responded more slowly to depth perception tasks than student-athletes with no concussion history (1493.1 ± 71.8 ms; $F_{1,196} = 6.47$; $P = 0.012$). Concussion history (31.8 ± 1.6) reduced the number of correct perception span (visual memory) responses compared to those with no concussion history (35.8 ± 0.9 ; $F_{1,196} = 4.72$; $P = 0.031$). College student-athletes had better visual acuity (LogMAR = -0.23 ± 0.02) than HS student-athletes (LogMAR = -0.16 ± 0.02 ; $F_{1,196} = 8.06$; $P = 0.005$). College student-athletes completed more correct repetitions of the near-far quickness assessment (college = 27.2 ± 0.5 ; HS = 25.0 ± 0.8 ; $F_{1,196} = 5.56$; $P = 0.019$) and go-no/go tasks (college = 24.9 ± 1.05 ; HS = 17.8 ± 1.6 ; $F_{1,196} = 14.37$; $P < 0.001$) in the allotted time, and more rapidly completed the eye-hand coordination task (college = 55.1 ± 0.5 sec; HS = 59.2 ± 0.8 sec; $F_{1,196} = 19.37$; $P < 0.001$) than HS student-athletes. No interaction effects or other main effects were observed ($P > 0.05$). **Conclusions:** Concussion history adversely affects visual acuity, depth perception and perception span performance, suggesting the visual system's ability to eliminate peripheral distractors may be compromised following concussion. It is possible that observed visual performance differences may have previously existed and subsequently placed those athletes at a higher risk for concussion. Unexpectedly, HS student-athletes perform relatively worse on measures of visual acuity, near-far quickness, eye-hand coordination, and go-no/go. Given the relatively higher concussion rates among HS student-athletes, our data suggest lower visual performance may be a potential concussion risk factor; although differences may be explained by athletic skill differences not measured

in this study. Future prospective studies should explore the predictive value of visual performance screening in reducing concussion injury risk.

Association Of Neck And Head Circumference With Concussions Among Youth American Football Players

Ryder JM, Caswell SV, Ambegaonkar JP, Caswell AM, Ausborn A, Cortes N: George Mason University, Manassas, VA

Context: Player size and head and neck circumference have been suggested to be related to concussion incidence in youth football. However, little research has examined relationships among these factors. **Objective:** To describe the relationship between Body Mass Index (BMI) and neck and head circumference ratio (NHR) and concussion injury rates (IR) among youth football players. **Design:** Cohort. **Setting:** Field. **Patients or Other Participants:** BMI and NHR of 401 male youth football players (age 11.9 ± 1.2 years) with 2.3 ± 1.7 years experience within a large metropolitan youth football league were analyzed in relation to the incidence of concussion during the 2012 season. **Intervention(s):** Height, cm; weight, kg; and head and neck circumference, cm; data were collected pre-season. Concussion injury information was tracked prospectively throughout the season by the leagues athletic trainer using an electronic medical record-keeping system. Mechanism of injury (MOI), and gameplay characteristics were also described. **Main Outcomes Measures:** Descriptive statistics were used to describe players anthropometric characteristics and concussions. Incidence rates were calculated based on 1000 athlete-exposures (AE), with an AE defined as 1 athlete's participation in 1 entire league sanctioned practice or game. Binary logistic regression using step-wise backward elimination examined potential relationships between anthropometric characteristics and the incidence of concussion in youth football players ($p \leq 0.05$). **Results:** The mean height, weight, and

BMI for all participants ($n = 329$) were 157.6 cm, 49.1 kg, and 24.5 kg/m^2 , respectively. The mean neck and head circumference and HNR ratio for participants ($n = 337$) was 31.7 cm, 55.4 cm, and 0.57, respectively. Of the 401 league participants, 32 (8.0%) were diagnosed with a concussion. The total concussion IR for practices and games in 2012 season was 1.8 per 1000 AE. Most concussions were reported during games (30, 93.8%) compared with practices (2, 6.3%). Most game related concussions also occurred during the 2nd half of play ($n = 23$, 76.7%) and resulted from helmet-to-helmet (13, 40.6%) collisions. Binary logistic regression failed to reveal NHR or BMI to be significant predictors of concussion IR 2 (1, $N = 305$) = 92.7%, $p = .61$. **Conclusions:** Our findings demonstrate a higher incidence of single season concussions than previously reported for this age group of American youth football players. While, NHR and BMI did not predict concussion IR, future efforts should assess these variables and neck strength as potential predictors of concussion in youth football players. Further research should also examine if the incidence of concussion during the 2nd half is related to fatigue (mental and physical), or possibly the result of multiple impacts sustained during a single game.

Free Communications, Oral Presentations: Post-Professional Clinical Education

Saturday, June 28, 2014, 1:45PM-2:30PM, Room 244; Moderator: Trevor Bates, MS, ATC, LAT

14423FOPE

Post-Professional Education: A Descriptive Analysis Of Clinical Education Experience Characteristics

Anderson BE, Welch CE, Parsons
JT: A.T. Still University, Mesa, AZ

Context: Accreditation standards that guide post-professional athletic training(PPAT) programs now require the preparation of students for advanced clinical practice(ACP) through didactic and clinical education experiences(CEEs). PPAT CEEs have traditionally occurred through graduate assistantships, however, little is known about the characteristics of such experiences, and whether they provide the necessary clinical education framework to prepare PPAT students for ACP. **Objective:** To provide a descriptive analysis of CEEs in PPAT. **Design:** Retrospective database analysis. **Setting:** Self-reported online clinical tracking system. **Patients or Other Participants:** 35 PPAT students(male = 17, female = 18) participating in CEEs at secondary school(n = 17), college(n = 7), clinic(n = 4), research(n = 2), and professional(n = 1) clinical settings between August 2011–July 2013. **Intervention(s):** CEEs and patient encounter characteristics were obtained via the AHST™ (Typhon Group, LA) online clinical tracking system during the 2011–2012 and 2012–2013 academic years. Students were required to document all clinical hours and a minimum of 30 patient encounters(PEs) per academic quarter. To determine the representativeness of data, injury diagnoses and frequencies from PEs were compared to published data in similar populations and were found to be similar. **Main Outcome Measure(s):** Summary statistics (means, percentages) were reported for clinical hours and CEE activities. Descriptive data(frequencies, percentages) were reported for PEs, including patient demographics(-sex,age,race), injury diagnosis, student participation, and practice domains.

Results: PPAT students participated in 32,687 CEE hours, averaging 15.96 hours per week(min = 7.5, max = 31.3). CEEs involved practice (34.3%) and game (27.5%) preparation and coverage, treatment and rehabilitation (18.8%), paperwork (5.9%), injury prevention (1.9%), travel (1.3%), facility management (0.8%), staff meetings (0.7%), and student teaching (0.5%). 4760 patient encounters involving 4207 unique patients were recorded. 50.3% of patients were pediatric/adolescent, and 48.6% were adult. Patients were Caucasian/non-Hispanic (61.8%), African-American (17.5%), Hispanic (15.0%), other (5.8%). Males comprised 59.9% of PEs vs. females at 39.7%. The most frequent diagnoses encountered were ankle sprain/strain (15.1%), knee sprain/strain (7.9%), unspecified joint pain (7.6%) peripheral enthesopathies (7.5%), concussion (7.0%), and hip/thigh sprain/strain (6.3%). Students reported using advanced skills in 37.6% of cases and basic skills in 60.1%. Practice domains included evaluation and diagnosis (27.9%), treatment and rehabilitation (26.4%), professional behaviors (22.6%), injury prevention (10.5%), organization/administration (7.4%), and emergency care (5.1%). **Conclusions:** This is the first study describing the characteristics of PPAT CEEs. Data suggest students have some opportunity to demonstrate ACP, utilizing advanced skills in one third of patient encounters. PPAT students have less opportunity to engage knowledge and skills from the domains of injury prevention, organization/administration, and emergency care. Professional behaviors (e.g., evidence-based practice, informatics, outcomes assessment, self-reflection) were utilized in less than 25% of encounters. These findings justify a greater focus on the quality of PPAT CEEs to ensure more opportunities for students to engage ACP, and for PPAT programs to meet accreditation requirements. Future research should identify and test strategies for integrating professional

behaviors and advanced skills and knowledge into CEEs, and identify appropriate metrics to measure the attainment of ACP knowledge and skills.

Perceptions Of Post-Professional Students Regarding Preceptors Abilities Related To The Six Core Competencies

Braun B, Szlosek PA, Van Lunen BL, Welch CE, Hankemeier DA, Cavallario JM: Old Dominion University, Norfolk, VA; A.T. Still University, Mesa, AZ; Ball State University, Muncie, IN

Context: Post-Professional athletic training (PPAT) programs are implementing six core competencies within their programming, which are currently assessed within other healthcare professions. Preceptors must be competent in these core competencies in order to foster the growth of the competencies in their students. **Objective:** To determine the Commission on Accreditation of Athletic Training Education (CAATE) post-professional students' perceptions of their preceptors' skills and abilities within the six healthcare core competencies associated with post-professional education. **Design:** Cross-sectional. **Setting:** Self-reported paper survey. **Patients or Other Participants:** One hundred three of 152 currently enrolled students (age = 24.07 ± 2.22yrs; 37 males, 66 females; 54 first year, 48 second year) from 7 CAATE accredited PPAT programs participated (response rate = 68%). **Intervention(s):** Participants completed the survey between June and October of 2013. The survey consisted of one section for each CAATE identified educational core competency: quality improvement (QI), professionalism (PROF), healthcare informatics (HCI), interprofessional education and collaborative practice (IPECP), evidence-based practice (EBP), and patient-centered care (PCC). Each of the concepts (range of 8-18) within a core competency described an ability that is related to the definition of the competency. The students were asked to rate their preceptor's ability to incorporate concepts of each core competency within clinical practice on a Likert scale of strongly

disagree(1), disagree(2), agree(3), and strongly agree(4). Reliability for each core competency was found to be extremely high: α ability = .955 within a preliminary study (N = 202) of post-professional students. **Main Outcomes Measure(s):** Composite ability Likert-scale scores were achieved by tabulating all values and then averaging the scores back to the Likert scale. Higher scores indicated that participants perceived their preceptors to have greater ability. Summary statistics, including means (SD), 95% confidence intervals, medians and interquartile ranges, as appropriate, were calculated for each of the six educational core competencies. **Results:** Participants reported they "agree" that their preceptors were able to implement the concepts of 5 core competencies into their daily practice (QI = 3.19/4.0 ± 0.56, PROF = 3.28/4.0 ± 0.52, HCI = 3.08/4.0 ± 0.56, IPECP = 3.14/4.0 ± 0.54, EBP = 3.16/4.0 ± 0.54) and "disagree" that their preceptors were able to implement the concepts of PCC (PCC = 2.98/4.0 ± 0.53). PCC concept values for surveying patients about care (2.33/4 ± .89), providing patients with real-time electronic information (2.49 ± .78) and utilizing patient-report outcomes (2.38 ± .97) were within the disagree range. **Conclusions:** Post-professional athletic training students believe that their preceptors are successfully implementing 5 of the 6 core competencies in their own clinical practice. Preceptors should utilize patient-report outcomes and surveying techniques to gain information from their patients, and they need to provide easy access information for patients to utilize to supplement their care. Preceptors are providing PCC that is efficient and supportive while also including a transitional continuity of care.

The Influence Of Electronic Medical Record Use On Post-Professional Students' Perceptions Of Preceptors' Abilities Related To The Six Core Competencies

Szlosek P, Braun B, Van Lunen BL, Welch CE, Hankemeier DA, Cavallario JM: Old Dominion University, Norfolk, VA; A.T. Still University, Mesa, AZ; Ball State University, Muncie, IN

Context: Six core competencies are being implemented into post-professional athletic training (PPAT) programs. Electronic Medical Record (EMR) documentation is increasing within athletic training clinical practice and preceptors usage is instrumental in guiding students within clinical decision making. **Objective:** To determine whether the Commission on Accreditation of Athletic Training Education (CAATE) PPAT students' perceptions of their preceptors' abilities within the six healthcare core competencies associated with post-professional education are effected by EMR use. **Design:** Cross-sectional. **Setting:** Self-reported paper survey. **Patients or Other Participants:** 103 of 152 currently enrolled PPAT students (age = 24.07 ± 2.22yrs; 37 males, 66 females; 54 first year, 48 second year) from 7 CAATE accredited programs participated (response rate = 68%). **Intervention(s):** Participants completed the survey between June and October of 2013. The survey consisted of one section for each CAATE identified educational competency: quality improvement (QI), professionalism (PROF), healthcare informatics (HCI), interprofessional education and collaborative practice (IPECP), evidence-based practice (EBP), and patient-centered care (PCC). Each of the concepts (range of 8-18) within a competency described an ability that is related to the definition of the competency. Students rated their preceptor's ability to incorporate concepts of each competency within clinical practice on a Likert scale of

strongly disagree (1), disagree (2), agree (3), and strongly agree (4). Reliability for each competency was found to be extremely high: α ability = .955 within a preliminary study ($N = 202$) of post-professional students. **Main Outcomes**

Measure(s): Composite ability Likert-scale scores were achieved by tabulating all values and then averaging scores back to the Likert scale. Higher scores indicated that participants perceived their preceptors to have greater ability. The independent variable was preceptor EMR usage (yes, no, unknown). Between-group differences were assessed with the Kruskal-Wallis H or Mann-Whitney U tests ($P < .05$), with Mann-Whitney U post-hoc tests (Bonferroni-correction).

Results: Significant differences were found for composite scores when comparing preceptors additional use of EMR for more than just documentation of injuries (QI: $\chi^2 = 10.50$, $p = 0.005$; PROF: $\chi^2 = 15.62$, $p = <0.001$; HI: $\chi^2 = 12.62$, $p = 0.002$; PCC: $\chi^2 = 6.32$, $p = 0.04$; IPECP: $\chi^2 = 9.71$, $p = 0.008$; EBP: $\chi^2 = 18.54$, $p = <0.001$). For QI, PROF, HI, PCC, IPEPC and EBP, students reported higher scores for preceptors who used their EMR for more than injury documentation (yes) than those who didn't (no) ($P < 0.05$), and the "unknown" were higher than the "no" ($P < 0.05$). Additionally, for EBP, students reported higher scores for preceptors who used their EMR for more than injury documentation (yes) than those preceptors for whom additional use of an EMR was "unknown" ($P < 0.05$). **Conclusions:**

Post-professional students perceive that preceptors who utilize EMR, and who utilize EMR for more than just documenting injuries are more effective at implementing the competencies into their clinical practice. PPAT programs may consider requiring EMR usage by preceptors and students in clinical practice in order to facilitate implementation of the core-competencies. EMRs can provide effective and efficient assessment of clinical outcomes for use in programmatic outcome assessment.

Free Communications, Oral Presentations: Movement Screening and Sports Injury

Thursday, June 26, 2014, 8:00AM-9:30AM, Room 245; Moderator: Dustin Grooms, MEd, ATC, CSCS

1432600IN

Previous Musculoskeletal Injury History Is Related To Functional Movement Screen Performance

de la Motte SJ, Lisman P, Beutler A, Deuster P, O'Connor F: Consortium for Health And Military Performance, Uniformed Services University of the Health Sciences, Bethesda, MD, and Towson University, Towson, MD

Context: Previous history of musculoskeletal injury (MSK-I) is one of the strongest predictors of future injury in active populations. Similarly, Functional Movement Screen (FMS) scores ≤ 14 have been associated with eventual MSK-I in athletes and military personnel. Understanding the relationship between previous injury history and performance on functional testing, such as the FMS, is paramount to creating effective predictive injury risk screening protocols. **Objective:** To examine the associations between previous history of MSK-I and FMS composite score in a deploying Infantry Marine Battalion. **Design:** Cross-sectional study. **Setting:** Marine Corps Base. **Patients or Other Participants:** Infantry Marines ($n=358$). **Methods:** Prior to deployment, participants completed a brief questionnaire to determine history of MSK-I, primarily lower extremity (hip, knee, and/or ankle/foot) injury. FMS testing included Deep Squat (DS), Hurdle Step (HS), Inline Lunge (ILL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Push-Up (PU), and Rotary Stability (RS), which were scored on a 0–3 ordinal scale with a maximum score of 21. A score of 3 on any individual test indicated movement was completed fully and without compensation; a score of 1 indicated the movement was not completed as instructed; and a score of 0 was recorded if pain were reported with any part of the movement. FMS composite scores were categorized as low (≤ 14) versus high (> 14) whereas previous history

of MSK-I was dichotomized into those who had and had not reported a previous injury prior to deployment. Pearson Chi-square tests for independence were conducted to determine the relationship between FMS and previous history of MSK-I. **Main Outcome Measures:** Means \pm standard deviations. Pearson Chi-square and significance values. **Results:** Mean FMS score was 13.1 ± 3.3 (Range 2–19), with over 60% (219/358) of Marines scoring ≤ 14 . Sixty-two percent (215/348) of Marines reported previous history of one or more MSK-Is. Specifically, 35% (128/348) reported prior history of ankle/foot injuries and 31% (115/348) reported previous knee injuries. FMS composite score was associated with previous history of MSK-I ($\chi^2 = 4.02$, $P = 0.05$), with significantly more Marines with previous MSK-I scoring ≤ 14 on the FMS (66% vs. 55% for no injury). A similar trend was found between previous history of ankle/foot injury and FMS performance ($\chi^2 = 3.74$, $P = 0.053$); 41% of Marines with FMS scores ≤ 14 reported a previous history of ankle/foot injury compared to 30% of those with scores > 14 . No other significant associations were found. **Conclusions:** Previous history of MSK-I was significantly associated with low FMS scores (≤ 14) in a Marine population prior to deployment. Given that previous history of MSK-I and low FMS scores both predict future injury in other military populations, we are continuing to follow this cohort of Marines to determine whether these two risk factors in combination are stronger predictors of MSK-I incidence during deployment.

1432400IN

Landing Error Scoring System (LESS) Items Are Predictive Of Lower Extremity Stress Fracture

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Context: Lower-extremity stress fracture injuries are a major cause of morbidity in physically active populations. The ability to efficiently screen for modifiable risk factors associated with injury is critical in developing and implementing effective injury prevention programs. **Objective:** The purpose of this study was to determine if baseline Landing Error Scoring System (LESS) scores were associated with the incidence rate of lower-extremity stress fracture. **Design:** Prospective cohort study. **Setting:** US Service Academy. **Patients or Other Participants:** 1772 eligible college freshmen with complete baseline data and no history of lower-extremity stress fracture. **Methods:** At baseline participants performed a standardized jump landing task that was evaluated using the LESS. Incident lower-extremity stress fracture cases were identified during the four year follow-up period using the injury surveillance systems at our institution. The electronic medical records of each potential incident case were reviewed and case status was determined by an adjudication committee consisting of two sports medicine fellowship-trained orthopaedic surgeons who were blinded to baseline LESS data. The association between baseline LESS scores and the incidence rate of lower-extremity stress fracture was examined for total LESS score and for each

individual LESS item. Univariate and multivariable Poisson regression models were used to estimate the association between baseline LESS scores and the incidence rate of lower-extremity stress fracture during follow-up. **Outcome Measures:** The primary outcome of interest was the incidence rate of lower-extremity stress fracture during follow-up. **Results:** During the follow-up period, 94 incident lower-extremity stress fractures were documented in the study cohort and the cumulative incidence of stress fracture was 5.3% (95% CI: 4.3%, 6.5%). In univariate analyses total LESS score at baseline was associated with the incidence rate of lower-extremity stress fracture during follow-up. For every additional movement error documented at baseline there was a 15% increase in the incidence rate of stress fracture during follow-up (IRR = 1.15; 95% CI: 1.02, 1.31, $p = 0.025$). Based on univariate analyses, several individual LESS items at baseline were also associated with the incidence rate of stress fracture during follow-up. Ankle flexion at initial contact, stance width at initial contact, asymmetrical landing at initial contact, trunk flexion at initial contact, and overall impression were significantly associated with the incidence rate of stress fracture. In multivariable analyses controlling for sex and cohort, subjects who consistently landed flat-footed or heel-to-toe were 2.33 times (IRR = 2.33; 95% CI: 1.36, 3.97, $p = 0.002$) more likely to sustain a lower-extremity stress fracture during follow-up. Similarly, subjects who consistently demonstrated asymmetric landing at initial contact were 2.53 times (IRR = 2.53; 95% CI: 1.34, 4.74, $p = 0.004$) more likely to sustain a stress fracture during follow-up. **Conclusions:** These data suggest that specific LESS items may be predictive of lower-extremity stress fracture risk and may be helpful in injury screening and prevention.

Pre-Participation Functional Status Survey For Assessment Of Injury Risk

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Context: Surveys used to document treatment outcomes can contribute to injury risk assessment, but administering and scoring multiple joint-specific surveys imposes a burden that limits the feasibility of acquiring such information during a pre-participation examination (PPE). **Objective:** To assess the predictive validity of responses to a 10-item survey for injury risk assessment. **Design:** A cohort study related pre-participation status to injury occurrence, both retrospectively and prospectively. **Setting:** NCAA Division-I athletic program. **Patients or Other Participants:** A cohort of 132 athletes were monitored over a 14-week period following a PPE ($n = 92$ males: 82 football, 10 tennis; $n = 40$ females: 20 soccer, 8 tennis, 12 volleyball). **Intervention(s):** Paper copies of 4 surveys with well-established psychometric properties were self-administered: Foot and Ankle Ability Measure (FAAM) sport subscale, International Knee Documentation Committee (IKDC) subjective knee form, Oswestry Disability Index (ODI) for low back status, and Kerlan-Jobe Orthopaedic Clinic (KJOC) measure for shoulder and elbow function. A 10-item Pre-participation Functional Status (PFS) survey that incorporated concepts from 25 of 46 items contained in the other 4 surveys was self-administered, along with a checklist for documentation of sprains and strains sustained during the preceding 12 months. **Main Outcome Measure(s):** For prospective analysis, an injury was defined as a sprain or strain that limited sport participation for at least one day.

For retrospective analysis, an injury was defined as any sprain or strain that completely restricted sport participation for at least one practice session or game. Receiver operating characteristic analysis classified each survey-derived score as high or low, and the odds ratio (OR) was used to assess discriminatory power. **Results:** PFS score ≤ 89 was strongly associated with the occurrence of a time-loss sprain or strain during the preceding 12 months (50 of 132 athletes): 54% sensitivity; 73% specificity; OR = 3.20 (90% CI: 1.72, 5.96). A total of 52 athletes sustained at least one sprain or strain during the prospective surveillance period. The same optimal cut-point value was identified for FAAM, IKDC, ODI, and KJOC scores (≤ 95 on a 0–100 scale), each of which provided high specificity (82–90%) and low sensitivity (14–29%). A prediction model that included these 4 dichotomous indicators of functional status identified ≥ 3 low values as providing optimal discriminatory power: 12% sensitivity; 95% specificity; OR = 2.48 (90% CI: 0.82, 7.49). PFS score ≤ 97 provided comparable discriminatory power, but much higher sensitivity as a prognostic risk indicator: 83% sensitivity; 34% specificity; OR = 2.43 (90% CI: 1.19, 4.99). **Conclusions:** The 10-item PFS survey appears to provide a meaningful contribution to injury risk assessment that does not impose a substantial respondent burden. Refinement of PFS item content and response scaling may improve its specificity, and further research will be needed to establish its internal consistency and test-retest reliability.

Differences In Star-Excursion Balance Test Performance Between High School And Collegiate Football Players

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Context: Musculoskeletal injuries of the lower extremity are extremely common in sports. Previous literature suggests that risk of lower extremity injuries may be predicted by reduced dynamic postural control. The Star Excursion Balance Test (SEBT) is a simple clinical tool used to assess dynamic postural control, with deficits in performance equating with increased risk of lower extremity injury. However, it is not known if the level of competition of the athlete influences SEBT performance. Such differences may be valuable for determining if performance levels specific to competition level should be applied for identifying individuals at risk for lower extremity injury. **Objective:** To examine differences in SEBT scores between high school and collegiate football players. **Design:** Cross-Sectional. **Setting:** High school and collegiate athletic training facilities. **Patients or Other Participants:** Three-hundred eighteen male high school football players (15.91 ± 1.14 yrs; 177.62 ± 10.18 cm; 81.89 ± 17.44 kg) and 180 male NCAA Division I collegiate football players (19.79 ± 1.38 yrs; 186.76 ± 6.66 cm; 102.29 ± 18.93 kg) volunteered to participate. **Intervention(s):** Prior to the 2010 and 2011 football seasons, football athletes cleared for competition completed the anterior, posterolateral, and posteromedial directions of the SEBT. **Main Outcome Measure(s):** Dynamic postural control was assessed bilaterally using SEBT scores for anterior, posterolateral, and posteromedial reach directions. The mean of three trials from

each leg was normalized to the stance leg length and presented as a percentage score. The normalized scores from the three directions were averaged to create a composite score. Average normalized scores of the four dependent variables were compared between the adolescent and collegiate players using independent t-tests. Significance was set a priori at $P < 0.05$. **Results:** The SEBT scores were significantly lower in high school compared college football players for the posterolateral ($P < 0.001$; high school: $72.8 \pm 11.4\%$; college: $77.1 \pm 10.2\%$), posteromedial ($P = 0.001$; high school: $83.5 \pm 10.2\%$; college: $86.7 \pm 10.7\%$), and composite scores ($P = 0.001$; high school: $75.4 \pm 8.5\%$; college: $78.0 \pm 7.4\%$). There was no significant difference in SEBT anterior reach distance between high school and college football players ($P = 0.545$; high school: $69.9 \pm 7.9\%$; college: $70.3 \pm 7.1\%$). **Conclusions:** High school football players demonstrated decreased levels of dynamic postural control compared to collegiate football players in two out of three reach directions as well as composite scores of the SEBT. Despite participation in a common sport, these age populations differ in their ability to perform dynamic balance tests. The findings suggest that age may need to be considered when using the SEBT as a prediction tool to identify risk of lower extremity injury in football athletes.

Functional Measures As Predictors Of Non-Contact Versus Contact Lower Extremity Injury Among High School Football Players

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Context: The star excursion balance test (SEBT) and the Functional Movement Screen (FMS) have been suggested as tools to assess athletes' functional movement performance and used to capture those at risk of a lower extremity (LE) injury. While the SEBT has been investigated in high school football players, little research has examined if the FMS provides strong predictive capabilities for LE injuries in this population. Mechanism of injury (MOI) may influence the prediction capability of these screening tools. Additional information is needed to further substantiate the predictability of these tests while considering the MOI, such as non-contact or contact. **Objective:** Examine the capability of the SEBT and FMS to predict non-contact and contact LE injuries in high school football players. **Design:** Prospective cohort. **Setting:** High school athletic training facilities. **Patients or Other Participants:** Ninety-two high school football players (15.40 ± 1.17 yrs; 175.12 ± 8.27 cm; 76.52 ± 17.49 kg) volunteered. **Intervention(s):** Prior to the 2013 football season, participants completed a single session in which the anterior reach of the SEBT (SEBT-A) and a modified version of the FMS (deep squat, hurdle step, in-line lunge, and active straight leg raise) were evaluated bilaterally. **Main Outcome Measure(s):** The mean of three SEBT-A trials (cm) from each leg was normalized to stance leg length (cm) and presented as a percentage. Each of the four stations of the modified FMS was

scored on a 0-3 scale, with a total possible score of 12 points indicating a perfect performance. The lowest score of three attempts in each station was used to create the total score. Certified Athletic Trainers tracked and reported LE injuries and the MOI (non-contact, contact). After the season, athletes were placed in a LE injured ($n = 21$) or uninjured ($n = 71$) group. Sensitivity and specificity were used to create positive and negative likelihood ratios, from which diagnostic odds ratios (DOR) were created separately for each outcome measure. **Results:** For all LE injuries (non-contact: $n = 11$, contact: $n = 10$), a SEBT-A score of 63.60% was associated with low sensitivity (0.48) and moderate-strong specificity (0.74), with a DOR of 2.64; and for the modified FMS, a score of 6.5 was associated with moderate-strong sensitivity (0.76) and low specificity (0.42), with a DOR of 2.3. For only non-contact injuries, the same cut-off scores of each measure were associated with improved sensitivity (SEBT-A = 0.64, FMS = 0.91) and specificity (SEBT-A = 0.73, FMS = 0.61), with DORs of 4.84 and 10.47 for the SEBT-A and FMS, respectively. **Conclusions:** The LE injury prediction models from the SEBT-A and modified FMS improved when focused on non-contact injuries. These functional assessment tools provide a strong capability to assess high school football players at risk for a non-contact LE injury and are easily performed by clinicians in the high school athletic training facilities.

Differences In Performance Of The Functional Movement Screen Between Men And Women Division I Athletes

Allen AE, Forbing M, Simon J, Chapman R, Docherty CL:
Indiana University, Bloomington, IN

Context: The Functional Movement Screen (FMS) is a screening tool used to identify discrepancies and body movement patterns. Further, the FMS was created to assess the development of functional movement and dynamic balance during movement oriented tests that require motor control. The goal of the FMS is to identify athletes at risk of injury. **Objective:** To distinguish differences in FMS scores between male and female NCAA Division I varsity athletes. **Design:** Cohort study. **Setting:** Division I university athletic training facility. **Patients or Other Participants:** Three hundred and nineteen athletes from a Division I university completed the study. Two groups were identified based on gender: 157 males (19.7 ± 1.4 years; 184.3 ± 8.6 cm; 80.1 ± 12.3 kg) and 162 females (19.7 ± 1.3 years; 172.1 ± 9.0 cm; 67.5 ± 12.6 kg). **Intervention(s):** All seven FMS tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Straight-leg Raise, Push-up, and Rotary Stability) were completed three times and the best score was recorded as the value for that test. The FMS tests were graded on a 0-3 scale with a total possible score of 21. All participants were tested by the same researcher who was also FMS certified. The independent variable was gender (male and female). **Main Outcome Measure(s):** The dependent variables were the score on each of the seven tests and total FMS score. Eight separate one-way ANOVAs were calculated to compare differences between men and women. Due to the high number of analyses, a Bonferroni correction was utilized. The corrected alpha level of $p < 0.006$ was identified for statistical

significance. **Results:** There was a significant difference between males and females for the In-Line Lunge tests ($F_{1,317} = 12.65$, $p < 0.001$), Shoulder Mobility tests ($F_{1,317} = 16.27$, $p < 0.001$), Straight Leg Raise tests ($F_{1,317} = 9.66$, $p = 0.002$), and Push-up tests ($F_{1,317} = 101.51$, $p < 0.001$). For the In-Line Lunge, Shoulder Mobility, and Straight Leg Raise tests females performed better than males (In-Line Lunge: mean difference = 0.18, 95% CI: 0.08 to 0.29; Shoulder Mobility: mean difference = 0.31, 95% CI: 0.16 to 0.46, and Straight Leg Raise: mean difference = 0.21, 95% CI: 0.07 to 0.33). However, for the push-up test males performed better than females (mean difference = 0.86, 95% CI: 0.69 to 1.03). No significant difference was identified between the males and females for the overall FMS score ($F_{1,317} = 0.48$, $p = 0.49$). The mean total score (SD) for the women was 16.8 (2.0) and for the men was 17.0 (1.6). **Conclusions:** Female Division-I athletes performed better than their male athlete counterparts on the tests that incorporate flexibility. Whereas, the male Division-I athletes performed better than females on the test that primarily measures strength. When evaluating the overall FMS score, no differences were identified between the sexes.

Free Communications, Oral Presentations: Master's Oral Student Award Finalists

Thursday, June 26, 2014, 9:45AM-10:45AM, Room 245; Moderator: Joseph M. Hart, III, PhD, ATC

14264MOIN

Age-Based Differences From Impacts To The Head Measured In Youth Football Players 8 To 13 Years Of Age: Heads-Up Intervention Pilot Study

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Context: There is limited data examining linear and rotational forces resulting from collisions in youth football. Even fewer studies have sought to test interventions aimed at reducing head impacts during youth football practices and games.

Objective: To compare the linear and rotational forces from impacts during youth football practices and games between younger and older players. **Design:** Cross-Sectional. **Setting:** Single youth football venue in the southeastern United States.

Patients or Other Participants: Child assent and parental consent was obtained from 40 youth football players (8-13 years of age) and their parents from a single league.

Intervention(s): Accelerometers were applied over the mastoid process or postero-lateral skull using standardized procedures and adhesive patches prior games and practices. Independent variables included age groups (8-10 and 11-13). **Main Outcome Measure(s):** Dependent variables included Peak Linear Acceleration (PLA) and Peak Rotational Acceleration (PRA) reported as m/s² (gravity or g's) and radians (rad), respectfully. The median (m), and lower and upper quartiles (QR) are reported in lieu of means and standard deviations because of the non-parametric nature of the data. Minimum and maximum accelerations are also reported. The minimum captured acceleration was 10g's. Because PLA and PRA are not normally distributed, the Kruskal Wallis Test chi-square (χ^2) statistic and z-approximation (z) was used to compare age groups. The a priori $\alpha=0.05$. **Results:** There were 679 recorded impacts (480 in the 11-13 year olds and 199 in the 8-10 year olds). The 8-10

group recorded a mPLA of 15.76g's (QR = 12.13; 23.03) and the 11-13 group recorded a mPLA of 18.03g's (QR = 13.67; 28.29). The mPRA of the 8-10 group was 2640.11rad (QR = 1515.63; 3054.41) and the mPRA of the 11-13 year olds was 3486.16rad (QR = 2130.95; 5538.48). The highest recorded PLA was 120.10g's and 119.20g's in the 8-10 and the 11-13 year olds, respectfully. Statistically higher PLA was measured in the 11-13 year old group ($z = -3.21$, $P = .0007$; χ^2 (df = 1) = 10.32, $P = .0013$). Similarly, a statistically higher PRA was also found in the 11-13 group ($z = -3.54$, $P = .0002$; χ^2 (df = 1) = 12.56, $P = .0004$). **Conclusions:** These results show that older football players sustain higher linear and rotational impacts than those players in the younger age group. These results are based on a small sample size (40 youth football players) from a pilot study of a larger planned future study. Further research should consider applying accelerometers to other athletes who experience high linear and rotational forces (gymnasts, equestrian, and others).

Effect Of Limited Hip Flexor Length On Gluteal Activation During An Overhead Squat In Female Soccer Players

Mills M, Frank B, Blackburn T, Cates S, Aguilar A, Fava N, Padua DA: Sports Medicine Research Laboratory, Human Movement Science Curriculum, Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC, and Stanford University, Palo Alto, CA

Context: Hip flexor tightness is theorized to alter antagonist muscle function through reciprocal inhibition and synergistic dominance mechanisms. Synergistic dominance may result in altered movement patterns and increased risk of lower extremity injury. However, there is a lack of evidence supporting the effects of hip flexor tightness on antagonist muscle function. **Objective:** To determine the effect of hip flexor tightness on biceps femoris (BF) and gluteus maximus (GM) muscle activation. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Female soccer players were screened using a modified Thomas Test. A digital inclinometer was aligned parallel with participant's femur as the leg was lowered from 90° of hip flexion until the point of first resistance. Participants were assigned to the Restricted ($> 0^\circ$ above horizontal; $n = 20$, age = 19.9, ht = 167.1 cm, mass = 64.7 kg) or Control ($> 15^\circ$ below horizontal, $n = 20$, age = 19.4, ht = 167.2 cm, mass = 61.2 kg) group based on their available hip extension motion.

Intervention(s): Surface electromyography data were sampled at 1,000 Hz from the GM and BF of the participant's kicking dominant limb while performing 5 double leg squats. **Main Outcome Measure(s):** GM and BF average muscle activation amplitude was quantified from the initiation of knee flexion until peak knee flexion during

each squat trial. The co-activation ratio of the GM and BF was also calculated ($[GM/BF]100$). All data were smoothed using a 4th order Butterworth 20-350 Hz bandpass digital filter and normalized to maximal isometric contraction for each muscle. Separate independent t-tests compared GM and BF muscle activation amplitude and the GM:BF co-activation ratio between the Restricted and Control groups ($\alpha < 0.05$). **Results:** GM activation was significantly less ($t = -2.43$, $P = 0.022$, $d = 0.78$) in the Restricted ($8.1 \pm 4.7\%$ MVIC) compared to the Control ($14.1 \pm 9.8\%$ MVIC) group. BF activity trended toward less ($t = 1.96$, $P = 0.064$, $d = 0.66$) activation in the Control ($7.1 \pm 4.0\%$ MVIC) compared to the Restricted ($13.0 \pm 12.0\%$ MVIC) group. However, the GM:BF co-activation ratio was significantly less ($t = -3.17$, $P = 0.005$, $d = 1.08$) in the Restricted (0.95 ± 0.63) compared to the Control group (2.28 ± 1.68). **Conclusions:** Individuals with hip flexor tightness demonstrate lesser GM activation during squatting tasks. While BF activation was not significantly different in those with hip flexor tightness, Restricted individuals demonstrated slightly greater BF compared to GM activation (GM:BF = 0.95). In contrast, the Control group displayed over 2-times greater GM compared to BF activation (GM:BF = 2.23). This suggests greater reliance on the BF relative to the GM in the Restricted group. Our findings support the theory of reciprocal inhibition of the GM and the potential for synergistic dominance of the BF secondary to hip flexor tightness. The influence of these findings on lower extremity injury risk, such as hamstring strains and ACL injury, requires further study.

The Immediate Effects Of A Talar Repositioning Taping On Ankle Range Of Motion In Dancers

LoCicero S, Simon J, Docherty CL: Indiana University, Bloomington, IN

Context: Dancers are required to have a greater range of motion (ROM) in both plantarflexion and dorsiflexion than the normal population in order to perform to their full artistic ability. Having a limitation in one of these motions may prove to be detrimental for a dancer.

Objective: To explore the effects of a talar repositioning taping on dorsiflexion and plantarflexion ROM in dancers.

Design: Crossover study design. **Setting:** Athletic Training Laboratory.

Patients or Other Participants: Twenty-eight collegiate dancers from Contemporary Dance and Ballet programs (166.7 ± 5.9 cm; 61.3 ± 7.9 kg; 20.2 ± 1.5 years), with no history of lower extremity surgery within six months and no lower extremity injury within six weeks of testing volunteered for this study.

Intervention(s): All subjects participated in two tape conditions: no tape and a talar repositioning tape. To apply the talar repositioning tape condition subjects were in a weight bearing position. First, leukotape (BSN Medical, Charlotte, NC) was placed on the lateral malleolus and then the dancer was instructed to lunge forward as far as possible and the tape was pulled anteriorly and then anchored on the medial malleolus. A second strip of tape was applied in the same protocol as the first. For each condition, ROM was measured before and after the tape application or rest in the no tape condition. To measure ROM during a dance specific task, subjects performed 3 pliés to measure dorsiflexion and 3 relevés to measure plantar flexion. Both ROM measures were completed with the feet in the parallel position and first position. Subjects were videotaped while performing these tasks and then data was digitized using video software (Dartfish Pro Suite

6.0, Alpharetta, GA). The maximum ROM of the 3 trials for each condition was used for statistical analysis. **Main Outcome Measure(s):** Maximal plantarflexion ($^{\circ}$) was captured during each relevé task and maximal dorsiflexion ($^{\circ}$) was captured during each plié task. Separate repeated measures analysis of variance was used to analyze each dependent variable. **Results:** No significant time by tape interaction was identified for either direction or foot position ($p > .05$). Following the application of talar repositioning taping the ROM did not change for plié in parallel (mean difference = $0.6 \pm 1.0^{\circ}$, 95% CI, -1.3 to 2.5) and first position (mean difference = $0.8 \pm .8^{\circ}$, 95% CI, -0.9 to 2.6), or in relevé in parallel (mean difference = $1.7 \pm 1.1^{\circ}$, 95% CI, -0.6 to 4.0) and first position (mean difference = $4.8 \pm 4.1^{\circ}$, 95% CI, -13.2 to 3.6). **Conclusions:** This talar repositioning taping did not significantly affect plantarflexion or dorsiflexion ROMs. Therefore while the tape application did not improve ROM, it did not limit it either. Future research should utilize this taping application in dancers with a talar fault to see if it creates a reduction in pain.

Relationship Between Drop Landing Performance And Knee Extension Torque Following ACL Reconstruction

Foot N, Kuenze CM, Saliba S, Hart JM: University of Virginia, Charlottesville, VA

Context: Individuals with a history of anterior cruciate ligament reconstruction (ACLR) are at greater risk of re-injury and developing early-onset osteoarthritis due to persistent abnormal joint loading during functional movement. Assessing landing biomechanics following ACLR provides a clinically relevant method to evaluate global lower extremity function during a common functional movement pattern. Real time clinical assessment tools may be useful in identifying patients experiencing abnormal movement patterns following ACLR.

Objective: To determine the relationship between Landing Error Scoring System (LESS) score and normalized knee extension maximal volitional isometric contraction (MVIC) torque strength in participants with a history of ACLR.

Design: Descriptive laboratory study.

Setting: Laboratory. **Patients or Other**

Participants: Twenty-four recreationally active healthy individuals (12M/12F, Age = 21.7 ± 3.6 years, BMI = 24.3 ± 3.2) and 22 recreationally active individuals with a history unilateral, primary ACLR at least 6 months prior to testing (12M/10F, Age = 22.5 ± 5.0 years, BMI = 24.6 ± 4.0 , time since surgery = 31.5 ± 23.5 months).

Intervention(s): Participates completed a single data collections session. **Main**

Outcome Measure(s): Patient reported knee related function as assessed using the IKDC Subjective Knee Evaluation Form, normalized knee extension MVIC torque (Nm/kg) and LESS scores were measured during a single testing session. Normalized knee extension MVIC torque was measured with the hip and knee flexed to 90 degrees using multi-mode isometric dynamometer. Participants were video recorded (front and side views) completing a drop-jump task from a 30cm box to a

target that was equal to $\frac{1}{2}$ of their body height which was later scored by a single assessor using the LESS. We performed a Mann-Whitney U test to compare total LESS scores between groups. Spearman's ρ correlations were used to determine the relationship between LESS score and normalized knee extension MVIC torque and participant reported knee related function.

Results: ACLR participants had more LESS errors (6.0 ± 3.6 errors) compared with healthy participants (2.8 ± 2.2 errors; $P = 0.002$). In ACLR participants, lower normalized knee extension MVIC torque in the injured limb ($\rho = -0.46$, $P = 0.004$) were associated with a greater number of landing errors. **Conclusions:** Participants with a history of ACLR had greater LESS scores compared to healthy participants. Patients with higher LESS scores tended to have weaker quadriceps on the involved side. These findings are consistent with previous reports of altered landing biomechanics following ACLR however; this is the first investigation to confirm these findings using a low cost, time efficient assessment tool.

Free Communications, Oral Presentations: Doctoral Oral Student Award Finalists

Thursday, June 26, 2014, 11:00AM-12:15PM, Room 245; Moderator: Joseph M. Hart, III, PhD, ATC

14128DONE

Prospective Analysis Of Quadriceps Spinal-Reflexive And Corticospinal Excitability In Anterior Cruciate Ligament Reconstructed Patients

Lepley AS, Gribble PA, Thomas AC, Sohn DH, Tevald MA, Pietrosimone BG: University of Toledo, Toledo, OH, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Alterations in spinal-reflexive and corticospinal excitability of the quadriceps muscle group have recently been identified following anterior cruciate ligament reconstruction (ACLR), and are hypothesized to influence persistent muscle dysfunction following surgery. Currently, no prospective data exists to determine how these neural excitability measures change following ACLR. We believe these data are critical for the development of novel interventions that will target the neuromuscular origins of persistent muscle dysfunction following joint injury. **Objective:** Investigate quadriceps spinal-reflexive and corticospinal excitability before, at 2-weeks post-surgery and at return-to-participation (RTP) following ACLR compared to healthy controls. **Design:** Case-Control. **Setting:** Laboratory. **Patients or Other Participants:** Seventeen ACL injured patients scheduled to undergo surgical reconstruction (9 Female, 8 Male; age: 21.0 ± 4.8 years; height: 173.1 ± 7.3 cm; weight: 77.7 ± 11.2 kg; 35.8 ± 14.8 days-post-injury) and seventeen healthy controls (9 Female, 8 Male; age: 22.1 ± 3.8 years; height: 173.3 ± 10.7 cm; weight: 75.3 ± 21.3 kg) volunteered. **Intervention(s):** Quadriceps spinal-reflexive and corticospinal excitability were tested pre-surgery, 2wks post-surgery and at return-to-participation (RTP; 28.1 ± 2.8 wks post-surgery). All measures were collected in the injured limb of ACL patients and a matched limb from the healthy control group. **Main Outcome Measure(s):** Quadriceps spinal-reflexive excitability was assessed by electrically stimulating

the femoral nerve to obtain Hoffmann reflexes normalized to maximal muscle responses (H:M). Corticospinal excitability was evaluated with active motor thresholds (AMT) elicited through transcranial magnetic stimulation (TMS). Participants performed knee extension at 5% of their maximal capabilities while magnetic stimuli were applied over the motor cortex. AMT was defined as the lowest TMS intensity that elicited a measurable motor evoked potential ($> 100\mu\text{V}$) in 5/10 consecutive trials. Higher H:M ratios denote increased spinal-reflexive excitability, while higher AMTs indicate decreased corticospinal excitability. Separate 2x3 (Group,Time) Repeated Measures ANOVAs were performed with Tukey post-hoc and t-tests where appropriate ($\alpha \leq 0.05$). **Results:** ACL patients demonstrated lower spinal-reflexive excitability than controls pre-surgery (ACL: 0.193 ± 0.126 , Control: 0.315 ± 0.109 ; $P = 0.01$) and 2-wks post (ACL: 0.109 ± 0.087 , Control: 0.334 ± 0.112 ; $P < 0.001$). At RTP, spinal-reflexive excitability was not different between groups (ACL: 0.251 ± 0.097 , Control: 0.298 ± 0.106 ; $P = 0.42$). Over-time, spinal-reflexive excitability in the ACL group decreased from pre-surgery to 2wks ($P = 0.008$), and increased higher than pre-surgery at RTP ($P = 0.01$), while controls did not change ($P > 0.05$). Corticospinal excitability was not different between groups at pre-surgery (ACL: 39.5 ± 8.7 , Control: 38.0 ± 9.6 ; $P = 0.22$) or 2-wks post-surgery (ACL: 32.2 ± 6.4 , Control: 36.7 ± 8.2 ; $P = 0.21$), however ACL patients had lower corticospinal excitability at RTP compared to controls (ACL: 44.7 ± 8.5 , Control: 37.2 ± 9.2 , $P = 0.004$). Corticospinal excitability in the ACL group increased from pre-surgery to 2wks ($P < 0.001$), and at RTP was decreased compared to pre-surgery ($P < 0.001$), while controls did not change ($P > 0.05$). **Conclusions:** Spinal-reflexive alterations are present before surgery and 2-weeks post-reconstruction, but not at RTP. In contrast, corticospinal

deficits existed at RTP, but not before or at 2-weeks post-surgery. Early rehabilitation strategies targeting spinal-reflexive excitability may help improve post-operative outcomes, while later-stage rehabilitation may benefit from modalities aimed at improving corticospinal excitability.

Clinical Utility Of Re-Baseline Computerized Neurocognitive Testing Following Concussion Recovery

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Context: Athletic trainers are increasingly expanding their multifaceted concussion management programs to include baseline computerized neurocognitive testing. Several position/consensus statements do not support this practice, and only recommend baseline computerized neurocognitive testing for specific populations, including those with learning disabilities, adolescent athletes, and those with a previous history of concussion. Collecting new baseline computerized neurocognitive measures once an athlete has fully recovered from his or her concussion (e.g. a “re-baseline” prior to the next season) is an emerging clinical practice. No previous studies have examined the clinical utility of re-baseline testing.

Objective: To determine if differences exist between pre-injury baseline and re-baseline scores prior to the season following a sustained concussion, and to compare these differences to clinical reliable change indices (RCIs). We hypothesized re-baseline scores would be statistically higher than baseline scores, but these differences would not exceed previously established RCIs.

Design: Prospective cohort. **Setting:** Clinical research center.

Patients or Other Participants: Thirty-four Division I collegiate athletes (age = 18.4 ± 0.8 yrs, height = 177.3 ± 12.7 cm, mass = 78.1 ± 17.8 kg at baseline, 550.5 ± 260.5 days between testing sessions) representing multiple varsity sports.

Intervention(s): Computerized neurocognitive testing (CNS Vital Signs) was performed at two time points: 1) Original healthy baseline, and 2)

Re-baseline completed before starting the competitive season following an athlete’s concussion recovery. Between the two time points, all athletes in our sample were diagnosed with a concussion based on a comprehensive, multi-faceted concussion management program employed by physicians, athletic trainers, and clinical researchers. **Main**

Outcome Measure(s): We performed paired-samples t-tests to compare neurocognitive test performance between baseline and re-baseline outcomes for the following CNS Vital Signs standard scores (composite scores that place all outcomes on the same scale designed for easier clinical interpretation): verbal memory, visual memory, psychomotor speed, cognitive flexibility, complex attention, processing speed, reasoning, reaction time, and executive functioning. We compared our mean differences to RCIs to determine if statistically significant changes would be clinically meaningful.

Results: Athletes performed significantly better at re-baseline compared to baseline in the following neurocognitive domains: psychomotor speed (baseline = 107.9 ± 10.2 ; re-baseline = 114.4 ± 14.6 ; $t_{33} = -3.71$; $P = 0.001$), cognitive flexibility (baseline = 101.5 ± 10.1 ; re-baseline = 106.9 ± 12.7 ; $t_{33} = -2.83$; $P = 0.008$), processing speed (baseline = 104.7 ± 11.6 ; re-baseline = 112.2 ± 13.5 ; $t_{32} = -3.99$; $P < 0.001$), reasoning (baseline = 95.7 ± 13.1 ; re-baseline = 103.3 ± 13.6 ; $t_{32} = -2.76$; $P = 0.009$), and executive functioning (baseline = 102.0 ± 9.8 ; re-baseline = 108.1 ± 12.4 ; $t_{32} = -2.08$; $P = 0.004$). There were no significant findings associated with verbal memory, visual memory, complex attention, or reaction time. None of the mean differences exceeded previously established RCIs. **Conclusions:** We observed improvements in several neurocognitive domains between baseline and re-baseline. All of the improvements were well within established RCIs, indicating that these improvements represent normal variations in

neurocognition. Therefore, there may be no clinical utility of computerized neurocognitive re-baseline testing in a collegiate setting. Further investigation is needed to determine the effect of time between sessions and total number of post-injury tests on improvement between baseline and re-baseline scores.

14139DOPR

Differences In Total Inversion Range Of Motion With And Without Prophylactic Ankle Support During Dynamic Sudden Inversion

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Context: Prophylactic ankle supports are commonly used in the prevention of lateral ankle sprains. However, the effectiveness of taping versus bracing in restricting total inversion range of motion is still an area that requires additional investigation.

Objective: The purpose of this study was to compare maximum inversion range of motion during ankle taping, bracing, and control conditions during a dynamic perturbation task.

Design: Crossover study. **Setting:** Athletic Training Research Laboratory.

Patients or Other Participants: Twenty-nine participants (11 males, 18 females, 21.4 ± 2.9 years, 169.5 ± 9.6 cm, 66.6 ± 12.1 kg) volunteered for this study. Participants were excluded if they had an acute lower extremity injury, history of fracture or surgery in the lower extremity, or any neuromuscular disease affecting their balance such as Parkinson's disease.

Intervention(s): Subjects walked on a custom-built 7.3m walkway, which was designed with sections that suddenly invert the subjects' ankle to 30° when triggered. All subjects completed three conditions: tape, brace, and control (no external support). The ankle taping condition used the closed basketweave technique, which was applied with 1.5-inch linen tape (Zonas, Johnson & Johnson Consumer Products, Bridgewater, NJ). The brace condition used an ASO Ankle Brace (Medical Specialties Inc, Charlotte, NC). During the control condition the subject had no ankle support. Order of test condition was counterbalanced and all testing was completed in a standardized shoe (Adidas Excelsior training shoe). Subjects completed 3 walkway trials

in each test condition. **Main Outcome Measure(s):** Maximum inversion($^\circ$) was captured using an electrogoniometer (SG110/A, Biometrics, Ltd, UK) placed on the lateral aspect of the ankle. Maximum inversion was defined as the maximum amount of ankle inversion within the 500 milliseconds following the door dropping. The average of three trials for each condition was used for statistical analysis. Repeated measures ANOVA was performed with one within-subjects factor at three levels (tape, brace, and control). Bonferroni post hoc testing was conducted for any significant findings. A priori alpha level was set at $p < 0.05$. **Results:** There was a significant difference between the three conditions ($F_{2,56} = 31.70$, $p < 0.001$). Specifically, both the tape and brace conditions decreased ankle inversion compared to the control condition (tape = $22.30 \pm 4.74^\circ$, brace = $19.97 \pm 4.47^\circ$, control = $25.37 \pm 4.50^\circ$). Additionally, the brace condition allowed less inversion than the tape condition (mean difference: $2.33 \pm 0.62^\circ$, $p = 0.002$). **Conclusions:** Prophylactic ankle supports reduce ankle inversion range of motion during a dynamic sudden inversion perturbation. Ankle braces provide the most support when compared to taping and no ankle support. Future research should evaluate whether bracing might also provide a greater reduction in lateral ankle sprains.

14F07DOTE

Combination Of Eccentric Exercise And Neuromuscular Electrical Stimulation To Improve Quadriceps Function Post-ACL Reconstruction

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Context: Quadriceps activation failure (QAF) and muscle atrophy are two critical components of quadriceps function that may contribute to weakness that lingers following anterior cruciate ligament reconstruction (ACLR). Neuromuscular electrical stimulation (NMES) has been found to reduce QAF, and eccentric exercise has been shown to improve quadriceps volume and strength in patients post-ACLR. Therefore, an intervention combining NMES and eccentric exercise may be effective at reinstituting quadriceps function post-surgery.

Objective: Determine the effectiveness of a combined NMES and eccentric exercise intervention to improve the recovery of quadriceps activation and strength following ACLR. **Design:** Parallel longitudinal. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-six individuals post-ACL injury were placed into three groups: NMES and eccentric exercise (N&E $n = 7$, 24.4 ± 5.7 years, 1.43 ± 0.7 m, 80.5 ± 16.0 kg) NMES-only (N-only $n = 10$, 21.8 ± 4.4 years, 1.77 ± 0.1 m, 81.7 ± 22.7 kg) and Control who received standard of care (Control $n = 9$, 17.4 ± 2.7 years, 1.74 ± 0.1 m, 76.9 ± 25.2 kg).

Intervention(s): All patients, regardless of group, received the standard of care post-ACLR. Patients in groups N&E and N-only received the NMES protocol 2x per week for the first six weeks following ACLR. Group N&E also received a single-legged eccentric leg press protocol 2x per week for six weeks beginning at week six post-ACLR. **Main Outcome Measure(s):** Quadriceps activation was assessed using the burst superimposition

technique and quantified by averaging three trials of the central activation ratio. Quadriceps strength was assessed using the average of three maximal voluntary isometric contractions that were normalized to subject body mass (Nm/kg). Quadriceps strength and activation were gathered on three occasions: prior to ACLr, 12 weeks post-ACLR and upon clearance to return to sport (RTS) (mean = 7.18 ± 1.0 mo). Repeated measures ANOVAs were utilized to compare groups on quadriceps activation and strength. Post-hoc univariate F tests and t-tests were utilized where appropriate. **Results:** A group by time interaction was found for quadriceps strength ($F_{4,46} = 2.70$, $P = 0.042$) not activation ($F_{4,46} = 1.34$, $P = 0.268$). N&E (mean \pm SD) 12 week = 2.38 ± 0.6 ; RTS = 2.94 ± 0.6) was stronger than N-only (12 week = 1.72 ± 0.4 ; RTS = 2.11 ± 0.6) and Control (12 week = 1.56 ± 0.5 ; RTS = 2.17 ± 0.7) at both post-operative time points ($P < 0.05$). N-only was not different than Control ($P > 0.05$). Pre-operative strength (2.72 ± 0.1) was not different from post-operative strength for N&E at either time point ($P > 0.05$), but N-only and Control had greater pre-operative strength (N-only = 2.70 ± 0.7 ; Control = 2.70 ± 0.7) than post-operative strength at both 12 weeks and RTS ($P < 0.05$). **Conclusions:** Patients receiving N&E demonstrated better recovery of strength compared to individuals that received NMES or standard of care. Given that the NMES intervention had no effect on strength, we surmise that eccentric exercise was likely the driving factor behind the improved strength in N&E patients. Current work in our laboratory is examining the effect of eccentric exercise alone on quadriceps strength and activation to help determine if the separate application of eccentrics is as effective as the combined application of NMES and eccentrics. Supported by NIH Grant K08 AR053152-01A2 and an NATAREF Doctoral Grant.

Descriptive Epidemiology In US Women's High School And NCAA Soccer: 2004/05–2012/13

Kerr ZY, Roos KG, Marshall SW, DiStefano LJ, Hayden R, Dompier TP, Comstock RD: University of North Carolina, Chapel Hill, NC; University of Connecticut, Storrs, CT; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; University of Colorado-Denver, Denver, CO

Context: Few studies have reported sport injury incidence across levels of competition; even fewer have combined datasets from different surveillance programs. The National Collegiate Athletic Association Injury Surveillance System (NCAA-ISS) and the High School Reporting Information Online system (High School RIO) are two programs similar enough that common data elements can be combined for comparison. **Objective:** To compare the past nine years of NCAA-ISS and High School RIO injury surveillance data for women's soccer. **Design:** Descriptive epidemiology. **Setting:** Online injury surveillance systems from 70 universities and 100 high schools. **Patients or Other Participants:** Women's soccer players from participating schools who participated in official practices or competitions from 2004/05 through 2012/13. A total of 5,617 and 2,839 injuries were captured by ISS and RIO, respectively. **Intervention(s):** Independent variables included level of competition and school size [Divisions in college, school size (< 1000 students vs. ≥ 1000 students) in high school]. **Main Outcome Measure(s):** Injury rates (IR), injury rate ratios (IRRs), injury proportions by body site, diagnosis, and severity, and injury proportion ratios (IPR) are reported with 95% confidence intervals (CI). **Results:** The collegiate women's soccer IR (7.69/1,000 AEs) was 3.35 (95% CI: 3.20, 3.50) times the high school women's soccer IR (2.30/1,000 AEs). Collegiate IRs were higher among Division I student-athletes (8.09/1,000 AEs) than Division II and III

(7.37/1,000 AEs) (IRR = 1.10; 95% CI: 1.04, 1.16; $P < 0.001$). High school IRs were higher among student-athletes from schools with < 1000 students (2.78/1,000 AEs) than athletes from schools with ≥ 1000 students (2.03/1,000 AEs) (IRR = 1.37; 95% CI: 1.28, 1.48; $P < 0.001$). Distributions of injuries were similar between age groups overall. Common injuries included ankle sprains (college: 16.1%; high school: 19.3%) and hip/thigh/upper leg strains (college: 17.2%; high school: 11.8%). However, concussions comprised a larger proportion of injuries among high school (18.3%) compared to collegiate (8.5%) athletes (IPR = 2.16 95% CI: 1.93, 2.43; $P < 0.001$). Injuries resulting in time loss of more than three weeks (i.e., severe injuries) comprised a larger proportion of injuries among high school (20.8%) compared to collegiate (11.1%) athletes (IPR = 1.87; 95% CI: 1.69, 2.08; $P < 0.001$). **Conclusions:** Although many similarities exist in injury rates and patterns across age groups, IRs were higher among collegiate women's soccer players compared to high school players. Concussions and severe injuries comprised larger proportions of injuries in high school athletes. These differences may be attributable to varying reporting characteristics between/within surveillance systems, and/or true differences in risk between the college and high school levels. Nevertheless, sport-related injury surveillance data can be used to drive the development of targeted injury prevention interventions in women's soccer.

Free Communications, Oral Presentations: Dance Biomechanics

Thursday, June 26, 2014, 12:30PM-1:15PM, Room 245; Moderator: Jeffrey Russell, PhD, ATC

14242MOBI

Lower Extremity Landing Biomechanics In Dancers And Nondancers

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Context: Prevention of anterior cruciate ligament (ACL) injury is paramount as they often cause short- and long-term deficits in function and quality of life. Dancers have a greatly reduced incidence of ACL injury than other jump-landing athletes. Evidence is lacking to explain the biomechanical differences in landing activities between dancers and non-dancing athletes. **Objective:** To compare landing biomechanics of dancers and non-dancing athletes during a drop-vertical-jump (DVJ). **Design:** 3 (group: dancers, nondancing females, nondancing males) x 2 (shoe condition: shod vs. barefoot) x 2 (jump condition: distracted vs. undistracted) mixed model. **Setting:** Laboratory. **Patients or Other Participants:** 37 subjects volunteered (11 female dancers: 20.8 ± 1.8 years, 166.2 ± 6.8 cm, 62.9 ± 17.3 kg; 14 female nondancers: 20.2 ± 0.9 years, 168.8 ± 5.0 cm, 61.6 ± 7.7 kg; 12 male nondancers: 22.0 ± 2.7 years, 181.2 ± 9.9 cm, 81.1 ± 13.6 kg). All subjects had to have at least 5 years of experience in dance, soccer, or basketball. **Intervention(s):** Kinematics were recorded as subjects performed a single-leg DVJ from a 30cm platform while shod and barefoot during distracted and undistracted jumping conditions. For the distracted jump condition, subjects stepped off the platform onto a force plate while a ball was tossed to them prior to landing. The toss occurred randomly during 3 of 6 DVJ trials. For the undistracted condition, no distraction was provided. **Main Outcome Measure(s):** Ankle, knee, and hip joint angles were recorded in the frontal and sagittal planes during each DVJ and values at points during the landing were identified for comparison: 100ms pre-initial contact

(PIC), when ground reaction forces became > 10 N (Initial Contact or IC), peak knee flexion (PKF), and peak angle achieved during landing phase (PEAK). Separate 3 (group) x 2 (shoe condition) x 2 (jump condition) analyses of variance with repeated measures was used to compare joint angles. Post-hoc pairwise-comparisons were used to identify differences. Alpha was set to $P \leq 0.05$. **Results:** Results reported here reflect significant group main effects only. Females nondancers displayed decreased ankle inversion compared to female dancers at PIC (Females = $4.16 \pm 2.4^\circ$, Dancers = $12.84 \pm 2.59^\circ$; $P = 0.048$) and male nondancers at PIC (Females = $4.16 \pm 2.4^\circ$, Males = $13.76 \pm 2.49^\circ$, $P = 0.023$) and IC (Females = $1.41 \pm 2.32^\circ$, Males = $11.01 \pm 2.41^\circ$, $P = 0.018$). Dancers experienced greater hip abduction at PIC compared to male nondancers (Dancers = $7.42 \pm 1.26^\circ$, Males = $2.63 \pm 1.22^\circ$, $P = 0.025$) but not female nondancers (Dancers = $7.42 \pm 1.26^\circ$, Females = $3.31 \pm 1.17^\circ$, $P = 0.057$). Male nondancers landed in greater knee adduction (Males = $7.337 \pm 1.68^\circ$, Females = $0.104 \pm 1.62^\circ$, $P = 0.01$) and less hip adduction (Males = $0.96 \pm 2.0^\circ$, Females = $8.42 \pm 1.92^\circ$, $P = 0.029$) than female nondancers at PKF. **Conclusions:** Dancers exhibit differences in landing preparation compared to female and male nondancers. These differences are most pronounced at the hip, with dancers landing in a more hip abducted position, and at the ankle, with dancers landing more inverted. This may offer a greater total range of motion during landing and allow them attenuate force more efficiently, thereby placing less strain on the ACL.

14239MOBI

Ground Reaction Forces In Ballet: Differences According To Footwear And Jump Conditions

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Context: Ballet dancers are reported in the literature to suffer high rates of overuse, lower extremity injuries. The cause of this trend has yet to be determined; however, high ground reaction forces (GRF) and shoe conditions have been identified in the past as possible contributing factors. Shoe conditions vary immensely between dancers and could have significant impact on biomechanics and injury rates. **Objective:** To investigate the maximal GRF when ballet dancers land from two different jump conditions; and to explore the possible effects that specific pointe shoe conditions have on GRF. **Design:** Crossover design. **Setting:** University biomechanics laboratory. **Patients of Other Participants:** Twenty-one healthy, female college ballet majors (19.28 ± 1.01 years; 167.45 ± 4.39 cm; 52.75 ± 3.43 kg.) volunteered for this study. All participants had similar years of classical ballet training (12.85 ± 2.37 years). Dancers were excluded if they had a history of an acute lower extremity injury within the past six weeks, lower extremity surgery within the past six months, or if they were experiencing any acute illness at the time of testing. **Intervention(s):** Subjects performed two different ballet jumps: *assemblé* and *grand jeté*. Each jump was performed in three different shoe conditions: barefoot, flat technique shoes, and pointe shoes. The order of jump type and shoe condition randomized. Participants landed each jump on a recessed force plate (AMTI Accugait System Model ACG, Watertown, Massachusetts) and maximal GRFs were recorded. **Main Outcome Measure(s):** Dependent variable was maximal ground reaction force (Newtons). A repeated measures analysis of variance was

calculated with two within subjects factors (shoe type at three levels and jump type at two levels). Bonferroni post hoc test was calculated on any significant findings. A priori alpha level was set at $p < 0.05$. **Results:** No significant differences in GRFs were identified between the 3 shoe conditions ($F_{2,20} = 1.95$, $p = 0.17$), however, significant differences in GRFs were identified between the jump types ($F_{1,20} = 5.85$, $p = 0.03$). Post hoc testing revealed that when dancers performed the grand jeté, higher GRFs were obtained compared to the assemblé (mean difference = 239.29N, 95% CI = 32.96N to 445.62N). **Conclusions:** Results of this study indicate that GRF varies between ballet jumps, with the grand jeté creating higher GRF values than the assemblé; however, it does not appear that shoe condition significantly affects GRFs. Overall, the results of this study indicate that shoe conditions do not have a significant impact on a dancers ground reaction force.

Dancers Land With Greater Knee Extension But An Anteriorly Positioned Center Of Mass Compared To Athletes During A Drop Jump Task

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Context: Anterior cruciate ligament (ACL) injuries frequently occur during landing maneuvers. Landing with an extended knee with a posteriorly positioned center of mass (COM) increases the anterior pull of the quadriceps on the proximal tibia, potentially causing increased ACL strain. Both female athletes and dancers land with an extended knee; however, dancers are 5x less likely to tear their ACL compared to athletes. Limited research has assessed how these populations position their COM, but a greater sagittal plane distance between the COM and the center of pressure (COP) during a landing task in athletes may help explain the difference in ACL injury risk. **Objective:** To compare knee flexion angles and COM relative to the COP sagittal position during a drop jump landing in female dancers and athletes. **Design:** Descriptive cohort study. **Setting:** Laboratory setting. **Patients or Other Participants:** Forty female subjects (12 dancers [21.3 ± 1.8 yrs; 1.6 ± 0.1 m; 58.67 ± 8.4 kg] and 28 athletes [20.5 ± 2.3 yrs; 1.7 ± 0.1 m; 62.7 ± 8.4 kg] with a minimum of 5 years of experience in their respective activities and currently active ≥ 3 hours per week participated. Dancers were enrolled in the University's Dance Department and had experience in ballet or modern dance. Athletes were intercollegiate or club level athletes who participated in sports that required running, cutting, and landing tasks. **Intervention:** Participants performed 3 trials of a drop jump task off a 0.45m box while 3D kinematic and kinetic data were collected. **Main Outcome Measure(s):** Knee flexion angle of the

dominant stance leg was assessed at initial foot contact (vertical ground reaction force > 10 N). Sacral COM represented the entire body COM. COP was used to represent the location of foot contact. The anterior-posterior distance between COM and COP was assessed at initial foot contact. Differences between dancers and athletes were assessed with independent t-tests ($P < 0.05$) and effect sizes. **Results:** Dancers landed with less knee flexion at initial contact (Dancers = $7.4 \pm 5^\circ$; Athletes = $11.1 \pm 4^\circ$; $P = 0.05$; Cohen's $d = 0.67$), and a more anteriorly positioned COM relative to their COP (Dancers = 22 ± 3 cm; Athletes = 25 ± 4 cm; $P = 0.03$; Cohen's $d = 0.71$). **Conclusions:** A more posteriorly positioned center of mass has been previously identified as a risk factor for ACL injury. Despite dancers landing with a more extended knee, the posterior positioning of the COM displayed by athletes may increase anterior knee loads and potentially contribute to the injury rate disparity between dancers and athletes. Future research should examine kinetic risk factors such as knee extensor moments and relative joint energy absorption to better understand the injury rate disparity.

Free Communications, Oral Presentations: Influence of Head Impacts on Concussion Measures

Friday, June 27, 2014, 8:00AM-9:00AM, Room 245; Moderator: Melissa Fraser, MS, ATC, LAT
14114DOIN 14369UOSP

Traumatic Brain Injury Does Not Increase Subsequent Risk Of Non-Contact Lower Extremity Injury

Mauntel TC, Lynall RC, Ney MJ, Kerr ZY, Mihalik JP, Padua DA: Sports Medicine Research Laboratory, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Traumatic brain injury (TBI) results in measurable postural control and neurocognitive deficits that may persist 10-14 days following injury. Gait deficiencies may persist beyond the typical recovery window of postural control and neurocognitive deficits. Deficits in postural control, neurocognitive function, and gait are frequently theorized risk factors for non-contact lower extremity (LE) injury. Since TBI is known to adversely affect these domains, TBI may be a potential risk factor for non-contact LE injury during sport. There is little evidence examining the association between TBI and non-contact LE injury. **Objective:** To determine the relative risk of sustaining a non-contact LE injury following TBI. **Design:** Cohort. **Setting:** Patient clinic. **Patients or Other Participants:** Seventy-seven NCAA division I varsity athletes (males=46, females=31; age at TBI=19.8±1.4yrs) were identified as having sustained one TBI during their collegiate career. A representative sample of sex and sports was included in our study. Participants self-reported as being TBI free for at least 1 year prior to and following the TBIs of interest. **Intervention(s):** A retrospective medical chart review was completed. Non-contact LE injuries and time at risk (any day the individual was capable of participating in physical activity) up to 365 days pre-TBI and post-TBI were recorded. We excluded direct contact, overuse, and fracture injuries. Multivariate Poisson regression models were used to estimate incidence rates of non-contact LE injuries pre-TBI and

post-TBI. **Main Outcome Measure(s):** Incidence rates of non-contact LE injuries at 90, 180, and 365 days pre-TBI and post-TBI were determined. Poisson regression models estimated the association between TBI and the incidence rate of non-contact LE injuries post-TBI ($\alpha \leq 0.05$). **Results:** No significant differences were observed between non-contact LE injury incidence rates pre-TBI and post-TBI for any time interval. The incidence rate ratio (IRR; where 1=no difference, <1 = decrease risk, >1 = increased risk) post-TBI compared to pre-TBI for the 90-day interval was 0.724 (95%CI: 0.323,1.624; P=0.433), 0.980 (95%CI: 0.539,1.780; P=0.946) for the 180-day interval, and 1.169 (95%CI: 0.700,1.950; P=0.551) for the 365-day interval. **Conclusions:** Traumatic brain injury is not a risk factor for non-contact LE injury as evidenced by the lack of differences observed in non-contact LE injury incidence rates pre-TBI and post-TBI. This finding contradicts previous research reports of increased non-contact LE injury rates following TBI. Several reasons for the differences in the studies exist: the current study looked at all recorded non-contact LE injuries, not just those resulting in time loss; and the current study did not use matched controls, but compared individuals to themselves. Further research is needed to determine what, if any, neuromuscular deficits exist which might explain the previously suggested increased risk of non-contact LE injuries post-TBI.

Comparing Computerized BESS Scores Between Student-Athletes Involved In Collision, Contact, And Non-Contact Sports

Lukk JL, Caccese JB, Kaminski TW: University of Delaware, Newark, DE

Context: The Balance Error Scoring System (BESS) test is often used as part of the concussion evaluation protocol, where pre-season baseline scores are used for comparison post-concussion. Recent technological advances using a pressure mat system has allowed for the development of computerized BESS scoring. Additionally, very little normative data exists with regard to BESS test scores derived from different athletic populations, especially those involved in heavy contact and collision type sports. Literature involving other neurocognitive measurements has indicated that males are more likely to be in the concussion group (79%) than the control group (44%); correlating with other reports that sports traditionally played by males are collision and contact types. **Objective:** To compare baseline BESS scores across collision (football [FB]), contact (men's [MSOC] and women's soccer [WSOC], and field hockey [FH]), and non-contact (volleyball [VB]) sports. **Design:** Between-groups baseline comparison. **Setting:** Athletic training room. **Patients or Other Participants:** One-hundred and eleven NCAA Division-I student-athletes (60 females, 51 males, height = 69.2 ± 3.9cm, mass = 76.4 ± 18.7kg, age = 19.4 ± 1.8yrs.) across five sports FB, MSOC, WSOC, FH, and VB volunteered for this study. Baseline BESS testing is routine as part of the university's concussion management plan. **Intervention(s):** Subjects were asked to perform the BESS, which includes 3 stances: single-leg (non-dominant), double-leg, and tandem (non-dominant in back) and two surfaces: firm vs.

foam, while standing on the Tekscan (Boston, MA) MobileMat™ BESS. Each stance was maintained for 20 seconds with the hands on hips and eyes closed. Stance and surface conditions were performed in random order. The MobileMat™ BESS software, guided by an algorithm based off the BESS scoring criteria, displayed an error score at the end of each trial. **Main Outcome Measure(s):** Total BESS error scores served as the dependent measure in this study. Group (collision, contact, non-contact) status served as the independent variable. A one-way ANOVA was used to compare BESS total errors across the groups. **Results:** Total BESS error scores ranged from 5 to 30. There was no significant difference in total BESS error scores across sport type ($p = 0.150$). The average number of errors for the collision sport (FB) was 18.7 ± 5.1 , while the contact (WSOC, MSOC, and FH), and non-contact (VB) sports had a similar number of total errors, 17.3 ± 4.5 and 16.3 ± 5.7 , respectively. **Conclusions:** The results suggest that there are no balance deficits across this group of collegiate collision, contact, and non-contact sport athletes, despite several years of participation. Although we did not examine/correlate previous concussion histories or numbers of sub-concussion impacts in the groups studied, we speculate that based on our data, BESS test scores would not appear to be negatively impacted as a result of the demands and rigors associated with the 3 different types of sports.

Cumulative Sub-Concussive Head Impacts Degrade Visual Target Capture Times In High School Football Players

Schmidt JD, Guskiewicz KM, Mihalik JP, Blackburn JT, Siegmund GP, Marshall SW: The University of Georgia, Athens, GA; The University of North Carolina at Chapel Hill, Chapel Hill, NC; MEA Forensic, Richmond, BC, Canada

Context: The frequency and magnitude of subconcussive head impacts sustained by football players may negatively affect neurological processes such as vision. **Objective:** To determine whether the frequency and/or magnitude of head impacts sustained by high school football players during a single season predict changes in visual performance. **Design:** Prospective quasi-experimental. **Setting:** Clinic/On-field. **Patients or Other Participants:** Twenty high school football players (height = 180.7 ± 7.2 cm, mass = 80.4 ± 13.5 kg, age = 16.3 ± 0.9 years). **Intervention(s):** Players completed a visual performance assessment prior to and following the 2012 football season. Visual performance was measured using the Nike SPARQ Sensory Station and included measures of Visual Acuity, Contrast Sensitivity, Depth Perception, Near-Far Quickness, Target Capture, Perception Span, Eye-Hand Coordination, Go/No Go, and Reaction Time. Head impact biomechanics were captured for each player using the Head Impact Telemetry System. **Main Outcome Measure(s):** We conducted nine separate multiple regression analyses for each of the visual performance measures using the forward method ($\alpha = 0.05$). Predictor variables included the total head impact frequency and sum of the peak linear acceleration (g) from all head impacts (>10 g) sustained over the course of the season. Criterion variables included change scores computed between pre- and post-season for all nine

visual performance measures. A negative change score indicated a decline in performance. **Results:** Players sustained 524.5 ± 340.2 head impacts with a sum peak linear acceleration of 13903.9 ± 9629.9 g. For each additional head impact sustained we observed a decline in Target Capture performance by 0.279 milliseconds ($R^2 = 0.20$, $F_{1,21} = 4.52$, $P = 0.048$). This means that for each additional 100 head impacts sustained during a single season, players would experience a 27.9 millisecond decline in Target Capture performance. No other models predicted significant variance in visual performance. **Conclusions:** A majority of visual functions remained relatively unaffected. Our results imply that football players' ability to quickly identify a target in the periphery may be negatively influenced by repeated head impact exposure sustained over a single season, but is not influenced by head impact magnitude. Certain player types, such as linemen, may be at greater risk because of the high frequency of head impacts that they sustain over a single season. Mitigating head impact exposure in adolescent athletes may be necessary to reduce the neurological effects of subconcussive head impacts. Further research is needed to continue determining the influence of subconcussive head impacts on neurological processes.

Health Related Quality Of Life Declines From Preseason To Midseason In High School Football Athletes

Mayfield RM, Rettmann AN, Moore BK, Broglio SP: School of Kinesiology, Neurosport Research Laboratory, University of Michigan, Ann Arbor, MI

Context: Contact sports, such as football, are commonly associated with repetitive head impacts. Literature suggests that sub-concussive impacts may lead to cognitive alterations, but little is understood about the effects on behavior, such as Health Related Quality of Life (HRQOL). **Objective:** To evaluate changes in HRQOL during a high school football season. **Design & Setting:** Research laboratory and high school football field. **Patients or Other Participants:** 24 male adolescent athletes participating in high school football (age = $16.21 \pm .78$, weight = 81.13 ± 13.4 (kg), height = 179.89 ± 6.61 (cm)). **Intervention(s):** As part of a larger study evaluating biomechanics in football, the student-athletes were evaluated prior to and midway through the competitive season. Each participant completed Satisfaction With Life (SWL) and Health Behavior Inventory (HBI) surveys. Each participant wore a Head Impact Telemetry System encoder to track the location and magnitude of head impacts during sport. **Main Outcome Measure(s):** The dependent variables were participants' responses to the HRQOL questionnaires and biomechanical variables associated with head impacts. Paired t-tests were used to assess relationships between pre-season and midseason scores for SWL and HBI individual items and total scores. Pearson correlations were completed between impact variables and pre-season to midseason HRQOL difference scores. **Results:** There was a significant decline on all SWL items (5/5 items were significant) and total score from

pre-season to midseason (baseline: 30.54 ± 2.69 ; midseason: 30.17 ± 3.14) (p 's < 0.005). A significant decline (p 's < 0.04) on HBI individual items (7/20 items were significant) and the total cognitive sum (baseline: 11.42 ± 3.62 ; midseason: 9.79 ± 4.09) was also revealed. Significant correlations were noted between the pre-season to midseason difference score for the HBI "Conditions of life are ideal" and: number of game impacts ($p = .045$), total number of practice and game impacts ($p = .026$), cumulative linear acceleration ($p = .020$), cumulative rotational acceleration ($p = .036$), and cumulative HITsp ($p = .029$). **Conclusions:** Health Related Quality Of Life in high school football players declined from pre-season to mid-point of the season. The correlational analyses suggest this may be the result of football participation (i.e. sub-concussive impacts), but other factors such as academics and/or social pressures may also play a role. It remains unknown if HRQOL measures will return to baseline following the competitive season. (This research was funded by the National Institutes of Health - National Institute of Neurological Disorders and Stroke [1R15NS081691]).

Free Communications, Oral Presentations: Biomechanics and Adaptations to Overhead Sports

Friday, June 27, 2014, 9:15AM-10:15AM, Room 245; Moderator: Stephen Thomas, PhD, ATC

14237MOBI

14169FOBI

Correlation Of Shoulder And Elbow Kinetics With Ball Velocity In Collegiate Baseball Pitchers

Post E, Laudner K, McLoda T, Wong R, Meister K: Illinois State University, Normal, IL, and Texas Metroplex Institute for Sports Medicine and Orthopedics, Arlington, TX

Context: Throwing a baseball is an extremely dynamic and violent act that places large amounts of stress on the shoulder and elbow. Specific injuries at the elbow and glenohumeral joints have been linked to several kinetic variables that occur throughout the throwing motion. However, very little research has been conducted to directly examine the relationship between these kinetic variables and ball velocity.

Objective: To examine the correlation of peak ball velocity with elbow valgus torque, shoulder external rotation torque, and shoulder distraction force in a group of collegiate baseball pitchers. **Design:** Cross-sectional. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** Sixty-seven, asymptomatic, NCAA Division I baseball pitchers (age = 19.5 ± 1.2 years; height = 186.2 ± 5.7 cm; mass = 86.7 ± 7.0 kg, 48 right-handed, 19 left-handed) participated. **Intervention(s):** We measured peak ball velocity using a radar gun (Stalker Sport, Plano, TX). We measured elbow valgus torque, shoulder external rotation torque and shoulder distraction force of the throwing arm using 8 electronically synchronized high-speed (240 Hz) digital cameras (Motion Analysis Corporation, Santa Rosa, CA). After warming up, participants threw 5 fastballs off an indoor pitching mound towards a regulation distance (18.4 m) strike zone target. The average of the 3 highest velocity fastballs thrown for strikes was used for data analysis. We used ExpertVision software (Eva 6.0, Motion Analysis Corporation) to track 26 reflective markers placed on various

anatomical landmarks of each participant and three-dimensional coordinate data were determined via direct linear transformation. We used a Pearson's correlation coefficient to determine the relationship between ball velocity and peak elbow valgus torque, shoulder distraction force, and shoulder external rotation torque ($p < .05$). **Main Outcome Measure(s):** Elbow valgus torque, shoulder external rotation torque, and shoulder distraction force. **Results:** Mean and standard deviation values for the group included ball velocity of 37.3 ± 1.6 m/s, elbow valgus torque of 5.7 ± 1.3 % body weightheight, shoulder distraction force of 110.0 ± 16.0 % body weight, and shoulder external rotation torque of 5.2 ± 1.0 % body weightheight. A weak positive correlation was found between ball velocity and shoulder distraction force ($r = .26$, $p = .02$). However, there were no significant correlations between ball velocity and elbow valgus torque ($r = .20$, $p = .05$) or ball velocity and shoulder external rotation torque ($r = .10$, $p = .22$). **Conclusions:** The results of this study indicate that there is very little association between peak ball velocity and several kinetic variables at the elbow and shoulder joints in collegiate baseball pitchers. While a weak positive correlation was found between shoulder distraction force and ball velocity, no significant association was seen between ball velocity and elbow valgus torque or shoulder external rotation torque. These results indicate that other factors, such as improper pitching mechanics, may contribute more to increases in joint kinetics than peak ball velocity.

Reliability And Validity Of Two-Dimensional Video Analysis Of Joint And Segment Angles During Baseball Pitching

Oyama S, Myers JB: Department of Health and Kinesiology, University of Texas San Antonio, San Antonio, TX, and Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Various baseball pitching kinematics have been linked to increased joint loading and injury risk in pitchers. Therefore, utilizing analysis of pitching technique in coaching and rehabilitation may be useful in training and injury prevention. Therefore, an increasing number of coaches and clinicians are using two-dimensional video recordings and application software to analyze pitchers' technique qualitatively and quantitatively. However, reliability and validity of the angles measured using two-dimensional analysis is unknown. **Objective:** To investigate the reliability and validity of two-dimensional analysis of joint and segment angles during baseball pitching. **Design:** Cross-sectional study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Thirty right-handed high school baseball pitchers (age = 15.7 ± 1.1 years, height = 179.6 ± 7.6 cm, mass = 73.7 ± 9.2 kg). **Intervention(s):** The participants performed pitches from an indoor mound until at least 3 strike-pitches were captured using a motion capture system and two high-speed video cameras that were placed directly in front and to the side of the mound. **Main Outcome Measure(s):** The fastest strike pitch from each pitcher was used for analysis. Two-dimensional elbow extension angle (EXT) at ball release (REL), shoulder abduction (ABD), trunk forward flexion (FF), and trunk contralateral flexion (CLF) angles at stride foot contact (SFC), maximal shoulder

external rotation (MER), and REL were calculated by visually identifying the time points and manually digitizing the segments. Each trial was processed three times by a single investigator. The corresponding three-dimensional anatomical angles were calculated from the data collected using the motion capture system. Intra-rater reliability of the two-dimensional angles were determined using intra-class correlation coefficients (ICC) and standard error of measurements (SEM). Validity of the two-dimensional angles were evaluated by assessing the correlations and mean absolute errors (Error) between the two-dimensional and three-dimensional angles. The validity of the variable was considered to be good if the correlation coefficient was < 0.80 and the Error was $< 10^\circ$. **Results:** The intra-rater reliability of the two-dimensional angles were high with ICC2,k and SEM ranging from 0.75-0.94 and 2.2-3.9°, respectively. The validity of the angles were good for ABD at SFC ($r = .80$, Error = 7.5°) and CLF at MER ($r = .88$, Error = 5.9°) and REL ($r = .81$, Error = 7.1°), but was not for the others. **Conclusions:** Two-dimensional angles at the shoulder, elbow, and trunk could be measured with high reliability. However, the angles are not necessarily anatomically correct from segments being out-of-plane, and thus use of two-dimensional videos should be limited to qualitative analysis and quantification of angles that can be measured with relatively good validity. Shoulder abduction angle at SFC and contralateral trunk flexion angles have been linked to greater joint loading. Therefore measuring these angles using two-dimensional video analysis may have potential implications for identifying and instructing pitchers who may be at higher risk of shoulder and elbow injuries.

Relationship Between Pitch Count And Infrapinatus Cross-Sectional Area And Shoulder Range Of Motion

Hibberd EE, Neuharth BM, Rucinski TJ, Myers JB: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Pitch count has been suggested as a risk factor for shoulder/elbow injury, but the physical and physiological responses to an acute bout of pitching are not clearly understood. The infrapinatus contracts eccentrically to decelerate the arm during the pitching motion cause sarcomere damage and muscle stiffness, previously identified in the literature as contributors to injury. It is important to understand the effect of an acute bout of pitching on infrapinatus cross-sectional area, which is an indicator of inflammation and the clinical measures of glenohumeral ROM to determine how physical and physiological characteristics change due to pitching. **Objective:** To evaluate infrapinatus cross-sectional area (CSA) and shoulder ROM before and after game pitching and to examine the relationship between pitch count and changes in infrapinatus CSA and shoulder ROM. **Design:** Pretest-Posttest Design **Setting:** Baseball Athletic Training Facility. **Patients or Other Participants:** 14 collegiate baseball pitchers during 36 bouts of game pitching participated (age = 19.4 ± 0.94 yrs, height = 188.1 ± 6.6 cm, mass = 89.0 ± 12.3 kg). **Intervention(s):** Infrapinatus CSA (diagnostic ultrasound) and shoulder internal rotation and horizontal adduction ROM (digital inclinometer) were measured prior to and following a bout of game pitching. **Main Outcome Measure(s):** A 3-trial mean was calculated for pre and post pitching infrapinatus CSA and shoulder internal rotation and horizontal adduction ROM. Paired samples t-tests were used to evaluate changes in infrapinatus CSA and ROM

variables from pre to post pitching. A percent change score was calculated for infrapinatus CSA and ROM variables. A linear correlation was calculated between pitch count and any variable that changed significantly from pre to post pitching. **Results:** Infrapinatus CSA increased significantly from baseline to post-pitching ($t_{35} = -7.8$, $p < 0.0005$, $md = 1.7\text{cm}^2$). There was no significant difference between in internal rotation range of motion ($t_{35} = -1.7$, $p = 0.095$) and horizontal adduction range of motion ($t_{35} = 0.8$, $p = 0.440$). There was a significant relationship between percent change in CSA and pitch count ($r_{36} = 0.5$, $p = 0.004$). **Conclusions:** There was a significant increase in infrapinatus CSA following a bout of pitching, which indicates inflammation from sarcomere damage that occurs as the infrapinatus contracts eccentrically to decelerate the arm following ball release. The significant correlation between infrapinatus CSA and pitch count indicates that as the pitch count increases, the damage to the sarcomeres, presenting as an increase in infrapinatus CSA, increases. While CSA significantly increases, the ROM measures do not significantly change from baseline to post-pitching. Inflammation, sarcomere damage, and increased passive muscle stiffness may limit ROM gains that would be expected acutely following pitching. These findings, as well as future research on the role of pitch type, mechanics and velocity on changes to CSA, can be used to help with pitching recommendations. In addition, tracking infrapinatus CSA may be an effective method for clinicians to use to track recovery in pitchers.

Acute Alterations Of Scapular Upward Rotation Following A Functional Fatiguing Protocol In Male Tennis Players

Rich RL, Tucker WS, Munkasy BA, Buckley TA: Samford University, Birmingham, AL; University of Central Arkansas, Conway, AR; Georgia Southern University, Statesboro, GA

Context: Alterations in scapular kinematics, specifically upward rotation, are associated with a variety of chronic shoulder conditions. Fatigue may exacerbate the mechanisms potentially resulting in microtrauma and impingement syndrome. **Objective:** To identify acute alterations of scapular upward rotation following a functional fatigue protocol. **Design:** Prospective longitudinal. **Setting:** Controlled laboratory environment. **Patients or Other Participants:** Twenty healthy, male competitive tennis players with no history of shoulder injury participated in this study: 10 experimental subjects (19.4 ± 1.07 years, 180.09 ± 8.92 cm 72 ± 11.56 kg) and 10 control subjects (19.6 ± 1.17 yrs., 181.1 ± 6.56 cm 81.56 ± 13.51 kg). **Intervention(s):** Static scapular upward rotation was measured three times per session on the dominant arm while at rest, 60°, 90° and 120° of humeral elevation in the scapular plane. Participants in the experimental group performed a tennis serving protocol and maintained at least 90% maximal exertion of the tennis serve. Fatigue was defined as reaching a rating of 15 using Borg's rate of perceived exertion scale as well as 70% HR max. Upward rotation measurements were taken before and immediately following the fatigue protocol, and 24, 48, and 72 hours post exercise. Control participants were tested at the same time intervals without the fatiguing protocol. The independent variables were group (experimental and control) and time (pre-fatigue, post-fatigue, 24 hours, 48 hours, and 72

hours post exercise). **Main Outcome Measure(s):** The dependent variables were the mean upward rotation at the four positions of humeral elevation (rest, 60°, 90°, and 120°). The influence of group and time on mean upward rotation was compared using a 2 x 5 factorial ANOVA with repeated measures followed by simple contrasts as appropriate. **Results:** Significant group-by-time interaction for scapular upward rotation was found at all testing positions (rest, 60°, 90°, and 120°). Contrasts revealed differences between the experimental group's pre-fatigue and post-fatigue values at all testing positions (pre-fatigue rest: 1.48 ± 2.66 post-fatigue rest: $-.68 \pm 2.66$ $p < .001$; pre-fatigue 60°: 7.87 ± 4.46 post-fatigue 60°: 5.67 ± 4.72 $p = .010$; pre-fatigue 90°: 22.51 ± 5.40 post-fatigue 90°: 19.29 ± 5.16 $p < .001$; pre-fatigue 120°: 37.34 ± 6.91 post-fatigue 120°: 33.35 ± 6.49 $p < .001$; as well as at 60° pre-fatigue and 72 hours post exercise measurements (pre-fatigue 60°: 7.87 ± 4.46 day 4 60°: 7.67 ± 4.55 $p = .031$). **Conclusions:** Fatigue appears to affect, specifically impairs, scapular upward rotation in male tennis players but returns to baseline values within twenty-four hours. Further research should identify when it returns to baseline to provide guidance for rest intervals for healthy male tennis players as well as if these changes are similar in an injured group of players.

Shoulder Evidence-Based Forum: Pathomechanics and Rehabilitation of Rotator Cuff Tendinopathy

Friday, June 27, 2014, 10:30AM-11:30AM, Room 245; Speakers: Stephen Thomas, PhD, ATC; Brian Leggin, PT, DPT, OCS; Moderator: Kathleen Swanik, PhD, ATC

Free Communications, Oral Presentations: Core and Spine

Saturday, June 28, 2014, 8:00AM-9:15AM, Room 245; Moderator: Matthew Gage, PhD, ATC

14167FOBI

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The Side Plank As A Measure Of Core Stability Is Not Associated With Landing Biomechanics

Pfile KR, Boling MC, DiStefano LJ, Nguyen A: College of Charleston, Charleston, SC; University of North Florida, Jacksonville, FL; University of Connecticut, Storrs, CT; High Point University, High Point, NC

Context: Diminished core stability, measured using advanced laboratory equipment, is an established risk factor for anterior cruciate ligament (ACL) injury. There is a need for a clinically applicable measure of core stability that can be implemented in a field setting to identify individuals potentially at risk for injury. **Objective:** To evaluate the relationship between the side plank exercise (SPE) and hip and knee kinematics during a jump-landing (JL) in high school female athletes. **Design:** Cross-sectional. **Setting:** Field. **Patients or Other Participants:** Thirty-one healthy female high school soccer players (14.8 ± 1.4 yrs, 166.0 ± 5.0 cm, 58.1 ± 10.0 kg) volunteered. **Intervention(s):** Participants performed the SPE by lying on their side (dominant limb towards the ground) with their elbow flexed under their shoulder. They were instructed to raise their hips up so that their body formed a straight line from shoulder to feet and maintain this position for as long as possible without losing form. Three-dimensional hip and knee joint kinematics were assessed on the dominant limb using an electromagnetic motion analysis system during three trials of the JL task. Participants jumped from a 30-cm high box set 50% of their height away from a platform and rebounded for maximum vertical height upon landing on a non-conductive force plate to complete the JL task. **Main Outcome Measure(s):** SPE total time was measured in seconds using a stopwatch. The participant pool was divided evenly into tertiles based on their time (SPEHIGH, SPEMID, SPELOW). Initial contact (IC)(ground reaction force > 10N) and peak angles during the deceleration

phase (IC to peak knee flexion) were analyzed. Separate one-way ANOVAs were performed to compare SPEHIGH, SPEMID, and SPELOW groups on kinematic variables. Effect sizes (Cohen's d) with 95% confidence intervals were calculated using pooled standard deviations. **Results:** Group descriptive data for the SPE: SPEHIGH ($n = 10$, 67.6 ± 17.8 "), SPEMID ($n = 11$, 33.3 ± 3.1 "), SPELOW ($n = 10$, 22.7 ± 4.6 "). No significant differences were identified for any of the kinematic variables ($P > .05$). Group kinematic means and standard deviations (SPEHIGH, SPEMID, SPELOW): peak knee flexion ($88.7 \pm 9.6^\circ$, $89.7 \pm 13.8^\circ$, $76.4 \pm 8.5^\circ$), knee flexion IC ($14.6 \pm 11.8^\circ$, $16.6 \pm 12.6^\circ$, $10.2 \pm 7.8^\circ$), peak knee valgus ($11.3 \pm 9.6^\circ$, $13.2 \pm 10.0^\circ$, $9.6 \pm 6.7^\circ$), knee valgus IC ($7.5 \pm 3.9^\circ$, $4.0 \pm 7.6^\circ$, $5.6 \pm 4.9^\circ$), peak knee rotation ($6.8 \pm 10.0^\circ$, $-1.5 \pm 10.3^\circ$, $2.6 \pm 6.3^\circ$), knee rotation IC ($-7.8 \pm 7.0^\circ$, $-10.4 \pm 7.0^\circ$, $-10.7 \pm 8.2^\circ$), peak hip flexion ($77.5 \pm 17.7^\circ$, $66.1 \pm 26.2^\circ$, $60.0 \pm 16.7^\circ$), hip flexion IC ($38.9 \pm 17.2^\circ$, $35.1 \pm 15.3^\circ$, $33.2 \pm 15.9^\circ$), peak hip adduction ($-1.2 \pm 4.0^\circ$, $2.6 \pm 12.8^\circ$, $2.5 \pm 7.4^\circ$), hip adduction IC ($-6.7 \pm 4.8^\circ$, $-7.4 \pm 12.0^\circ$, $-4.0 \pm 8.1^\circ$), peak hip rotation ($5.5 \pm 8.9^\circ$, $5.1 \pm 13.0^\circ$, $8.8 \pm 9.7^\circ$), hip rotation IC ($-8.2 \pm 5.2^\circ$, $-5.5 \pm 6.7^\circ$, $-4.3 \pm 9.2^\circ$). Peak knee flexion approached statistical significance ($F_{2,19} = 3.2$, $P = 0.064$, $d_{SPELOW, SPEHIGH} = 1.36$ (0.15, 2.57), $d_{SPELOW, SPEMID} = 1.13$ (0.07, 2.20)). **Conclusions:** In adolescent female athletes, the SPE may not be an effective clinical test to assess core stability differences leading to altered landing kinematics. There is a statistical trend indicating better performance on the SPE relates to increased knee flexion, a desirable strategy to decrease ACL injury risk.

The Effect Of Target Position On The Accuracy Of Cervical Spine Rotation Active Joint Position Sense

Nagai T, Clark NC, Abt JP, Sell TC, Heebner NR, Smalley BW, Wirt MD, Lephart SM: Warrior Human Performance Research Center, Neuromuscular Research Laboratory, University of Pittsburgh, Pittsburgh, PA; US Army School of Aviation Medicine, Fort Rucker, AL; Blanchfield Army Community Hospital, Fort Campbell, KY

Context: Proprioception mediates neuromuscular control of joint stability. Clinically, previous studies have reported that individuals with neck pain can present with impaired cervical spine rotation active joint position sense (AJPS). The cervical spine can be divided into upper and lower units, and each unit contributes differently to the magnitude of rotation range-of-motion (ROM). It is clinically important to determine if there are positional differences in cervical spine rotation AJPS. **Objective:** To compare cervical spine rotation AJPS near mid-ROM (30°) and near end-ROM (60°). It was hypothesized that AJPS is more accurate near end-ROM versus mid-ROM. **Design:** Cross-sectional. **Setting:** Warrior human performance research laboratory. **Patients or Other Participants:** Fifty-three Soldiers (5 males/48 females, age: 28.5 ± 6.4 years, height: 175.3 ± 9.8 cm, mass: 80.1 ± 11.8 kg) without a history of neck pain were recruited from the 101st Airborne Division (Air Assault). **Intervention(s):** A motion analysis system was used to record cervical rotation kinematics. Subjects sat in a chair wearing a headband and blindfold. Reflective markers were placed on the headband and over the sternum and cervical-thoracic spine. From a front-facing neutral start position, subjects actively rotated the head right or left to a target position ($30^\circ/60^\circ$) with real-time verbal cues provided by the tester. Subjects held the

target position for five seconds and then returned to the start position. Subjects then replicated the target position as closely as possible. Five trials were performed in both directions to both target positions (R30/R60/L30/L60). Order of direction/position was randomized. The difference between target position and replicated position was recorded. Friedman tests and post-hoc tests were used to compare AJPS at the different target positions ($p < 0.05$). **Main Outcome Measure(s):** The difference between the target and replicated angle was calculated and defined as absolute error (AE), the mean of five trials used for analyses. The standard deviation of five trials was also calculated and defined as variable error (VE) and used for analyses. **Results:** There was a significant difference for AE and VE ($p < 0.001$). End-ROM AE was significantly more accurate than mid-ROM AE (R30/L30: $3.0 \pm 1.3^\circ/3.2 \pm 1.6^\circ$; R60/L60: $2.2 \pm 1.0^\circ/2.2 \pm 1.2^\circ$; $p = 0.001$). End-ROM VE was significantly more accurate than mid-ROM VE (R30/L30: $2.7 \pm 1.1^\circ/3.0 \pm 1.5^\circ$; R60/L60: $2.1 \pm 0.9^\circ/2.3 \pm 1.5^\circ$; $p < 0.010$). **Conclusions:** Cervical spine rotation AJPS is more accurate near end-ROM versus mid-ROM in those without history of neck pain. Both target positions should be used to encompass cervical spine rotation AJPS of both the upper and lower units. Future studies should evaluate AJPS in Soldiers with neck pain and examine if ROM-specific interventions should be developed/evaluated for reducing the incidence and severity of neck pain. Supported by USAMRMC #W81XWH-11-2-0097.

Reliability Of Sacroiliac Joint Pain Provocation Tests In Experienced And Inexperienced Athletic Trainers

Sandrey MA, Turner T: West Virginia University, Morgantown, WV

Context: Sacroiliac joint tests assess mobility and pain; however, there are few reliable tests for sacroiliac joint dysfunction and virtually no studies which examined the reliability of experienced and inexperienced athletic trainers. **Objective:** To determine reliability between experienced and inexperienced examiners while performing a battery of valid sacroiliac joint (SIJ) pain provocation tests. **Design:** Single blind cross-sectional reliability. **Setting:** Sports Medicine Clinic. **Patients or Other Participants:** Two inexperienced graduate certified athletic trainers and two examiners with 5 of more years of SIJ experience were used. Four recorders recorded data. Thirty healthy male and female subjects (21.43 ± 3.1 yrs) without a previous history of back surgery or lower limb surgery within the last two years volunteered. **Intervention(s):** After a practice session, 2 experienced and 2 inexperienced examiners performed a battery of SIJ pain provocation tests in a randomized testing order. The tests performed were sacral distraction (SD), sacral compression (SC), sacral thrust (ST), thigh thrust (TT), and sacral sulcus tenderness (SST). The examiners performed each test and then reported to the recorder if the test created concordant, discordant, or no pain. Examiners rotated between subjects in 4 examination rooms. The procedure was completed in two rounds, the original day and again after the first round was completed. Each examiner was blinded to the previous rounds results. **Main Outcome Measure(s):** Independent variables were the 4 evaluators and the two rounds with the dependent variable being the response of

concordant, discordant or no pain for the SIJ tests. Intra- and inter-rater reliability was determined using Cohen's Kappa for the agreement between experienced and inexperienced athletic trainers for the battery of SIJ tests. In addition percent agreement and k/k_{max} were calculated for each evaluator (between experienced and inexperienced). **Results:** Kappa ranges for intra-rater and inter-rater reliability for all examiners, respectively were: SD ($k=1.0$; 0.012 to 1.0), SC ($k=0.65$ to 1.0; 0.02 to 0.74), ST ($k=0.37$ to 0.84; 0.39 to 0.84), TT right ($k=0.47$ to 0.65; 0.47 to 1.0), TT left ($k=1.0$; 0.47 to 1.0), SST right ($k=.71$ to 0.88; 0.52 to 1.0) and SST left ($k=0.52$ to 0.69; 0.27 to 0.86). All tests except for SD and TTL resulted in a higher inter-rater reliability for experienced examiners than that of inexperienced examiners. Percent agreement for all tests ranged from 80-100%. A k/k_{max} score for intra-rater reliability ranged from 6%-100% with the SD and TTL $k/k_{max}=100\%$ for experienced and inexperienced examiners. For inter-rater reliability, k/k_{max} ranged from 63%-100%. The experienced examiners $k/k_{max}=100\%$ in round 2 for SC, ST SSTR and SSTL. Both the experienced and inexperienced $k/k_{max}=100\%$ in round 2 for SD, TTR and TTL. **Conclusions:** Overall, intra-rater reliability was higher than inter-rater reliability and experienced examiners were more consistent. The findings of this study may determine whether inexperienced examiners need more clinical exposure in evaluating SIJ dysfunction.

Relationship Among Subjective And Objective Measures Of Disability In Patients With Non-Specific Low Back Pain

Sutherland MA, Hart JM: University of Virginia, Charlottesville, VA

Context: Individuals with non-specific low back pain (NSLBP) often self-report disability or limitations with activities of daily living. However, some NSLBP individuals may continue to participate at exercise or athletic levels similar to healthy individuals despite these limitations. Currently, factors associated with self-reported disability in this group of NSLBP patients are unknown. **Objective:** To identify the relationship among perceived levels of disability, patient demographics and objective measures of muscle function in physically active individuals with or without a history of NSLBP. **Design:** Case control. **Setting:** Clinical research laboratory. **Patients or Other Participants:** A total of 24 subjects participated (12 NSLBP, age: 24 ± 4 years; height: 168.70 ± 12.42 cm; mass: 72.61 ± 17.59 kg; body mass index (BMI): 25.19 ± 3.44 kg/m²; Tegner activity scale (Tegner): median 7, range 4-10; pain visual analog scale (VAS): 1.06 ± 0.88 ; Oswestry pain questionnaire (Oswestry): $17.33 \pm 11.23\%$; Fear Avoidance Beliefs Questionnaire (FABQ): 18.0 ± 8.1 , and 12 Healthy, age: 22 ± 3 years, height: 175.90 ± 8.94 cm; mass: 65.81 ± 8.84 kg; BMI: 21.28 ± 2.40 kg/m²; Tegner: 6, 3-10; VAS 0 ± 0 ; Oswestry: $1.33 \pm 2.46\%$; FABQ: 0 ± 0 ; Total sample, age: 23 ± 3 years; height: 172.30 ± 11.20 cm; mass: 69.21 ± 14.05 kg; BMI: 23.24 ± 3.52 kg/m²; VAS 0.53 ± 0.81 ; Oswestry: $9.33 \pm 11.4\%$; FABQ: 9.0 ± 10.8 ; current Tegner activity level: 7, 3-10). **Intervention(s):** All participants completed a single data collection session in a clinical research laboratory. **Main Outcome Measure(s):** All participants completed the Oswestry, VAS and

FABQ. Isometric hip abduction strength and fatigue were measured bilaterally in side-lying for a 30 second trial. We recorded peak torque as the mean of the 2nd second of the contraction and fatigue as the percent change in torque at the 26th second. Mann-Whitney U tests compared all measurements between groups. Pearson's r s and Spearman rho correlation coefficients were calculated to determine relationships among the variables. Level of significance was set at $P < 0.05$. **Results:** We observed significantly higher BMI ($P = 0.008$), VAS ($P = 0.001$), Oswestry ($P < 0.001$), and FABQ ($P < 0.001$) in patients with NSLBP (data reported above). Oswestry and FABQ scores were related ($r = 0.771$, $P < 0.001$), however neither Oswestry nor FABQ were associated with activity level (Oswestry: $\rho = 0.190$, $P = 0.374$, FABQ: $\rho = 0.174$, $P = 0.415$) or strength (Oswestry, strength: $r = 0.127$, $P = 0.553$; fatigue: $r = 0.291$, $P = 0.168$; FABQ, strength: $r = 0.043$, $P = 0.842$; fatigue: $r = 0.198$, $P = 0.354$). Relationships were observed for both Oswestry and FABQ with pain (Oswestry: $r = 0.737$, $P < 0.001$; FABQ: $r = 0.458$, $P = 0.024$) and with muscle fatigue (Oswestry: $r = 0.449$, $P = 0.028$; FABQ: $r = 0.420$, $P = 0.041$). Age ($r = 0.506$, $P = 0.012$) and BMI ($r = 0.413$, $P = 0.045$) were also related with FABQ. **Conclusions:** Individuals with NSLBP reported greater levels of disability than controls. The relationships between muscle function and patient reported outcomes indicated that poorer hip abduction endurance is associated with lower perceived levels of dysfunction. Strength and current highest activity level were not related to disability or fear of movement.

Diagnostic Ultrasound Imaging To Measure The Thickness Of The Transversus Abdominis Muscle During A Supine Abdominal Bridge

Green ME, Mensch JM, Blanck EL, Stacy J, Gage MJ: University of South Carolina, Columbia, SC, and Liberty University, Lynchburg, VA

Context: The transversus abdominis (TA) has been identified as a primary spine stabilizer. Abdominal hollowing is the standard way to activate the TA, but it is unclear whether the TA can remain contracted during a supine abdominal bridge. Being able to train the TA to contract, not only in a static exercise, but also in a functional movement may increase core performance and decrease low back pain. **Objective:** To examine TA thickness at rest, during abdominal hollowing, and an abdominal bridge (with & without abdominal hollowing). **Design:** Descriptive laboratory study. **Setting:** Research was conducted in a controlled athletic training research laboratory. **Patients or Other Participants:** Twenty-six subjects (11 female, 15 male; age = 23.77 ± 3.128 yrs; height = 68.31 ± 3.52 in; weight = 168.19 ± 25.33 lbs) were recruited from a university population. All subjects signed an informed consent document and completed a basic demographic questionnaire. Subjects were excluded if they were not 18-35 years of age, unable to perform the activities pain free, or if they had been pregnant within the last 12 months. **Intervention(s):** The thickness of the TA muscle was measured via a Venue 40 diagnostic ultrasound machine five times each at rest and during a supine bridge. The subjects then received instructions on how to perform abdominal hollowing and practiced with visual feedback from the ultrasound. The thickness of the TA was then measured five times during the abdominal hollowing and then a supine bridge with specific instructions

to maintain abdominal hollowing throughout the bridge. **Main Outcome Measure(s):** TA thickness during the four positions. **Results:** A LSD pairwise comparison found rest (R) (41.68 ± 13.32), abdominal bridge (B) (48.47 ± 15.24), abdominal hollowing (AH) (mean = 63.60 ± 15.59), abdominal bridge with abdominal hollowing (BAH) (mean = 67.55 ± 17.78), and to be significantly different between each position with each position greater than rest (R to B and AH to BAH $p < .05$ and all other relationships $p < .001$). Pillai's Trace showed that gender ($p = .45$), activity level ($p = .15$), prior core training ($p = .59$), and prior abdominal hollowing training ($p = .45$) did not affect the results significantly. **Conclusion:** TA thickness was greater during the supine abdominal bridge compared to at rest. The greatest TA thickness was observed during the abdominal bridge with abdominal hollowing; therefore, proper training and instructions are vital in the most beneficial rehabilitation process.

Free Communications, Oral Presentations: Risk Factors, Disability, and Prevention of Pitching Injuries

Saturday, June 28, 2014, 9:30AM-10:45AM, Room 245; Moderator: Aaron Sciascia, MS, ATC, PES
14195FOMU 14329OOMU

Discriminant Analysis Of A Region Specific Patient Self-Report Scale In Baseball And Softball Players: The Functional Arm Scale For Throwers (FAST)

Huxel Bliven KC, Bay RC, Snyder Valier AR, Sauers EL: Post-Professional Athletic Training Program, A. T. Still University, Mesa, AZ

Context: Upper extremity (UE) patient-rated outcomes measures that possess items important to throwing athletes and have the ability to discriminate between injured and healthy athletes are limited. The Functional Arm Scale for Throwers (FAST) is a region-specific, patient self-report scale designed to measure the health-related quality of life (HRQOL) of baseball and softball players with UE injury.

Objective: To determine the ability of the FAST to discriminate between throwers who have current UE injury and currently healthy throwers. **Design:** Cross-sectional. **Setting:** Multiple patient clinics contributed data. **Patients or Other Participants:** Five-hundred fifty-seven subjects (age: 18.8 ± 2.2 years, experience: 10.7 ± 3.9 years) consisting of high school ($n = 257$) and college ($n = 300$) baseball ($n = 409$) and softball ($n = 148$) players who were pitchers ($n = 240$) and position players ($n = 317$). **Intervention(s):** Subjects completed the FAST and a self-report UE injury questionnaire and were grouped as current UE injury or currently healthy. Discriminant function analyses and receiver operating characteristic (ROC) curves using known group (current UE injury, currently healthy) as the state variable were used to estimate cut-off scores that discriminate the two groups with corresponding sensitivity and specificity.

Main Outcome Measure(s): The FAST contains 22-items across five subscales (throwing, pain, advancement, ADLs, psychological) to produce a total score

(FAST-TS) and a separate 9-item pitching module (FAST-PM) for pitchers only. The FAST-TS, individual subscales, and the FAST-PM, scored from 0–100, with higher scores indicating lower HRQOL, were calculated and used in discriminant and ROC analyses. **Results:** Mean FAST-TS for current UE injury ($n = 142$) and currently healthy ($n = 415$) throwers were 33.5 ± 18.5 and 7.3 ± 10.4 , respectively. The FAST-TS was able to discriminate between current UE injury and currently healthy throwers (canonical correlation = .66, $P < .001$). The aggregated individual subscales have good discrimination between groups (canonical correlation = .68, $P < .001$). Discriminant correlations for individual subscales were good to excellent: throwing = .96, pain = .85, advancement = .83, ADLs = .65 and psychological = .50. Mean FAST-PM scores for current UE injury ($n = 62$) and currently healthy ($n = 163$) pitchers were 52.8 ± 35.0 and 7.2 ± 14.2 , respectively. The FAST-PM was able to discriminate between groups (canonical correlation = .68, $P < .001$). Area under the curve (AUC) for the FAST-TS was 0.91, 95% C.I. (.89-.94), $P < .001$. A FAST-TS cut-off score of 10.0 is 91% sensitive and 75% specific for predicting injury status. AUCs for FAST subscales were 0.78-0.90, $P < .001$. AUC for the FAST-PM was 0.91, 95% C.I. (.87-.95), $P < .001$. A FAST-PM cut-off score of 10.0 is 87% sensitive and 78% specific for predicting injury status. **Conclusions:** The FAST has good-to-excellent ability to discriminate between currently UE injured and currently healthy baseball and softball players, suggesting that the FAST should be considered for routine assessment of HRQOL in throwing athletes with UE injury. Clinically, FAST-TS and FAST-PM scores above 10.0 increase the likelihood that a player has UE injury with diminished HRQOL.

Shoulder Adaptations Of Youth Athletes To Overhead Throwing

Astolfi MM, Swanik CB, Struminger AH, Kaminski TW, Royer TD: University of Delaware, Newark, DE

Context: The high repetitions and forces associated with overhead throwing lead to anatomical adaptations in elite and professional baseball athletes. However, little is known about the origin and progression of these changes that may account for the increasing trend of chronic shoulder injuries in youth baseball, and precipitate subsequent pathologies throughout a young athlete's lifetime. Elite adults experience structural changes with throwing, such as humeral retroversion (HR) and posterior capsule thickness (PCT), but the time at which these adaptations occur and the influence of age on these adaptations is unknown. **Objective:** To investigate the relationship of age and arm dominance on HR, PCT, glenohumeral internal rotation (IR), and glenohumeral external rotation (ER). **Design:** Post-test only control group. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-five subjects ages 8-12 (age = 10.94 ± 1.34 years; height = 151.31 ± 12.17 cm; weight = 42.51 ± 10.32 kg) who were active participants in youth baseball. Subjects had no arm injury in the past 6 months or history of upper extremity surgery. Subjects had been playing baseball for an average of 6 years. **Intervention(s):** The independent variables were arm dominance (side) and age (8-10 and 10-12 years). Diagnostic ultrasound was used to obtain measures of HR and PCT. HR was defined as the angle of the forearm when the bicipital groove was vertically oriented on the ultrasound monitor, and greater retroversion was noted by a lower number. PCT was determined by using the caliper software on the ultrasound system to measure the tissue between the labrum and

rotator cuff. A handheld inclinometer was used to collect IR and ER data. IR and ER were measured by rotating the humerus with the elbow and shoulder at 90°. Motion was stopped when scapular motion was detected by the investigator. All measurements produced excellent ICC(3,1) values above .92. **Main Outcome Measure(s):** 2x2 mixed model ANOVAs were used to compare influence of arm dominance and age on the dependent variables of HR, PCT, IR, and ER. **Results:** Significant main effects existed for arm dominance for HR ($p < .001$), ER ($p < .001$), IR ($p < .001$), and PCT ($p = .004$). Specifically, the dominant shoulders of youth throwers exhibited significantly less IR ($61.93 \pm 12.01^\circ$) but greater HR ($-11.18 \pm 13.39^\circ$), PCT ($1.294 \pm .239\text{mm}$), and ER ($152.47 \pm 14.08^\circ$) than the non-dominant shoulders (IR = $75.10 \pm 8.50^\circ$, HR = $-24.04 \pm 10.58^\circ$, PCT = $1.183 \pm .185\text{mm}$, ER = $131.50 \pm 12.14^\circ$). A significant interaction effect was observed between age group and arm dominance ($p = .05$). Post-hoc analysis showed that dominant internal rotation was significantly greater in the under 10-year-old group ($64.20 \pm 10.88^\circ$) compared to the over 10-year-old group ($60.2 \pm 12.79^\circ$). **Conclusions:** Negative structural adaptations of younger baseball players' dominant shoulders are similar to those adaptations observed in older baseball athletes. This study indicates that more examination of youth athletes is needed to determine the extent of these adaptations and whether they lead to injury.

Shoulder Flexibility And Humeral Retrotorsion Do Not Prospectively Predict Throwing-Related Arm Injury In High School Baseball Players

Myers JB, Hibberd EE, Oyama S: University of North Carolina at Chapel Hill, Chapel Hill, NC, and University of Texas at San Antonio, San Antonio, TX

Context: Decreased throwing arm humeral rotation and horizontal adduction flexibility and increased humeral retrotorsion have been identified in baseball players with throwing-related arm injuries, and therefore hypothesized to be risk factors for throwing-related arm injury. Potentially, assessments of shoulder flexibility and retrotorsion conducted during pre-participation screenings might aid clinicians in prospectively identifying players at risk of developing an arm injury during the season. **Objective:** To prospectively evaluate whether shoulder flexibility and humeral retrotorsion are predictors of throwing-related arm injury in high school baseball players. **Design:** Prospective cohort design. **Setting:** Field Laboratory. **Patient or Other Participants:** 832 males (age = $16.4 \pm 1.1\text{yrs}$; height = $179.9 \pm 6.5\text{cm}$; mass = $77.5 \pm 12.3\text{kg}$) on high school junior varsity or varsity baseball teams. **Intervention(s):** Participant demographics, humeral rotation and horizontal adduction flexibility (assessed as range of motion (ROM) with a digital inclinometer) and humeral retrotorsion (assessed with ultrasonography) were measured during preseason screenings. Practice and game exposures and injury surveillance data were collected weekly with the aid of the athletic trainers. **Main Outcome Measure(s):** Separate incidence rate ratios were estimated with Poisson regression models for throwing-related arm injury (an arm injury that resulted in a missed exposure) for each flexibility variable (dominant limb internal rotation, external rotation, total

humeral rotation arc, and horizontal adduction ROM and limb differences in these variables), humeral retrotorsion (dominant limb and limb difference) and playing position. Player exposures were used as an offset. An a priori alpha level was set for 0.05. **Results:** There were 41 throwing-related shoulder or elbow injuries that resulted in at least one missed exposure, equating to an injury rate of 0.96/1000 athlete-exposures. Only the playing position resulted in a significant rate ratio, with pitchers being 3.84 times more likely to sustain a throwing-related arm injury than position players (95% CI = 1.70-8.65; $p = 0.0012$). No flexibility or retrotorsion variables were associated with increased rate ratios (risk ratio = .82-1.11; $p = .38$ -.96). Similarly, none of these flexibility or retrotorsion variables were significant in additional analysis of the pitching cohort that occurred after identifying the increased pitching risk (rate ratio = .89-1.11; $p = .44$ -.99). **Conclusions:** Pitchers were at a greater risk of developing a throwing-related shoulder and elbow injury that resulted in time loss. In high school players and the subset of pitchers, pre-season measures of shoulder flexibility and humeral retrotorsion were not predictive of subsequent throwing-related arm injury during the season. While alterations of these variables have been identified in participants with injuries retrospectively in the literature, our observations do not support the ability of a pre-season screening to predict injury risk in high school baseball players. These pre-season screenings may be useful as baseline measures to evaluate range of motion alterations that might occur throughout the season.

Influence Of A Prevention Program On Arm Injury Risk: A Randomized Control Trial In Adolescent Pitchers

Shanley E, Bailey LB, Rauh MJ, Kissenberth MJ, Noonan TJ, Hawkins RJ, Thigpen CA: Proaxis Physical Therapy, Greenville, SC; San Diego State University, San Diego, CA; Greenville Hospital System, Greenville, SC; Hawkins Foundation, Greenville, SC; Steadman Hawkins Clinic, Denver, CO

Objective: High school pitchers are at three times greater risk of an overuse arm injury compared to position players, with most(69%) injuries occurring during the first month of the season. The purpose of this study was to determine the effectiveness of a preseason training program in decreasing the injury rate and altering the pattern of injuries. **Design:** Clinical Trial. **Setting:** Field. **Patients or Other Participants:** Healthy high school pitchers(n = 196; age = 15.7 ± 1.2; height = 165.0 ± 43.8 cm; weight = 72.2 ± 12.6kg) who were participating in all team activities were block randomized by school to intervention (INV, n = 103) or control (CON, n = 93) groups. **Intervention(s):** The INV group received an Athletic Trainer supervised posterior shoulder flexibility and strengthening program (3x/week for 8 weeks). The CON group participated in the teams' usual training. All players training activities were recorded and they participated in a 4-week interval-throwing program. **Main Outcome Measure(s):** Incidence rates were calculated per 1000 AEs and monthly trends for injury were examined by group, injury history, and body location. Additionally, injury rates from 2009 in the same schools were compared to their 2012 data. Rate ratios (RR) and 95% confidence intervals (CIs) were used to compare injury rates by group, injury history, body location,

and year. **Results:** There were 27 arm injuries among the pitchers;15 in the INT group and 12 in the CON group. The injury rate was similar in the INT (RR = 0.86; 95% CI:0.43-2.2) and CON (RR = 0.86;95% CI:0.43-2.2) groups. Previous arm injury did not increase the risk of an arm injury in the INV group (RR = 1.0; 95% CI: 0.38-2.8) but did in the CON (RR = 3.7,95% CI: 1.3-10.7). The seasonal pattern of arm injuries was evenly distributed in both groups (Cumulative Incidence: February INV = 2%; CON = 4%, March INV = 6%; CON = 5%, April INV = 5%; CON = 5%, May INV = 1%; CON = 0%). In 2012, 67% of CON teams participated in a general "arm care" program compared to 6% of all teams in a previous 2009 prospective cohort study. The injury incidence rate for pitchers was 12 times higher in 2009 (29.3/1,000 AEs) than in 2012 (3.4/1,000 AEs) (RR = 11.6, 95% CI: 7.1-16.1). In 2009, 18% of pitchers sustained an overuse arm injury in the first month of the season compared 3% of pitchers in 2012. **Conclusions:** Our results show similar injury rates between the INV and CON pitchers, however, the injury rates were significantly lower in 2012 than 2009 without a spike in injury over the course of the season. It appears that a general "arm care" and interval-throwing program is effective in reducing adolescent pitchers injury risk, especially early in the season. Pitchers in the INT group with a previous injury were less likely to suffer an injury in 2012 than control pitchers with a previous injury. Thus, a targeted pre-season conditioning program supervised by Athletic Trainers appears to reduce adolescent pitchers' injury risk with a history of arm injury. Further studies are warranted to confirm our results.

Effectiveness Of A Preseason Prevention Program On Arm Injury Risk Factors: An RCT In Adolescent Pitchers

Thigpen CA, Bailey LB, Kissenberth MJ, Noonan TJ, Hawkins RJ, Shanley E: Proaxis Physical Therapy, Greenville, SC; Greenville Hospital System, Greenville, SC; Hawkins Foundation, Greenville, SC; Steadman Hawkins Clinic, Denver, CO

Context: Deficits in posterior shoulder flexibility and strength have been identified as modifiable risk factors for pitching arm injuries. A prevention program targeted on posterior shoulder flexibility and strengthening may be effective in improving known baseline risk factors and decrease arm injury risk. **Objective:** The purpose of this study was to compare the effectiveness of a preseason prevention program in improving posterior shoulder flexibility and strength in a cohort of high school pitchers. **Design:** Clinical Trial **Setting:** Field. **Patient or Other Participants:** Baseball pitchers (n = 143 age = 15.7 ± 1.2; height = 165.0 ± 43.8cm;weight = 72.2 ± 12.6kg) who were participating in all team activities were block randomized by school to intervention (INV n = 88) or control (CON n = 76) groups. **Intervention(s):** The INV group received an Athletic Trainer supervised program (3x/week for 8-weeks). The CON group participated in the teams' usual training. All players participated in a 4-week interval-throwing program. **Main Outcome Measure(s):** Pre and post program bilateral shoulder ROM and strength were assessed using a digital inclinometer (DI) to measure supine external rotation (ER), internal rotation (IR), and horizontal adduction (HA) ROM with the scapula stabilized at 90° of abduction. The arm was stabilized at the side for ER-0 and in a 90°/90° position in supine for ER-90 and IR-90

strength assessments using a hand held dynamometer then normalized to body weight. Two trials of each measure were averaged and then used to calculate side to side deficits (non-dominant – dominant) and pre-post change scores to examine the ability of the program to ameliorate baseline deficits associated with injury risk. A one way ANOVA was used to compare the deficit change scores between groups and a 2 way ANOVA (group by injury) was used to examine the impact of the deficit change scores of the baseline risk factors on prospective injury. Statistical significance was set a priori $\alpha = 0.05$. **Results:** There was a 13% post-program loss to follow up with the majority no longer participating in baseball. There were 19 arm injuries among the pitchers with pre and post season measures over the subsequent season (INV = 11, 8 shoulder & 3 elbow injuries; CON = 8, 6 shoulder & 2 elbow injuries). The INV group displayed a greater reduction in IR deficit (INV = $7.3^\circ \pm 11$; CON = $1.8^\circ \pm 9$; $P = 0.05$) and HA deficit (INV = $3.3^\circ \pm 13$; CON = $-2.4^\circ \pm 11$; $P = 0.02$) compared to the CON group. The INV group also displayed a trend towards improved maintenance of their dominant arm ER-0:IR-90 ratio by 2% body weight (INT = $-1.6\% \pm 5$; CON = $-3.5\% \pm 5$; $P = 0.09$) compared to the CON group. Pitchers who went on to suffer an injury in the INT group did not show the same reduction of HA deficit (INT = $4.3^\circ \pm 8$; CON = $-9.2^\circ \pm 14$; $P = 0.03$) when compared to the CON group. There were no other differences between the INT and CON groups ($P > 0.05$). **Conclusions:** Adolescent pitchers displayed clinically meaningful improvements in posterior shoulder flexibility during an Athletic Trainer supervised preseason program. While there were trends suggesting posterior shoulder strength gains these were not greater than the other strength gains during these teams usual activities. Additionally, the improvements in posterior shoulder flexibility in the

preseason, particularly HA were associated with decreased injury risk over the course of the subsequent high school season. Thus, a targeted pre-season program appears to be effective in improving known risk factors related to arm injury and may reduce the injury risk in pitchers. Further studies are warranted to confirm our results.

Free Communications, Oral Presentations: Chronic Ankle Instability

Saturday, June 28, 2014, 11:00AM-12:15PM, Room 245; Moderator: Kathy Liu, PhD, ATC

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Sensorimotor Control Is Predictive Of Self-Reported Ankle Dysfunction In Patients With Chronic Ankle Instability

Kim KM, Hertel J: Texas State University, San Marcos, TX, and University of Virginia, Charlottesville, VA

Context: Disability associated with chronic ankle instability (CAI) has been associated with deficits in postural control and alterations in appropriately modulating Hoffmann reflex (H-reflex) amplitudes, yet it is unknown how both the H-reflex modulation and postural control directly affect ankle function. **Objective:** To examine the extent to which H-reflex modulation and postural control predict self-reported ankle dysfunction associated with CAI. **Design:** Descriptive. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen subjects with CAI (9 males, 6 females; age = 23 ± 5.8 years; height = 174.7 ± 8.1 cm; mass = 74.9 ± 12.8 kg) participated. **Intervention(s):** The Foot and Ankle Ability Measure (FAAM) was administered to quantify self-reported ankle function during activities of daily living (ADL) and sports. Maximum H-reflexes (H-max) and motor waves (M-max) from the soleus and fibularis longus were recorded while subjects lied prone and then stood in unipedal stance. Postural tasks of quiet unipedal standing with eyes closed for 10 seconds were assessed with a forceplate. **Main Outcome Measure(s):** Self-reported function was estimated with the FAAM-ADL and Sport scales. Each score was converted to a percentage score with a higher score representing a higher level of ankle function. H-max was normalized to M-max to obtain Hmax:Mmax ratios for the two positions. For each muscle, H-reflex modulation was quantified with the percent change scores in Hmax:Mmax ratios calculated between the two positions. Center of pressure data were used to compute 4 specific

time-to-boundary (TTB) parameters including mean and standard deviation (SD) of TTB minima in the anteroposterior (AP) and mediolateral directions. Separate Pearson correlations were conducted to identify relationships of FAAM scores with H-reflex modulation and TTB measures. Separate multiple regressions were performed with each of FAAM scores as the outcome variable and H-reflex modulation of each muscle and one of TTB measures as predictors that are significantly correlated with the FAAM scores. **Results:** FAAM-ADL scores were correlated only with soleus H-reflex modulation ($r = .64$, $P = .019$) while FAAM-Sport scores were associated with H-reflex modulations of soleus ($r = .69$, $P = .010$) and fibularis longus ($r = .68$, $P = .018$) and mean of AP-TTB ($r = .71$, $P = 0.003$) and SD of AP-TTB ($r = .53$, $P = .042$). These results indicate better ankle function is associated with better postural control or greater H-reflex modulation. Regression analyses with FAAM-Sport scores as the outcome variable found 4 significant models (All P s $< .05$) with R^2 ranging from .53 to .75; the strongest model discovered the combination of soleus H-reflex modulation and mean of AP-TTB was the most significantly predictive ($F[2,10] = 14.79$, $R^2 = .75$, $P = .001$). Both sensorimotor measures in the model uniquely predicted FAAM-Sport scores (soleus: $B = .119$, $P = .032$, $R^2 = .156$; AP-TTB mean: $B = 3.622$, $P = .008$, $R^2 = .278$). **Conclusions:** Greater soleus H-reflex modulation during a postural transition and better postural control are predictive of a higher level of ankle function in patients with CAI. These results provide insights into treatments for ankle disability associated with CAI.

Jump Landing Time To Stabilization Is Different Among Individuals With Chronic Ankle Instability, Copers, And Controls

Wright CJ, Arnold BL, Ross SE: Whitworth University, Spokane, WA; Indiana University-Purdue University, Indianapolis, IN; University of North Carolina, Greensboro, NC

Context: Jump landing time to stabilization (TTS) has been used to identify dynamic stability deficits in individuals with chronic ankle instability (CAI). However, little data exists regarding TTS patterns in copers (individuals with a history of ankle sprain and no subsequent instability). Investigation of TTS in a copers population may shed light on the dynamic stabilizing mechanisms utilized by copers to maintain stability post-injury. **Objective:** The purpose was to capture jump landing TTS among CAI, copers and healthy control individuals. We hypothesized that copers would display greater dynamic stability. **Design:** 3 group observational cross-sectional design. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** Sixty-seven physically active volunteers participated (36 males, 31 females, age = 23.4 ± 3.8 years, height = 1.7 ± 0.09 m, weight = 69.6 ± 13.5 kg). Participants included 22 individuals with a history of at least 1 ankle sprain and at least 2 episodes of giving-way in the past year (CAI, Cumberland Ankle Instability Tool [CAIT] = 20.27 ± 2.75 , episodes of giving-way = 5.68 ± 8.67 per month), 21 subjects with no history of ankle sprain or instability in their lifetime (controls, CAIT = 29.00 ± 1.30), and 19 individuals with a history of a single ankle sprain and no subsequent episodes of instability (copers, CAIT = 28.11 ± 1.40). **Intervention(s):** Participants completed 10 single-leg drop jump landings off a 40cm box onto a force plate (Bertec, Columbus, OH) collecting at 1000Hz. Participants jumped off their uninjured limb, landing on their

involved limb and remaining in single leg balance for at least 10 seconds. **Main Outcome Measure(s):** TTS in seconds in the anterior-posterior (AP) and mediolateral (ML) directions was calculated for each trial, then averaged across trials for each subject. TTS was calculated using a custom MATLAB program which fit a polynomial to the rectified force data, calculated a normalized reference variable based on quiet stance, and identified the first instance the polynomial dropped below the reference variable as the TTS. An ANOVA with Bonferroni post hoc tested group differences in each direction. **Results:** TTS was significantly different among groups (TTSAP: $F_{2,61} = 12.00$, $p < 0.001$; TTSML: $F_{2,61} = 3.40$, $p = 0.040$). Post hoc tests indicated that AP TTS was significantly longer in the coper group than in controls and CAI (Coper = 1.99 ± 0.78 s, Control = 1.45 ± 0.21 s, CAI = 1.32 ± 0.16 s), however the control and CAI groups were not significantly different from each other. ML TTS was significantly longer in the CAI group than controls, however copers were not significantly different from either CAI or control groups (Coper = 1.32 ± 0.78 s, Control = 1.05 ± 0.30 s, CAI = 1.47 ± 0.43 s). **Conclusions:** As expected, individuals with CAI took longer to stabilize in the ML direction than healthy individuals. However interestingly, copers demonstrated longer AP TTS than either CAI or control individuals. Copers increased time in AP sway may be a compensatory technique, allowing greater freedom in the AP plane while quickly controlling ML sway in order to limit the potential of ML forces to create a destabilizing inversion moment.

Balance Error Scoring System Stances That Identify Division I Athletes With Chronic Ankle Instability

Linens SW, Dobo B, White A:
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Context: The Balance Error Scoring System (BESS) has identified subjects with Chronic Ankle Instability (CAI), but cutoff scores for discriminating between CAI and stable ankles have not been reported for Division I athletes competing in a mid-major conference. **Objective:** To identify CAI in Division I athletes with cutoff scores for significant BESS stances. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Division I mid-major athletes that participated in any one of the following sports: baseball, basketball, cross country, soccer, track & field, softball, or volleyball. CAI subjects had a history of ankle sprains and symptoms of "giving way" ($N = 32$; 177 ± 11 cm; 71 ± 16 kg; 20 ± 1 yrs) and stable ankle subjects had no history of ankle injuries ($N = 19$; 178 ± 8 cm; 73 ± 16 kg; 20 ± 1 yrs). **Intervention(s):** Subjects were videotaped performing the BESS on stable and unstable surfaces using three stances in the following order: double leg, single leg, and tandem. One trial on each surface for each stance was performed. Subjects kept their eyes closed, hands on hips, and remained as motionless as possible for 20 seconds. **Main Outcome Measure(s):** Error scores were later tallied for excessive sway, use of vision, change in body position, or touching down with the non-weight bearing leg for each stance of BESS. Sensitivity (SN) and 1-specificity (1-SP) values were calculated for each dependent measure across the range of possible scores to compute ROC curves. Area under the curve (AUC) and asymptotic significant values were then calculated ($\alpha = 0.05$). Next, cutoff scores were computed with

Youden's Index. Positive and negative likelihood ratios were calculated from the sensitivity and specificity values, and odds ratios were used to determine if a specific cutoff score could distinguish individuals with and without CAI. A one-tailed Fisher's Exact Test (FET) determined the statistical significance of the selected cutoff score for each stance ($\alpha = 0.05$). **Results:** Significant AUC values and cutoff scores were found for single leg stance on foam surface (AUC = 0.88, $p < 0.001$, SN = 0.81, 1-SP = 0.21; cutoff = 5 errors, positive likelihood ratio = 3.85, negative likelihood ratio = 0.24, odds ratio = 16.26, FET: $p = 0.00003$), and tandem stance on foam surface (AUC = 0.80, $p < 0.001$, SN = 0.81, 1-SP = 0.47; cutoff = 3, positive likelihood ratio = 1.72, negative likelihood ratio = 0.36, odds ratio = 4.82, FET $p = 0.01$). Significant AUC values, but with insignificant cutoff scores, were also found for single leg stance (AUC = 0.55) and tandem stance (AUC = 0.64) on firm surfaces. **Conclusions:** Clinicians can use single leg stance and tandem stance on a foam surfaces with the associated cutoff scores to identify balance deficits associated with CAI in Division I mid-major athletes that could benefit from a rehabilitation program.

14319MOTH

The Effects Of Sub-Sensory Plantar Stimulation On Plantar Pressures During Single-Limb Stance In Participants With Chronic Ankle Instability

Adams KKE, Gaven SL, Taggart JR, Hoch MC: Old Dominion University, Norfolk, VA, and Franklin College, Franklin, IN

Context: Individuals with chronic ankle instability (CAI) have demonstrated deficits in postural control and plantar cutaneous sensation. Improving the ability of the plantar cutaneous receptors to detect perturbation may enhance postural control in these individuals. **Objective:** To examine the effect of sub-sensory plantar cutaneous stimulation on plantar pressure (PP) distributions during single-limb balance in individuals with CAI. **Design:** Cross-over, double-blinded. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen adults with CAI (Male: 4, Female: 12; age = 23.38 ± 5.19 years; height = 168.25 ± 8.98cm; mass = 69.71 ± 13.06kg) participated. All participants reported a history of ≥ 1 ankle sprain; ≥ 2 episodes of giving way in the past three months, a score of ≤ 25 on the Cumberland Ankle Instability Tool, and ≥ 5 yes responses on the Ankle Instability Instrument. **Intervention(s):** Participants completed 4 testing sessions in which they received 1 of 4 sub-sensory electrical stimulation conditions on the plantar aspect of the foot during each session. Sub-sensory electrical stimulation was delivered using a transcutaneous electrical nerve stimulation unit and 2 pairs of electrodes positioned over the medial and lateral heel and forefoot. The 4 conditions included heel (HL), forefoot (FF), combined HL and FF (HL/FF), and sham stimulation. For each condition, the amplitude of the active electrodes was set below the sensory threshold for each participant. With the stimulation in place, participants performed 5 trials of eyes open

single-limb balance for 10 seconds on a pressure platform. All participants and the investigators measuring balance were blinded to stimulation condition. **Main Outcome Measure(s):** The dependent variables included the peak-PP and mean-PP for 8 regions of the foot (hindfoot, medial midfoot, lateral midfoot, medial forefoot, central forefoot, lateral forefoot, great toe, and toes 2, 3, 4, 5). For both PP variables, higher values indicated greater force within the respective foot region. The average peak-PP and mean-PP during the 5 balance trials was used for analysis. Peak-PP and mean-PP were analyzed using separate 4x8 ANOVA to examine differences across stimulation conditions and foot regions. For significant main effects or interactions, post-hoc Fisher's LSD tests were performed. The significance level was $p \leq 0.05$ for all analyses. **Results:** For peak-PP, significant main effects were identified for region ($p < 0.001$) and condition ($p = 0.009$); however, there was no condition-by-region interaction ($p = 0.29$). Post hoc testing revealed FF stimulation ($206.35 \pm 8.15\text{kPa}$) yielded lower peak-PP than all other conditions (FF/HL: $217.45 \pm 9.02\text{kPa}$, $p = 0.019$; HL: $219.81 \pm 10.55\text{kPa}$, $p = 0.007$; sham: $221.02 \pm 11.08\text{kPa}$, $p = 0.002$). No other differences were identified between conditions ($p < 0.05$). For mean-PP there was a significant main effect for region ($p < 0.001$); however, there was no condition main effect ($p = 0.28$) or condition-by-region interaction ($p = 0.53$). **Conclusions:** Sub-sensory plantar stimulation over the FF reduced the peak-PP exhibited by individuals with CAI during single-limb balance. This may indicate that participants could more readily detect perturbation and make subtle postural corrections prior to the need for large corrective strategies to maintain balance.

14137DONE

Sagittal-Plane Ankle And Knee Biomechanics And EMG Activity During A Forward Side Jump In Subjects With Chronic Ankle Instability

Kim H, Seeley MK, Reese S, Hopkins JT: Brigham Young University, Provo, UT

Context: Lateral ankle sprains are common sport-related injuries which often lead to chronic ankle instability (CAI). Specifically, CAI has been shown to impair neuromuscular control as well as proprioception of the lower extremity. However, few studies have comprehensively examined demanding movement strategies in subjects with CAI to identify risk factors such as lower extremity kinematic, kinetic and muscle activity. Examining this relationship may further clarify possible mechanisms of CAI. **Objective:** To investigate the effect of CAI on sagittal plane ankle and knee angles and moments as well as muscle activity during a forward side jump. **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** 56 CAI (31M, 25F: 22.4 ± 2.2yrs, 174.1 ± 9.4cm, 72.5 ± 14.4 kg), and 43 controls (18M, 25F: 22.3 ± 2.7yrs, 172.9 ± 9.6cm, 70.7 ± 14.1kg). **Intervention(s):** Subjects were tested on the dominant limb with eight sEMG electrodes, and fifty-nine reflective markers were placed over anatomical landmarks to calculate joint angles and moments as well as muscle activation. Subjects performed five trials of a forward-side jump on the force plate, which was to jump forward 1 m to the center of the force plate, land with the dominant leg, and then immediately jump to the contralateral side. A functional analysis ($p < 0.05$) was used to compare the entire stance phase of CAI subjects to Control subjects (function). This analysis allowed us to compare variables as polynomial functions rather than discrete values. We plotted our estimates of pairwise

comparison functions of each condition as well as 95% confidence interval (CI) bands to determine significant differences. If these 95% CI bands did not cross the zero line, we considered the difference significant. 0–40% and 40–100% of stance represented landing and push-off, respectively. **Main Outcome Measure(s):** Joint angles ($^{\circ}$), moments (N·m), and EMG amplitude (%) were measured from initial foot contact to take-off. Group-difference curves were obtained by subtracting the Control mean curve from CAI curve. **Results:** The CAI group showed increased plantarflexion and decreased knee flexion during 0–40% and 0–30% of stance, respectively. Plantarflexion moments were increased during 0–20% of stance while knee extension moments were decreased during transition from landing to push-off (30–50% of stance). CAI displayed greater gastrocnemius activation throughout entire foot contact (0–100% of stance) during the forward-side jump. Tibialis anterior activation was decreased during 10–20% of stance. Vastus lateralis activation decreased during 30–40% of stance (right before peak knee flexion). **Conclusions:** CAI subjects demonstrated a potentially high-risk movement strategy which included: increased plantarflexion, likely a result of greater plantarflexion moments and gastrocnemius activation and decreased knee flexion accompanied by decreased extension moments due to decreased vastus lateralis activation. CAI may alter lower extremity biomechanics in a way that could increase injury risk during functional activities.

Free Communications, Rapid Fire Poster Presentations: Professional Development and Commitment in the Workplace

Thursday, June 26, 2014, 8:00AM-9:30AM, Room 203/204; Moderator: James Mensch, PhD, ATC
14391FOPE 14398UOHE

Career Commitment Of Post-Professional Athletic Training Program Graduates

Mazerolle SM, Bowman TB, Goodman A: University of Connecticut, Storrs, CT; Lynchburg College, Lynchburg, VA; Appalachian State University, Boone, NC

Context: Choosing to pursue an advanced degree in athletic training appears to indicate professional commitment and passion for the profession. Many factors contribute to the initial attraction of a degree from a Post Professional Athletic Training Program (PPATP) and the choice to enter indicates a strong interest in the material, the desire to advance entry-level skill sets, and the intention to pursue a career in athletic training. Currently, there is a paucity of information regarding the decision to pursue enrollment in a PPATP indicating commitment to the profession, but later departing for another primary role outside of athletic training.

Objective: To understand why athletic trainers (ATs) invested in advanced training via a PPATP but decided to leave the profession. **Design:** Qualitative study. **Setting:** Online data collection utilizing QuestionPro™, a secure online research website. **Patients or Other Participants:** Twelve graduates (8 females, 4 males, 8 married/partnered, 4 single, average age = 31.58 ± 3.06 years, average years working as an AT = 4.71 ± 2.60 years) from PPATPs who no longer had primary employment as an AT. Popular current careers included physician assistant and nursing. Recruitment of participants was terminated upon saturation of the data. **Data Collection and Analysis:** Participants, identified by criterion and professional networking, responded to an email invitation to participate by completing a confidential online questionnaire. We developed the questions based upon the research agenda and previous literature on retention in the workplace. We analyzed data using a general inductive

approach and secured trustworthiness using multiple analyst triangulation, peer review, and member checks. **Results:** Two higher-order themes emerged on the career commitment of former ATs who were PPATP graduates: 1) Departure from an athletic training career and 2) Partial continuance in athletic training. Two second-order themes emerged from the reasons for departure: 1) Decreased recognition of value and 2) Work-life imbalance. Finally, we identified 2 third-order themes from the participants' reasons for departure due to a perceived lack of value: 1) Low salary and 2) Long, inconsistent hours worked. Participants had strong intentions to remain in their professional roles as ATs, however time and money strongly influenced career planning. Our participants did demonstrate respect for the role, but were unable to commit long-term. **Conclusions:** The majority of our participants intended to stay in the profession when they chose to attend a PPATP. However, during role inductance either during the clinical experience of the PPATP they attended or early on during their career, they began to have thoughts of leaving mainly due to inadequate financial compensation, work schedules, or both. Our findings unfortunately continue to support the negative impact long work hours and lower salaries can have on the professional commitment of the AT; despite intentions of longevity and passion for the role.

Impact Of Various Collegiate Settings On Athletic Trainers' Definition Of Professional Commitment

Goldstein SG, Scanlon DM, Busque KL, Mazerolle SM, Eason CM: University of Connecticut, Storrs, CT

Context: Professional commitment is an individualized concept that combines commitment to a profession and the organization of employment. For athletic trainers (ATs), the demanding work environment and job expectations may impact their characterization of professional commitment. The obligations and expectations imposed on ATs at various collegiate divisional settings may influence how ATs stay committed and excited in the profession. Currently there is no defined definition of professional commitment within the context of athletic training.

Objective: To evaluate the impact of collegiate divisional setting on the ATs' definition of professional commitment.

Design: Structured, online asynchronous interviews. **Setting:** Full-time ATs working in the collegiate setting with at least 1 year of experience beyond a graduate assistantship. **Patients or Other Participants:** Thirty-three BOC certified ATs employed in the collegiate setting (Division I = 11, Division II = 9, Division III = 13) volunteered with an average of 10 ± 8 years of clinical experience. Data saturation guided the total number of participants. **Data Collection and Analysis:** Participants responded to a series of questions by journaling their thoughts and experiences via QuestionPro™. Multiple analyst triangulation and peer review were included as steps to establish data credibility. The data was analyzed general inductive analysis. **Results:** Results were evaluated holistically as well as by Division. The emergent theme among ATs in the Division I setting was providing optimal medical care to their student

athletes. Professional commitment was operationalized as advocating for their student athletes, providing the best care possible, and mentoring them as young adults. In the Division II setting, ATs were focused on life-long learning as a reflection of commitment. This was often accomplished by attending seminars, completing CEUs, and continually adding to their skill set in order to provide the best care for their student athletes. Lastly, Division III focused their definition on being a multifaceted health care provider. It was commonly stated that giving all that you can and going beyond your normal duties was an aspect of professional commitment. **Conclusions:** The definition of professional commitment is dynamic and highly influenced by the setting of employment. Overall, ATs' professional commitment is derived from providing optimal quality of care to student-athletes, continuously advancing education within the profession, and being a multifaceted healthcare provider. Through this research it was determined that work setting creates an emphasis on different aspects of professional commitment. It is important to understand what keeps ATs motivated in the profession in order to enhance retention strategies. In the future, creating a work environment that has qualities from each divisional setting may help to make professional commitment of the ATs more well rounded.

Self-Reported Job Titles Among Athletic Trainers Who Participated In The Work-Related Risks Of Certified Athletic Trainers WRROCAT Study

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Context: Job titles have been associated with compensation, job satisfaction, status and intention to leave the profession. A previous study found that among collegiate Athletic Trainers (ATs), job titles (eg, head vs. associate vs. graduate assistant) have been linked to fringe benefits or non-salary items of value and workplace conditions and policies. ATs are increasingly assuming joint job titles (eg, Athletic Trainer/Professor, Clinician/Manager) and multiple roles (eg, patient care and teaching, patient care and administrative tasks). Researchers found that ATs in joint positions (academic/clinical) have an increased intent to leave the profession when job stress and role conflict are present. **Objective:** To describe the distribution of self-reported job titles, including joint job titles, and multiple responsibilities, among ATs working in a variety of settings who participated in an online survey. **Design:** Cross-sectional. **Setting:** Population based online survey. **Patients or Other Participants:** Eligible participants were ATs currently certified by the Board

of Certification, Inc (n = 29,051) who worked as athletic trainers and reported patient contact. Of 10,000 randomly selected ATs, 1,984 participated in the survey (19.8%). **Intervention(s):** The online survey was pilot tested with 25 AT volunteers. Online survey links were emailed May 17, 2012 and followed by three reminders. **Main Outcome Measure(s):** Self-reported job title in response to "what is your current job title" (n = 1911, 96% of participants). Responses were categorized into 1) single or joint job titles, and 2) clinical, academic, administrative and joint groupings. Age was categorized into groups for analysis (18–29, 30–49, 50+). Descriptive statistics included frequency, percentages, means, standard deviations and ranges. Chi-square tests and p-values < 0.05 determined significant differences. **Results:** Among survey participants, 1406 (73.8%) reported single job titles and 471 (24.6%) reported joint titles. The majority of single titles were clinical (n = 1171, 83.2%) and administrative (n = 201, 17.2%). The majority of joint titles (n = 471) were clinical/academic (36.2%) and clinical/administrative (29.7%). Men were more likely to have joint titles than women (men 27.2% vs. women 23.0%; $X^2 = 3.80$, $p = 0.051$). Older ATs were more likely to have joint titles than younger ATs (18–29: n = 65 [16.6%]; 30–49: n = 284 [26.0%]; 50+: n = 79 [37.4%]; $X^2 = 36.69$, $p < 0.0001$). Participants who reported a single job title reported performing patient care on average 71.3% (SD: 27.0%; range: 0–100%) of their work day. Fifty percent of ATs who report an administrative only title reported spending $\geq 50\%$ of their work day performing patient care. **Conclusions:** Even among ATs who report one job title, many ATs assume multiple roles within their employment. As professional demands and expectations on ATs increase, the potential for job stress and

conflict increases. Development of protective strategies and ways to mitigate these negative consequences are areas worthy of future efforts to preserve the workforce.

Work-Life Balance Perspectives Of NCAA Division I Male Athletic Trainers: Positive And Negative Influences

Trisdale W, Mazerolle SM, Goodman A, Eason CM: University of Connecticut, Storrs, CT, and Appalachian State University, Boone, NC

Context: Athletic Trainers (ATs) not only have to manage their responsibilities in the workplace, but also those associated with their personal and family lives. This is referred to as work-life balance (WLB). Long work hours, inflexible work schedules, travel, and coaches' expectations have all been found to be major contributors of work-life imbalance especially at the NCAA Division I clinical setting where performance expectations are high. Organizational factors receive much attention in the literature, however other factors such as gender have been suggested as facilitators as well. Demographic data has demonstrated a decline in female ATs after age 28 thus most WLB research in AT is centered around females. WLB issues have been found to influence attrition for the male athletic trainer in this setting as well, warranting future study.

Objective: Determine factors that negatively affect WLB among male ATs working in the NCAA D-I clinical setting and strategies they use to create a balance in their personal and professional lives? **Design:** Mixed-methods study. **Setting:** NCAA D-I collegiate setting. **Patients or other**

Participants: Twenty-two BOC certified male ATs (10 single, 5 married, 7 married with children) working in the Division-I clinical setting with 10.5 ± 7.68 years of experience. **Data collection and Analysis:** Participants responded to a series of close and open-ended questions on QuestionPro™. Data source, multiple analyst triangulation, and peer review were used to establish

data credibility. Data was analyzed following a general inductive approach. Close-ended data consisted of 7-point Likert Scale questions related to finding and maintain WLB. **Results:** Two major categories emerged: 1) Positive and 2) Negative influences on WLB. Positive influences were divided into: 1. time away and personal time, 2. separation, and 3. support networks. Time away included the utilization of vacation time whereas separation highlights the ability to delineate between professional and personal roles essentially leaving work at work. The main support network mentioned by participants was administrative/supervisor support. The negative influences on WLB consisted of 1. time of year, 2. spouse and family needs, and 3. demands of the profession. Time of year demonstrated challenges faced during different competitive seasons. Demands of the profession include hours worked, travel requirements, practice/competition schedule and workload. Spouse and family needs demonstrated the challenges males face balancing their personal roles. Likert Scale data revealed work demands interfere with home/personal life and ATs often miss important non-work events due to their job responsibilities. **Conclusion:** Male ATs working in the D-I setting are able to identify factors that inhibit work life balance and also factors that help maintain a balance. Identifying the sources of conflict and strategies used to help mitigate imbalance can help create an organizational strategy for a more balanced lifestyle.

Athletic Trainers' Experiences With Workplace Bullying In The Secondary School Setting

Pitney WA, Weuve C, Mazerolle SM: Northern Illinois University, DeKalb, IL; Lincoln Memorial University, Harrogate, TN; University of Connecticut, Storrs, CT

Context: Workplace bullying (WPB) is a series of persistent acts that negatively impact a clinician's role in the work setting. Recent athletic training research identified that WPB occurs in the college setting and that coaches are the primary perpetrators. To date, however, no information exists pertaining to WPB experienced by athletic trainers (ATs) in the secondary school setting. **Objective:** Determine the prevalence of WPB in the secondary school setting and explore the factors that relate to its occurrence. **Design:** Cross sectional. **Setting:** Secondary school setting. **Patients or Other Participants:** 567 (322 (56.8%) female and 245 (43.2%) male ATs aged 36.5 ± 11.1 years with 11.9 ± 9.5 years of experience. **Intervention(s):** Data were collected via a previously validated and reliable (Chronbach's α of .84) online Athletic Training Environment Survey that included the Negative Acts Questionnaire-Revised (NAQR). The NAQR involves responding to 22 negative acts in terms of the frequency of occurrence. Acts that occurred daily or weekly are scored as 1; acts occurring monthly, yearly, or never receive a 0. Individuals scoring 2 or higher on the instrument are classified as a target of bullying. **Main Outcome Measure(s):** Descriptive statistics were obtained to determine a bullying score for each AT and examine the prevalence of WPB. Chi square analyses were performed to examine the differences between the categorical variables of sex and Institution Bullying Policy, as well as the proportion of bullying perpetrators.

Results: 44 (7.8%) participants had a bullying score of 2 or higher on the NAQR, empirically identifying them as targets of bullies in the secondary school work setting; though a higher percentage (12.7%, $n = 70$) of the sample perceived they were the targets of negative acts. Of those experiencing bullying, 29 (65.9%) were female and 15 (34.1%) were male, though there was no difference between males and females with respect to having experienced bullying ($\chi^2_1 = 1.62$, $P = .204$). There was less prevalent bullying when a workplace bullying policy was in place ($\chi^2_1 = 4.44$, $P = .02$). Significantly more ($\chi^2_1 = 12.55$, $P = <.001$) perpetrators were male (71.6%, $n = 48$) than female (28.4%, $n = 19$) as identified by those who perceived they were the targets of negative acts. A significant difference in proportion was also observed ($\chi^2_6 = 33.82$, $P = <.001$) with the vast majority of bullies being coaches (31.3%, $n=21$) or administrators (26.9%, $n=18$). **Conclusions:** Bullying is experienced by a small percentage of both males and female ATs in the secondary school setting, a contrast to the findings in the collegiate practice setting. Gender was not found to be relevant in the experiences of WPB, similar to the college setting. When a WPB policy is in place, bullying is less prevalent, indicating the need for the implementation of policy to help mitigate WPB in the secondary school setting.

Perceptions Of Professional Socialization Of Graduate Assistant Athletic Trainers In The Collegiate Setting

Thrasher AB, Walker SE, Hankemeier DA: Ball State University, Muncie, IN

Context: Graduate assistantships are prevalent with many new athletic trainers (ATs) allowing them to gain experience while being supervised by a veteran AT. The graduate assistant athletic trainers' (GA) perception of their socialization process into the collegiate setting is unknown. **Objective:** To explore the professional socialization of GAs in the collegiate setting. **Design:** Phenomenological qualitative. **Setting:** Phone interviews. **Patients or Other Participants:** 19 collegiate GAs participated in this study (15 female, 4 male; average age 23 ± 0.15 ; NCAA Division I: 13, II: 3, III: 2, NAIA: 2; post-professional AT program: 5). **Data Collection and Analysis:** Participants who met the inclusion criteria were recruited via email from the National Athletic Trainers' Association database. Data were recorded via phone interviews and transcribed verbatim. Interviews were conducted until data saturation occurred. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via member checks and peer debriefing. **Results:** Five themes emerged: 1) Role identity, 2) Initial entry into role, 3) Maturation, 4) Role of supervisor, and 5) Success. Prior to beginning their role, GAs envisioned the assistantship as a way to gain independent experience. GAs perceive themselves as the primary care provider for their athletic team; however, some have unanticipated responsibilities in addition to patient care (eg, teaching, providing services to local high schools). Those who were immediately immersed into clinical practice adapted

to their role quickly. GAs felt a formal orientation process and policies and procedures manual would have alleviated some of the stress experienced initially. GAs matured as they practiced clinically but felt too much oversight or interference from the supervisor (e.g. taking over interesting case) hindered maturation. GAs in post-professional programs felt their academic coursework improved their maturation as a clinician. Some GAs in non-athletic training programs felt further athletic training coursework would have improved their maturation. GAs expected supervisors to provide support and feedback, but realized supervisors are busy with patient care responsibilities. Some GAs felt their supervisors were available, while other GAs felt their supervisors were too busy to provide support and feedback. GAs felt maturation would be enhanced if supervisors initiated communication regularly and established a formal mentorship. Personal attributes, prior clinical experience, and peer and supervisor support contributed to success as GAs. Factors that hindered success were lack of confidence, poor time management, an unsupportive environment, and long hours. **Conclusions:** When looking for assistantships, GAs should find a position that allows them to practice independently but provides a formal mentorship, didactic educational opportunities, and professional development opportunities. While the assistantship is difficult, GAs highly recommend the experience to all new ATs. Supervisors should include formal mentorships and orientation as a way to socialize GAs into their roles.

Perceptions Of Support Networks During The Graduate Assistant Athletic Trainer Experience

Clines SH, Mazerolle SM, Eason CM, Pitney WA: University of Connecticut, Storrs, CT, and Northern Illinois University, DeKalb, IL

Context: The Graduate Assistant Athletic Trainer (GAAT) position often serves as the first experience independently working as an AT, and the next stage in professional socialization process. GAATs have three academic program tracks to choose from when selecting their assistantship: 1) Accredited postprofessional athletic training (APPAT), 2) Postprofessional athletic training (PPAT), and 3) Nonathletic training. The graduate assistantship experience can highly influence professional commitment and retention within the field due to the perception of being a rite of passage. **Objective:** To gain an understanding of how GAATs perceive professional socialization and mentorship during their graduate experiences. **Design:** Semi-structured phone interviews. **Patients or Other Participants:** 25 GAATs (20 females and 5 males) studying in all three academic tracks (APPAT = 8, PPAT = 11, NAT = 6) volunteered. The average age was 25 ± 5 years with the median age being 24 years. Participant ages ranged between 23 and 47 years. Participants were BOC certified for an average of 2 ± 0.4 years. **Data Analysis:** The interview protocol was divided into 2 sections: basic demographic information and open-ended questions regarding the GAAT's experiences. All phone interviews were conducted by the same two researchers, digitally recorded with the consent of the participant, and transcribed verbatim. Data was analyzed borrowing from the principles of general inductive approach. Data

credibility was maintained using peer review, field notes, and intercoder reliability. Data saturation guided participant recruitment. **Results:** Two main themes were identified: 1) Peer Support and 2) Supervisor support. Our participants identified a strong sense of peer support throughout their experiences, both in the academic and clinical settings. GAATs frequently utilized other GAATs for support due to shared experiences and understanding of workloads. GAATs often described difficulty receiving supervisor support from full-time staff due to the staff AT's workload and resulting time constraints, which limited their availability for mentoring. Similar issues were also expressed with coordinating time with academic faculty by those studying in PPAT programs. Communication emerged as helpful for the incoming GAAT, where the previous GAAT provided formal mentorship via a job description used to highlight responsibilities and expectations of the role. Differences among assistantship type was only noted in terms of receiving balanced mentorship between academic and clinical instructors, where students studying in APPAT programs perceived more balanced support. **Conclusions:** Our results support the literature regarding the GAAT's pursuit of continued formal mentoring. Our results, however also, indicate that GAATs perceive less support from their full-time ATs and academic staff due to limited availability. As a result GAATs are leaning on other GAATs for support during the graduate experience. The GAAT position remains an educational experience for the AT, and warrants mentorship from more experienced ATs.

14417FOHE

Issues Facing The Athletic Training Profession: A Survey Of State Leaders

West TF, Janik GK: California University of Pennsylvania, California, PA, and Kings College, Wilkes-Barre, PA

Context: There are many issues facing the profession of athletic training today. Some of these issues are national in scope, while others hold primarily state level implications. Since resources are often limited, state athletic training leaders must often prioritize efforts on behalf of their constituents. **Objective:** The purpose of this study was to examine state leaders' opinions in regards to the importance of various issues facing the profession and assess where state societies are directing their efforts. **Design:** Observational study. **Setting:** The study was conducted through an online questionnaire. **Patients or Other Participants:** Invitations to participate in the survey were sent to all individuals listed as members of the executive board (or similar) of NATA recognized state professional associations. 190 invitations were sent with 85 individuals completing the questionnaire (return rate 44.7%). Participants included 57 males and 26 females with 30 (35.7% of the sample) holding the office of President. All NATA Districts were represented. **Intervention(s):** Participants were sent an email with a cover letter and a link to the survey. The survey was created by two past state Presidents and included issues faced during their involvement as leaders and discussed in NATA led state leader meetings. **Main Outcome Measure(s):** Participants were asked to utilize a Likert scale to rate the importance (not at all important to very important) of various issues to the AT Profession as a whole, AT profession within their state, and to the participant personally. Leaders were also asked to estimate how much time and effort their

association places on addressing the issues utilizing a Likert scale (no effort/time at all to significant effort/time). **Results:** State leaders saw "increasing awareness of the AT profession among the general public" and "third party reimbursement" as the most important issues for the AT profession as a whole and within their state. "Performing outcomes research" was also identified as an important issue facing the AT profession as a whole. AT leaders identified many issues as important to them personally as a state leader, with the highest being "increasing public relations efforts" and "improving the relationship between your society and state legislators." These two issues were also identified as issues that their state association is "placing significant effort/time to address." AT leaders also indicated their associations are spending significant time addressing "appropriate sport safety legislation." **Conclusions:** AT leaders demonstrated that there are many issues that are important to their constituents, led by public relation efforts with various groups and interactions with state legislators in regards to credentialing and sports safety legislation. Leaders at the state and national levels should examine how to work together so states are supported in their efforts to address these issues.

14180FOHE

Continuing Professional Education Factors Associated With Maintaining Or Enhancing Competence Among Athletic Trainers

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Context: Continuing professional competence is necessary for public protecting and maintaining a level of proficiency at a time when society seeks a higher level of competence from healthcare providers. Unfortunately, little evidence exists regarding the factors that help predict professional competence once an ATC is credential. **Objective:** Extend a previous study where athletic trainers (ATs) completing their recertification process took a retired version of the Board of Certification (BOC) credentialing exam to determine what factors were related to performance on this recertification assessment. **Design:** Prospective, cross-sectional. **Setting:** AT practice settings. **Patients or Other Participants:** Convenience sample of 1,025 ATs from a solicitation of 9,789 who re-certified in 2010 and 196 ATs whose certification lapsed (overall response rate was 10.3%). Participants were predominantly female (61%) and Caucasian (91%). Average years practicing as AT was 10.2±7.4 years; 72% held a Master's degree or higher. **Intervention(s):** Participants in this research project previously completed an on-line recertification assessment after completing their three-year recertification process; earning a minimum of 75 CEUs. In addition to exam scores, information about continuing education (CE) activities as entered in the BOC database along with demographic and practice variables were analyzed. **Main Outcome Measure(s):** Six predictive factors (total CEUs earned, timing of CE, relevance of CE, years experience,

highest educational level, and time in direct patient contact) were used in four-separate multiple linear regressions with (1) total exam, (2) knowledge recall, (3) application, and (4) analysis scores as dependent variables. Alpha was set at .0125 to control for experiment-wise error.

Results: The regression of total exam score on the six-predictive factors was statistically significant, $F(6, 683)=16.69$, $p<0.0001$. This model accounted for 13% of the variance with two significant factors: relevance of the CE and highest educational level. Twenty-nine percent taking the recertification assessment passed at a proficient level, 4% passed at the advanced level. Those passing at the proficient level had longer years practicing as an AT (+2 years), greater perceived relevance of CE (average CE rated as extremely or very relevant was 71%), higher educational level (doctorate and AT master's degree), more CEUs (averaged earning almost 4 more CEU credits), and a lower percentage of CEUs earned in Year-3. ATs earning 90 or more CEUs had the highest passing rates at the proficient level. **Conclusions:** The results suggest that greater relevance of CE activities are more likely to aid ATs in maintaining "entry-level" competence. When CE activities are not very relevant or not at all relevant, ATs appear less engaged in and/or take less ownership in the activity and complete the activity for a certificate rather than for competence. A mechanism should be established allowing ATs to select CE activities viewed as extremely or very relevant to practice.

Free Communications, Thematic Poster Presentations: Reliability of Concussion Assessment Tools

Thursday, June 26, 2014, 10:00AM-11:00AM, Room 203/204; Moderator: Susan Saliba, PhD, ATC, FNATA

14145DOSP

Reliability Of Three Computerized Neurocognitive Assessments Used For The Assessment Of Concussion

Littleton AC, Guskiewicz KM, Mihalik JP, Register-Mihalik JK: University of North Carolina at Chapel Hill, Chapel Hill, NC, and WakeMed Health & Hospitals, Raleigh, NC

Context: Neurocognitive testing is a recommended component of concussion assessment. However, use of these testing measures should be performed with caution, as the reliability of computerized neurocognitive assessment tests has been underexplored. Understanding the reliability of neurocognitive performance will ensure clinicians appropriately interpret test results. **Objective:** To determine the reliability of three computerized concussion assessment tests: Axon Concussion Assessment Test (Axon), CNS Vital Signs, and the Immediate Postconcussion Assessment and Cognitive Test (ImPACT) across two weeks. **Design:** Repeated Measures. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Fifty healthy, physically active college-aged students (age: 21.4 ± 1.5 years; 13 males, 37 females) participated. Those with a concussion history in the previous 6 months, learning disabilities, attention disorders, and psychiatric conditions were excluded. **Intervention(s):** Participants completed four separate testing sessions. The first two testing sessions were 24-48 hours apart. The last two testing sessions were two weeks later (15.2 ± 2.9 days), and these two sessions were also 24-48 hours apart. Participants completed two of the three computerized tests: one at the first and third session, and a different one at both the second and fourth session (Axon: $n = 17$; CNS Vital Signs: $n = 16$; ImPACT: $n = 17$). The testing order was counterbalanced across sessions. **Main**

Outcome Measure(s): To determine practice effects across the two test sessions for each computerized outcome measure (scores for 5 Axon cognitive domains, 8 CNS Vital Signs domains and 5 ImPACT composite domains), a series of dependent t-tests were employed. Intraclass correlation coefficients (ICC2, 1) were calculated to determine the reliability of performance across two weeks for all outcome measures. **Results:** There were no significant differences across the two testing sessions on any Axon domains, any ImPACT composites, or 6-of-8 CNS Vital Signs domains ($P > 0.05$). Participants performed better at time 2 (111.56 ± 8.88) compared to time 1 (99.33 ± 20.25) on CNS Vital Signs processing speed ($t_{1,15} = -2.88$; $P = 0.01$). Participants performed better at time 1 (106.11 ± 11.19) compared to time 2 (96.56 ± 16.34) on CNS Vital Signs visual memory ($t_{1,15} = 2.40$; $P = 0.03$). The ICC2,1 values ranged as follows: Axon from 0.24 (Attention) to 0.71 (Processing Speed); CNS Vital Signs from 0.23 (Visual Memory) to 0.62 (Psychomotor Speed); and ImPACT from 0.09 (Verbal Memory) to 0.63 (Visual Motor Speed). **Conclusions:** Overall, performance on many computerized neurocognitive assessments seems to be stable over time. Some scores, such as visual and verbal memory, appear to be less reliable, and may lead to misinterpretation of test results and premature or delayed return to play decisions. Clinicians should be aware of the reliability of the specific measures they use in clinical practice in order to ensure proper interpretation of test results and appropriate management decisions.

14147DOSP

Test-Retest Reliability Of The Headminder Concussion Resolution Index In Collegiate Student-Athletes

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Context: Computerized neurocognitive assessment batteries are used to assist sports medicine professionals with the management of concussive injuries. The reliability of these test batteries is important for accurate baseline and post-injury neurocognitive comparisons. However, there are currently inconsistent findings of test-retest reliability on computerized neurocognitive test batteries. **Objective:** To determine the one-year test-retest reliability of the computerized Concussion Resolution Index (CRI) assessment in collegiate student-athletes. **Design:** Retrospective Case Series. **Setting:** Sports Medicine Clinic. **Patients or Other Participants:** 450 NCAA Division I varsity student-athletes (274 males/176 females; age: 19 ± 1 years) **Intervention(s):** A retrospective analysis was completed on CRI baseline tests administered between August 2006 and December 2011. Subjects completed annual CRI baseline tests in accordance with their university's pre-participation physical examination protocol. All tests were administered by a certified athletic trainer in an isolated office on a desktop computer. **Main Outcome Measure(s):** CRI composite scores of complex reaction time, simple reaction time, and processing speed were collected for repeated baseline measurements. Two-way random effects analysis of variance interclass correlation coefficients (ICC) were calculated to estimate the test-retest reliability of the CRI composite scores from baseline to one-year. An ICC value of 0.6 is the minimum acceptable value for test-retest reliability with >0.75 representing strong reliability. **Results:** Of the three CRI composite scores, processing speed was the most reliable (mean ICC=0.695;

95% CI: 0.644-0.740) with a change of mean scores from 2.762 ± 0.576 (SE = 0.027) seconds at baseline to 2.559 ± 0.476 (SE = 0.022) seconds at one-year. Complex reaction time had moderate test-retest reliability (0.545; 0.477-0.607) with a change of mean scores from 0.697 ± 0.109 (SE = 0.005) seconds at baseline to 0.712 ± 0.121 (SE = 0.006) seconds at one-year. The least reliable composite score was simple reaction time (0.480; 0.406-0.548) with a change of mean scores from 0.366 ± 0.066 (SE = 0.003) seconds at baseline to 0.373 ± 0.067 (SE = 0.003) seconds at one-year. Processing speed was the only composite score to fall above the minimum acceptable ICC value of 0.6 for reliability. **Conclusions:** Overall, the CRI is a moderately reliable computerized neurocognitive test battery across a one-year time period for collegiate student-athletes. This one-year reliability data for the CRI is higher than previously reported ICCs calculated from baseline to 45 days and 45 to 50 days. These findings suggest that the CRI is a useful tool that can assist in concussion management, but clinicians should take into account the moderate reliability when interpreting serial measures of the CRI. Based on these findings, it is recommended that sports medicine professionals continue to use a multi-dimensional approach for concussion management in accordance with current position statements.

Alternate Forms Of The Standard Assessment Of Concussion: Are They Truly Equivalent?

Farnsworth JL, Haley J, Ragan BG, Kang M: Middle Tennessee State University, Kinesmetrics Lab, Murfreesboro, TN, and Ohio University, Division of Athletic Training, Athens, OH

Context: The Standard Assessment of Concussion (SAC) is an orally administered concussion screening tool that identifies concussions by comparing baseline scores to post-injury scores. Test scores for alternate forms of the SAC test are used interchangeably despite evidence suggesting marginal differences between the three forms. Without proper adjustment for non-equivalence this could lead to potential misdiagnosis of a concussed athlete.

Objective: The purpose of this study was to determine the equivalence of the SAC's three alternate forms (A, B, & C) and develop a raw-score conversion table to allow direct comparisons among test forms. **Design:** Counter-balanced observational design. **Setting:** Data were collected from student-athletes by certified athletic trainers in their respective athletic training rooms.

Patients or Other Participants: A convenience sample of 142 healthy high school student-athletes (89 males and 53 females; mean age = 16.13 SD = 1.18) was recruited for the study. **Intervention(s):** Student-athletes were administered each of the three alternate SAC forms. To determine test order, athletes were randomly assigned to one of three groups. Possible order of test administration included "A,B,C", "C,A,B", and "C,B,A". The test administration order was randomized to limit measurement errors associated with practice effects. **Main Outcome Measure(s):** Item Response Theory (IRT) Test Equating was computed using PIE (Hanson & Zeng, 2004) software to examine equivalence among SAC test forms and develop raw-score conversions for

score comparisons. Dependent variables included mean item difficulty logits, mean test score, and raw score conversions among alternate forms. **Results:** We found non-equivalence among alternate test forms of the SAC. Mean item difficulty parameters for alternate test forms A, B, and C were -0.59, -0.57, and -0.68 logits, respectively; indicating test form C as the easiest of the three forms. Comparison of mean scores between alternate test forms indicated a significant difference ($F_{2,423} = 5.180$, $p < 0.05$) in the average score for test forms A (25.5 ± 2.8 ; $M \pm SD$), B (25.8 ± 2.6 ; $M \pm SD$), and C (26.4 ± 2.3 ; $M \pm SD$). Variations as high as four points were found in raw score conversions from alternate test forms using IRT test equating. For example, a score of 20 on test form C would be equivalent to a 16 on test form A. Raw-score conversion for each form have been calculated to allow direct comparisons among scores for each form. This is especially alarming considering a change in score of three points is classified as significant change. **Conclusions:** Alternate form equivalence is necessary to minimize measurement error and optimize clinical decision making. Clinicians using the SAC and other cognitive assessment tools should consider using raw-score conversions to place scores on an equivalent scale when interpreting test score results following sports concussion.

The Reliability Of Three Computerized Neurocognitive Measures Of Sport-Related Concussion

Resch JE, Schneider M, Cullum CM: The University of Texas at Arlington, Arlington, TX, and The University of Texas Southwestern Medical Center, Dallas, TX

Context: Computerized neurocognitive tests (CNTs) are widely used at all competitive levels of sport to assess sport-related concussion (SRC). Despite the adoption of CNTs into a majority of SRC management protocols, a dearth of psychometric evidence exists to support their clinical utility. Recent studies suggest CNTs possess sub-optimal reliability which inherently limits validity and clinical utility. **Objective:** To investigate the test-retest reliability of Automated Neuropsychological Assessment Metrics (ANAM), Concussion Vital Signs (CVS) and the Immediate Postconcussion and Cognitive Testing battery (ImPACT) using empirically derived time points.

Design: Repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** One hundred and twenty-nine healthy participants (30 males, 99 females): mean age 19.4 ± 1.70 years with no history of concussion within six months of participation, a diagnosed psychiatric condition, learning disability, and/or ADD/ADHD. **Intervention(s):** Participants were randomly assigned into one of three groups which were administered ANAM ($n = 42$), CVS ($n = 46$) or ImPACT ($n = 41$) at Days 1, 45, and 50. Green's Word Memory Test (WMT) was also administered pre- and post-completion of each CNT to assess effort for at each time point. **Main Outcome Measure(s):** Reliability was calculated using intraclass correlation coefficients (ICCs) utilizing a one-way random model between time points for each CNT's summary scores. Repeated measures ANOVAs were used to determine significant differences in CNT and WMT

performance across time. Greenhouse-Geisser corrections were utilized to correct for violations of sphericity. Paired t-tests were used for post-hoc analyses. Analyses were performed with $\alpha = .05$. **Results:** Participants were tested approximately 47.0 ± 2.75 days after time point 1 and approximately 7.0 ± 2.40 days after time point 2. Groups differences ICC values ranged from .11 (Mathematical Processing) to .70 (Simple Reaction Time) for ANAM, -.02 (Continuous Performance Test) to .87 (Psychomotor Speed) for CVS, and .32 (Verbal Memory) to .94 (Visual Motor Speed) for ImPACT. Results of the repeated measures ANOVA revealed one significant improvement over time for ImPACT's Visual Motor Speed ($F(1.739, 69.574) = 3.34, p = .048$) summary score between time points 1 and 3 ($t(40) = -2.19, p = .034$). WMT scores exceeded 85 percent for all participants suggesting a good effort was provided at each time point. **Conclusions:** This is one of the first studies addressing the reliability of three commonly used CNTs administered in a healthy college aged sample. Overall, weak to strong reliability coefficients for ANAM, CVS, and ImPACT were observed. Results suggest that regardless of the CNT used to manage SRC, caution is necessary when interpreting repeated CNT scores over time and furthermore support the use of a multidisciplinary approach to SRC management.

Free Communications, Rapid Fire Poster Presentations: Biomechanical and Neuromuscular Consequences of ACL Injury

Thursday, June 26, 2014, 11:30AM-12:45PM, Room 203/204; Moderator: Lindsey DiStefano, PhD, ATC
14163FOBI 14135DONE

Asymmetry Of Lower Extremity Biomechanics In Patients With Prior ACL Injury: The JUMP-ACL Study

Goerger BM, Marshall SW, Beutler AI, Blackburn JT, Wilckens JH, Padua DA: Georgia State University, Atlanta, GA; The University of North Carolina at Chapel Hill, Chapel Hill, NC; Uniformed Services University of the Health Sciences, Bethesda, MD; Johns Hopkins University, Baltimore, MD

Context: Those with a prior ACL injury are at an increased risk for subsequent ACL injury. Differences in lower extremity biomechanics have been previously observed for these individuals, and may influence their risk for re-injury. Quantifying asymmetry between limbs may provide an estimate of between-limb differences that remain following ACL injury. The amount of asymmetry for those with prior ACL injury has never been directly compared to healthy matched controls. This is important information as asymmetry is thought to represent movement dysfunction and increased risk for re-injury in this patient population. **Objective:** The purpose of this study was to compare asymmetry in lower extremity biomechanics during a double leg jump landing task between those with and without a prior ACL injury. **Design:** Cross-Sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Sixty-three participants of the JUMP-ACL Study were recruited to participate in this study; 24 who had a prior ACL injury [ACLR (14 male, 10 female) Age = 21.58 ± 0.78 years, Height = 172.01 ± 8.85 cm, Mass = 74.69 ± 12.50 kg] and 39 who did not [Control (20 male, 19 female) Age = 21.00 ± 0.77 years, Height = 172.25 ± 8.94 cm, Mass = 72.27 ± 13.72 kg]. Participants were matched for cohort year, academy, and gender. **Intervention(s):** Bilateral three-dimensional lower extremity biomechanics were collected during a

double leg jump landing. **Main Outcome Measure(s):** Joint angles at initial ground contact (IGC), and peak angles during the landing phase (LP), normalized internal joint moments, vertical ground reaction force (VGRF), and anterior tibial shear force (ATSF) were recorded during the LP. Limb asymmetry was quantified as the absolute value of the difference scores between limbs for each variable. Between group differences were evaluated using two-sample Kolmogorov-Smirnov tests; a priori alpha level 0.05. **Results:** We observed no between group differences in limb asymmetry for kinematics at IGC ($p > 0.05$) or peak kinematic values during the LP ($p > 0.05$). We did observe significant between group differences in limb asymmetry for peak internal knee flexion moment (ACLR: 0.039 ± 0.029 Nm/BWxBH, Control: 0.026 ± 0.030 Nm/BWxBH; Zks = 1.421, $p = 0.035$) and peak VGRF (ACLR: 0.682 ± 0.508 N/BW, Control: 0.465 ± 0.279 N/BW; Zks = 1.445, $p = 0.031$) during the LP. Group means indicated that the ACLR group demonstrated greater asymmetry in peak internal knee flexion moment and peak VGRF than the Control group. We observed no other between group differences ($p > 0.05$). **Conclusions:** Only peak internal knee flexion moment and VGRF displayed greater magnitudes of limb asymmetry in ACLR compared to Control participants. Thus, asymmetries in movement patterns are similar between ACLR and Control participants. Our observations are consistent with those previously reported, and suggest that assessment of asymmetry in movement patterns alone for those with ACLR may not be sufficient to detect altered biomechanics. The influence of greater limb asymmetry in peak internal knee flexion moment and VGRF on the long-term outcomes of those with ACLR requires further study.

Brain Neuroplastic Hip And Knee Control Changes In ACL Reconstructed Individuals

Grooms D, Schussler E, Miller M, Onate J: The Ohio State University, Columbus, OH

Context: Anterior cruciate ligament (ACL) injury may cause neuroplastic changes that affect the motor control capabilities of the proximal segments. These alterations may not be adequately addressed with reconstruction or rehabilitation as typical neuromuscular control assessments do not adequately capture neurological function. Assessing the central nervous system more directly after injury with functional magnetic resonance imaging (fMRI) provides a means to address this gap in knowledge.

Objective: To investigate the brain activation differences during a controlled hip and knee flexion task (heel slide) in those with ACL reconstruction and matched healthy controls. **Design:** Descriptive laboratory study. **Setting:** Center for neuroimaging. **Patients or Other Participants:** Participants were matched on height, mass, extremity dominance, history and current physical activity level. Four left ACL reconstructed (23.76 ± 3.20 years, 1.80 ± 0.08 m, 83.0 ± 19.8 kg, Tegner activity level 6.75 ± 2.0 , 42 ± 36 months post-surgery) and 4 matched healthy controls (24.6 ± 2.08 years, 1.74 ± 0.06 m, 80.5 ± 12.55 kg, Tegner activity level 6.75 ± 2.0) participated. **Intervention(s):** The functional data were collected on a 3T Siemens Magnetom scanner with an eight channel array head coil with ninety whole brain gradient-echo scans every 3 seconds with slice thickness of 2.5 mm for 55 transversal slices. Before the functional run an anatomical 3-D high resolution T1 scan was taken for anatomical registration. The movement task was block designed consisting of four repeated 30 second cycles of unilateral left (involved) knee and hip extension/flexion while lying supine

in the MRI scanner. Brain activation patterns during movement were contrasted with an interspersed rest condition. **Main Outcome Measure(s):** fMRI analysis is commonly reported in terms of the z-score for the respective voxels and brain regions. The z-score is indicative of the likelihood of activation, with higher being more likely and the p value indicating probability of finding activation when there was none. The two groups were compared with a general linear model second-level fixed-effects paired analysis a priori threshold at $p < .01$ corrected. **Results:** Patients with ACL reconstruction had increased peak activation in the contralateral cerebellum ($z = 4.86 \pm 0.33$, $p < .001$) and diminished peak activation in the contralateral primary sensorimotor area ($z = 7.75 \pm 1.23$, $p < .001$) when compared to healthy matched controls. **Conclusions:** Brain activation pattern differences exist following ACL reconstruction and rehabilitation. The higher cerebellar activation indicates an increased demand on the brain to coordinate the movement and fine tune the motor output. The decreased primary sensorimotor area activation may be due to the decreased afferent input from the loss of the native ACL as this area is highly sensitive to the degree of somatosensory input. The decrease may also reflect an alteration in the cortical drive to the hip and knee to control motion. These preliminary findings shed light on the motor control differences that remain in ACL reconstructed individuals.

Jump Landing Mechanics In Those Who Pass And Fail Return To Sport Criteria

Kulow SM, Pennuto AP, Gire CD, Stiffler MS, Bell DR: University of Wisconsin, Madison, WI

Context: In the United States, more than 175,000 anterior cruciate ligament reconstructions (ACLRs) are performed annually. ACLR patients can exhibit altered movement patterns for months or years following surgery, even after returning to sport and are at increased risk of future ACL injury. Currently, there is a need to investigate common return-to-sport (RTS) criteria as the literature is inconsistent. **Objective:** To examine jump landing mechanics and hop test performance in ACLR patients who pass or fail return-to-sport criteria. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-six volunteers with unilateral ACLR (34 patellar tendon, 20 hamstring, 12 allograft) that were cleared to return-to-sport (females = 59, males = 7, height 168.5 ± 7.1 cm, mass = 68.3 ± 11.8 kg, age = 19.0 ± 1.7 yr, IKDC = 84.3 ± 10.4 , 34.5 ± 18.4 months from surgery). **Intervention(s):** Following a battery of RTS tests, subjects were grouped based whether the subject would pass or fail clinical RTS. In order to pass RTS, the subject must have an IKDC score >85 and single and triple hop for distance testing $>90\%$ of the healthy limb. The independent variable was group (pass or fail). Subjects performed five trials of a standardized jump-landing task. Each subject jumped from a 30cm box onto force plates located 50% of the subject's height from the box. Upon landing, the subjects immediately jumped for maximum height. Vertical ground reaction forces (VGRF) as well as joint kinematic data were recorded during each trial and averaged over the five trials. The subject also performed three trials of a single (SHD) and triple hop for distance (THD) test.

The distance jumped during each trial was averaged to calculate an average score on each limb. Limb symmetry indices (LSI) were calculated for SHD, THD, and VGRF ($LSI = (\text{reconstructed limb/healthy limb})100$). **Main Outcome Measure(s):** An electromagnetic tracking system interfaced with force plates was used to capture joint motion and forces during landing. The dependent variables were VGRF asymmetry, maximum VGRF, peak kinematic and kinetics from the reconstructed limb (knee, hip, and trunk), and the single hop (SHD LSI) and triple hop indices (THD LSI). Independent t-tests were used for group comparisons with significance set a-priori at $p < 0.05$. **Results:** Significant group differences were reported for SHD LSI ($p = 0.015$, fail = $95.00 \pm 7.03\%$, pass = $98.98 \pm 5.54\%$) and THD LSI ($p = 0.009$, fail = $95.34 \pm 6.92\%$, pass = $99.44 \pm 5.01\%$). VGRF LSI did not differ between groups ($p = 0.149$, fail = 84.42 ± 16.44 , pass = 91.08 ± 20.98). **Conclusions:** Subjects who failed return to sport criteria had lower hop indices than those who passed. Though not statistically significant, those who did not pass RTS criteria tended to have lower VGRF LSI than those who passed. We were not able to discern any biomechanical changes between groups during the jump landing, perhaps due to the bilateral nature of the jump-landing task. Our findings indicate that bilateral tasks may mask underlying biomechanical deficiencies in the involved limb. Funding: UW Graduate School and the Sports Medicine Classic Fund.

14171FOBI

Hamstrings And Quadriceps Peak Torque And Rate Of Torque Development During A Time-Critical Period Following ACL-Reconstruction

Johnson ST, Norcross MF, Hoffman MA: Oregon State University, Corvallis, OR

Context: Following ACL reconstruction, it is essential that strength be regained in order to aid in dynamic joint stability. Traditionally, the focus during rehabilitation is often on recovering maximal strength (i.e., peak torque) to a certain proportion of the uninvolved limb. However, the time needed to attain peak torque is often greater than the time available to stabilize the joint during explosive movements and injury situations. Due to this, there is increased interest in evaluating rapid torque production during time critical periods, rather than just peak torque. **Objective:** To compare hamstrings and quadriceps peak torque (PkTorq) and rate of torque development (RTD) during the initial 50 ms (RTD0-50) of contraction between the involved (Inv) and uninvolved (Uninv) legs of individuals following ACL-reconstruction for a non-contact ACL injury. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Eight female volunteers cleared for return to full activity following unilateral ACL-reconstruction (age: 21.7 ± 2.5 years, height: 1.64 ± 0.15 m, mass: 74.24 ± 17.30 kg, months since reconstruction 44.8 ± 27.6 months). **Intervention(s):** Isometric knee extension and knee flexion torque-time curves of the involved (Inv) and uninvolved (Uninv) limbs were recorded using a Biodex System3 dynamometer interfaced with an Biopac MP100 data collection system. Participants were seated with the knee flexed to 60° and instructed to contract as hard and fast as possible for 3-5 seconds against the dynamometer arm following presentation of a light stimulus. Three valid

trials with 60 seconds rest between trials were collected in a counterbalanced order. **Main Outcome Measure(s):** RTD was calculated by taking the line of best fit of the torque-time curve during the 0-50 ms interval immediately following torque onset ($0 = 2.5\%$ of peak torque). PkTorq was the maximal value of the torque-time curve. Torque data were normalized to [Body Mass] 0.67 . Four dependent t-tests were used to compare hamstrings and quadriceps RTD0-50 and PkTorq between of the hamstrings and quadriceps of the involved and uninvolved legs ($\alpha \leq 0.05$). **Results:** Hamstrings PkTorq (Nm) was not different between (Inv = 4.14 ± 1.28 vs. Uninv = 4.45 ± 1.51 Nm, $p = 0.374$), hamstrings RTD0-50 (Inv = 14.23 ± 5.11 vs. Uninv = 15.25 ± 7.29 [Nm/s]/kg(.67), $p = 0.371$), and quadriceps PkTorq (Inv = 6.53 ± 2.08 vs. Uninv = 7.73 ± 1.77 Nm, $p = 0.127$) were not different between legs. However, quadriceps RTD0-50 was significantly less in the involved leg compared to the uninvolved leg (Inv = 18.91 ± 5.54 vs. Uninv = 27.79 ± 9.44 [Nm/s]/kg (.67), $p = 0.016$). **Conclusions:** While quadriceps and hamstrings peak torque and hamstrings RTD during the initial 50 ms of contraction were not different between legs, rapid torque production of the quadriceps was significantly lower on the reconstructed limb despite participants being cleared for full-unrestricted activity. Given that the initial 50 ms of contraction is likely important during both deleterious situations and explosive movements, the results suggest that a focus during rehabilitation should be on developing rapid torque production to prevent reinjury and performance improvement.

14126DONE

Thigh Muscle Volume In Relation To Knee Extensor Torque, Quadriceps Activation, And Patient Reported Outcomes In ACL Deficient Patients

Norte GE, Mitha Z, Kuenze C, Read K, Handsfield G, Blemker S, Hertel J, Hart JM: University of Virginia, Charlottesville, VA

Context: Conventional strength measures may be inadequate to identify specific muscular impairments. Muscle volume has been purported to be directly associated with muscular strength and/or patient reported outcomes following knee injury. MRI-based muscle modeling is a novel approach used to quantify muscle morphology that has yet to be explored in sports medicine research. **Objective:** To assess the relationship between individual and composite muscle volumes of the quadriceps femoris muscle group with knee extensor torque, quadriceps activation, and knee-specific self-reported function. **Design:** Case series. **Setting:** Research laboratory and University MRI facility. **Patients or Other Participants:** Five ACL deficient patients (3 men, 2 women; age = 25.2 ± 7.3 years; height = 172.5 ± 10.1 cm; mass = 77.6 ± 17.6 kg; time since injury = 0.7-24.3 months) volunteered. **Intervention(s):** Knee-specific function was assessed using the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form. Normalized isometric knee extensor torque was assessed bilaterally with the knee flexed to 90° , and participant firmly secured to a stationary multi-mode dynamometer. Participants reported to an off site University facility immediately following the strength assessment for a closed, 3.0 Tesla, bilateral lower extremity MRI. All muscle volumes were obtained using custom MRI muscle-modeling sequencing. **Main Outcome Measure(s):** Normalized isometric knee extension maximal volitional isometric contraction (MVIC) torque, quadriceps central activation ratio (CAR), IKDC

score, and quadriceps femoris volume (individual and composite) were the primary outcomes of interest. Muscle volumes (ml) were calculated using custom MATLAB software. CAR was measured using the superimposed burst technique (SIB). Mean MVIC (Nm) and SIB torques (Nm) were normalized to body mass (kg), and used to calculate CAR (%). Pearson's r correlation coefficients were calculated between each dependent variable. **Results:** Mean normalized knee extension MVIC torque was lower in the involved limb (2.6 ± 0.7 Nm/kg vs. 3.6 ± 1.0 Nm/kg) compared to the uninvolved limb, whereas quadriceps CAR (89.2 ± 11.0 % vs. 87.1 ± 8.1 %) was greater. Mean IKDC score was 50.6 ± 23.8 . In the involved limb, knee extensor torque and composite quadriceps volume were strongly correlated ($r = 0.609$, $P = 0.276$), specifically among the vastus lateralis ($r = 0.630$, $P = 0.255$) and rectus femoris ($r = 0.778$, $P = 0.121$). A strong negative correlation was found between quadriceps CAR and composite quadriceps volume ($r = -0.693$, $P = 0.195$), specifically in the vastus medialis ($r = -0.727$, $P = 0.164$), lateralis ($r = -0.675$, $P = 0.211$), and intermedius ($r = -0.790$, $P = 0.112$). Individual and composite quadriceps volumes were strongly correlated with IKDC score ($r = 0.925$, $P = 0.075$). **Conclusions:** Quadriceps muscle volume is associated with knee extensor torque and knee-related function after ACL injury. Muscle volume estimates using an MRI-based model can be a useful tool used to detect muscular impairments following ACL injury.

Knee Extensor Torque Variability And Subjective Knee Function In Patients With ACL-Reconstructed Knees

Goetschius J, Hart JM: University of Virginia, Charlottesville, VA

Context: Patients with a history of anterior cruciate ligament reconstruction (ACL-R) often experience limitations in knee joint function when returning to physical activity that may be due to chronic impairments in quadriceps neuromuscular control. Assessment of knee extensor torque variability may exploit underlying impairments in quadriceps neuromuscular control in ACL-R patients. **Objective:** To compare knee extensor torque variability in ACL-R participants and healthy controls, as well as the relationship between knee extensor torque variability and patient reported knee function. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-six individuals with a history of primary, non-complicated ACL-R (sex: 11f/15m, 25.1 ± 5.4 yrs, 78.1 ± 15.9 kg, 1.7 ± 0.1 m) and twenty-nine healthy controls (sex: 14f/15m, 24.4 ± 4.5 yrs, 66.4 ± 12.8 kg, 1.7 ± 0.1 m) with no history of lower-extremity injury or surgery. **Intervention(s):** None. **Main Outcome Measure(s):** All participants completed three, 3-second seated knee extensor maximum volitional isometric contraction (MVIC) trials at 90-degrees of knee flexion using a multi-mode dynamometer. The injured limb of participants in the ACL-R group and a randomly selected limb of participants in the control group were used for testing. A 500-ms time epoch during torque plateau was processed for mean torque (Nm) and torque standard deviation. Mean coefficient of variation was calculated for each torque MVIC trial using the formula: Coefficient of variation = [standard deviation/mean] \times 100). All participants completed the International Knee Documentation

Committee Subjective Knee Evaluation Form (IKDC) and IKDC scores were calculated. Independent samples t-tests were used to assess between group differences in coefficient of variation and IKDC score. Pearson's product-moment correlation coefficients were calculated to assess the relationship between coefficient of variation and IKDC scores (r interpretation: 0.0-0.3 = small, 0.3-0.5 = moderate, 0.5-1.0 = large). **Results:** The ACL-R group (1.24 ± 0.52) demonstrated significantly greater torque coefficient of variation ($P = 0.01$) than the control group (0.90 ± 0.46). The ACL-R group (87.6 ± 10.8) reported significantly lower IKDC scores ($P < 0.001$) compared to the control group (98.7 ± 3.2). Overall, coefficient of variation was moderately negatively correlated with IKDC score ($r = -0.44$, $P = 0.001$) in the sample population indicating that less torque variability was associated with higher IKDC scores. In the ACL-R group, coefficient of variation was moderately negatively correlated with IKDC scores ($r = -0.43$, $P = 0.03$) indicating that less force variability was associated with higher IKDC scores. In the control group, coefficient of variation was not significantly correlated with IKDC scores ($r = -0.13$, $P = 0.50$). **Conclusions:** Patients with a history of ACL-R demonstrated greater knee extensor torque variability and poorer self-reported knee function than healthy controls. These two measures were moderately correlated to each other in patients with ACL-R. Clinicians may need to consider addressing knee extensor torque variability as a unique neuromuscular deficit in patients following ACL-R.

Single Leg Squat And Landing Error Scoring System Between Knee Injured And Healthy Individuals

Inama M, Sutherlin MA, Saliba S, Hart JM: University of Virginia, Charlottesville, VA

Context: Individuals with knee joint injuries often present with abnormal movement patterns during functional activities. Altered movement patterns have been associated with risk for injury however there is little information about altered movement patterns in patients who have recovered from injury. The development of a movement screen that involves unilateral testing could help identify abnormal movement patterns in individuals who may be at risk for knee injury or re-injury. **Objective:** To compare errors while performing a single leg squat test (SLS) and during the landing error scoring system (LESS) test in individuals with history of knee injury versus healthy controls. **Design:** Descriptive laboratory study. **Setting:** Clinical research laboratory setting. **Patients or Other Participants:** A total of 49 subjects (32 healthy; age: 22 ± 2 years; height: 175.15 ± 8.68 cm; mass: 69.13 ± 10.42 kg; international knee documentation committee (IKDC): 98.65 ± 3.02 ; knee injury osteoarthritis outcome score (KOOS): 166.41 ± 2.82 ; Godin leisure time activity scale (Godin): 123.13 ± 55.87 ; current Tegner activity scale (Tegner): median 7, range 5-10; 17 knee injured [14 unilateral, 3 bilateral] age: 24 ± 3 years; height: 175.21 ± 10.06 ; mass: 71.77 ± 12.79 ; IKDC: 88.74 ± 10.77 ; KOOS: 154.11 ± 11.18 ; Godin: 138.71 ± 50.46 ; Tegner: median 7, range 5-9). **Intervention(s):** All participants completed SLS bilaterally followed by the LESS. **Main Outcome Measure(s):** Total scores using the LESS scoring system and unilateral scores on the SLS using clinical scoring criteria. Assessments were made by a single, blinded rater. SLS scores were

compared between limbs (healthy, injured, contralateral) using a Kruskal-Wallis test with post hoc univariate testing where appropriate. LESS scores and paired comparisons between healthy versus injured and healthy versus contralateral limbs were made using a Mann-Whitney U test. Wilcoxon signed ranks tests were used for side-to-side comparisons for healthy, unilateral injured and bilateral injured knees. All results are reported as median and range. The level of significance was set at $P < 0.05$. **Results:** There was a significant difference for average SLS squat scores reported between limbs (healthy: 3.3, 0.0-5.7 errors; injured: 3.5, 2.0-6.3 errors; contralateral: 4.2, 2.3-5.8 errors, [$\chi^2 = 7.715$, $P = 0.021$]). Post hoc testing revealed significantly increased errors in the contralateral limbs of the injured group versus healthy limbs ($z = -2.584$, $P = 0.010$), but not between healthy and injured limbs ($z = -1.557$, $P = 0.119$). No side-to-side differences were observed for any group (healthy: right = 3.0, 0.0-5.7 errors; left = 3.3, 1.0-5.7 errors [$z = -0.770$, $P = 0.442$]; unilateral: Injured = 3.5, 2.0-5.0 errors; uninjured = 4.2, 2.3-5.8 errors, [$z = -1.260$, $P = 0.208$]; bilateral: right = 3.3, 2.0-5.7 errors; left = 4.3, 2.3-6.3 errors, [$z = -1.604$, $P = 0.109$]) on the SLS or between groups for the LESS (healthy = 5.17, 0.0-10.33 errors; knee = 5.0, 0.0-8.33 errors, [$z = -0.959$, $P = 0.337$]). **Conclusions:** More errors during single leg squatting were observed in the contralateral limb in patients with unilateral injury. Individuals with unilateral injuries may develop altered movement strategies that may explain higher rates of injury to the healthy contralateral side following unilateral injury.

Free Communications, Thematic Poster Presentations: Emergency Care and Management in Sports Medicine

Friday, June 27, 2014, 8:00AM-9:30AM, Room 203/204; Moderator: Robb Rehberg, PHD, ATC, NREMT 14175FOEM 14323OOEM

Opinions Of Athletic Trainers On The Effectiveness Of Two Spine Immobilization Techniques In A Gymnastics Pit

Bonacci JA, York RL, McDermott BP, Chalk KA, Thornton KT, Williams SM: University of Arkansas, Fayetteville, AR

Context: Current gymnastics pit immobilization and extraction practices are recommended to include rescuers in a prone position on gymnastics mats bridged to the patient in the pit (unstable). There has not been compared to rescuers using no mats and entering the pit (stable). **Objective:** Assess athletic trainer (AT) opinions of stable and unstable techniques in a gymnastics pit before and after reading written instructions and participating in hands-on application. **Design:** Crossover trial. **Setting:** Content validity of our 14-item Likert instrument was verified during a 2-hr meeting with 3 ATs, 4 EMTs and 1 EMT-educator (minimum 10y professional experience). Experts provided feedback on appropriateness of questions relating to the outcome goals of our survey instrument. **Patients or Other Participants:** A convenience sample (N=23; age range: 24-55y; 6±7y AT experience) voluntarily participated. **Intervention(s):** Participants read written instructions, then completed the survey of professional opinions prior to and following application of the stable and unstable techniques in a gymnastics pit. Participants were allowed as much time as needed to review and ask questions to verify knowledge and clarity of the techniques. **Main Outcome Measure(s):** Two groups were established by years of experience; those with ≤ 4y AT experience (Group A; n = 11), and those with >4y AT experience (Group B; n = 9). Three subjects did not self-report AT experience and were excluded from group analysis. Participants performed all application sessions on the same model in the supine position. Pre- to post-application survey results

were compared using dependent t-tests, while independent t-tests were used to compare group responses. **Results:** Subjects response to the question “I am very familiar with spine boarding in a gymnastics pit technique” showed a significant pre- to post-application improvement (P=.031). Pre-application, group A’s opinion on the question “the unstable position provided the most stability of the rescuer securing the victim” was significantly greater than group B (P=.040). Post-application, group A and B did not differ on a favored technique (P=.293). Group A tended to increase their familiarity rating pre- to post-application more than B (P=.055). Other survey questions regarding favored technique, ease of use, and stability for the rescuer and victim demonstrated no significant time or group differences (P>.05). **Conclusion:** Minimal hands-on practice improved overall familiarity with gymnastic pit spine boarding. Even though novice ATs preferred the unstable technique pre-application, groups A and B agreed that neither technique was superior post-application. ATs working in gymnastics pit sports should practice these techniques, compare stable and unstable in order to develop a favored technique and clear direction for their emergency action plans. Future studies should utilize motion analysis in different victim positions to provide more robust evidence for clinical practice recommendations.

Football Equipment Removal Time And Difficulty In An Exertional Heat Stroke Scenario

Endres BD, Decoster LC, Swartz EE, Chester TE: New Hampshire Musculoskeletal Institute, Manchester, NH, and University of New Hampshire, Durham, NH

Context: Immediate cold water immersion (CWI) is the gold standard for exertional heat stroke treatment. Delays delivering this critical care may compromise survival by allowing core temperature to remain elevated. Removing football equipment and clothing immediately is recommended in preparation for CWI yet the associated time and difficulty for this task has not been reported. Should this process take too long, immediate initiation of CWI without removal of equipment might be indicated. **Objective:** To determine the time and the difficulty associated with complete removal of a full American football uniform in preparation for CWI. Two shoulder pad styles were compared. **Design:** Repeated measures. **Setting:** Gymnasium. **Patients or Other Participants:** Convenience sample of 28 certified athletic trainers (16 females, 12 males age = 29.5 ± 7 years, height = 169.27 ± 10.65 cm, mass = 75.29 ± 16.10 kg, years certified = 6.20 ± 6.83 years) with no history of injury in the last 6 months provided informed consent. **Intervention(s):** Full uniforms consisting of a Riddell (Elyria, OH) 360™ helmet, skull cap, game-style jersey, pants, full leg padding, belt, t-shirt, socks, and sneakers were removed from healthy human models. The independent variable was shoulder pad style: the Riddell quick-release (RipKord™) and traditional (CPX™) shoulder pads. Clothing was cut with Prestige Medical (Northridge, CA) 7.5” Premium Fluoride Scissors. A digital stopwatch timed trials. A DataTherm® II Continuous Temperature Monitor (Geratherm Medical AG, Geschwenda, GER) with flexible disposable thermistor

probe was inserted into a Nasco (Salida, CA) LifeForm Enema Simulator that was placed adjacent to the model to simulate core temperature reading after uniform removal. Subjects worked in pairs. Three trials of equipment removal with each shoulder pad style were completed in random order for a total of 6 trials. The order of uniform component removal was pre-determined starting with the helmet and shoulder pads and ending after simulated rectal temperature probe insertion. Timing started when the subject said "begin" and ended when the temperature reading was verbalized. Participants' ratings of difficulty were obtained using a modified Borg CR-10 scale. **Main Outcome Measure(s):** Dependent variables were time and difficulty of uniform removal. Paired t-tests were conducted in IBM SPSS Statistics 18.0 to compare time and difficulty between conditions. The alpha level was set a priori at <0.05. **Results:** Equipment removal times (162.37 ± 24.48 sec, 162.87 ± 19.77 sec, $p = 0.87$, $t = 0.166$) and rating of difficulty (2.12 ± 0.94 , 2.22 ± 0.81 , $p = 0.36$, $t = -0.948$) were similar for the RipKord™ and traditional shoulder pad styles, respectively. **Conclusions:** The time to prepare for CWI was performed in compliance with recommendations to initiate cooling within 10 minutes. However, this time does not include initial assessment nor did the study factor in the location of the CWI bath. The RipKord™ shoulder pad system did not improve the time or difficulty of removing football equipment in this scenario.

A Comparison Of Head Acceleration, Time And Difficulty During Helmet Removal With And Without Facemask Removal

Tucker WS, Chester TE, Decoster LC, Swartz EE, Endres BD: University of Central Arkansas, Conway, AR; New Hampshire Musculoskeletal Institute, Manchester, NH, University of New Hampshire, Durham, NH

Context: With potential cervical spine injury, immobilization and removal of barriers to the airway, such as a facemask (FM), are essential. Helmet removal may be indicated in certain situations. It is unknown if removing the FM prior to helmet removal is beneficial. **Objective:** To compare head acceleration, time and difficulty during helmet removal with and without facemask removal. **Design:** Quasi-experimental. **Setting:** Controlled laboratory. **Patients or Other Participants:** Twenty-eight certified athletic trainers free of physical ailments participated in this study (12 males: age = 30.8 ± 8.5 yrs, height = 179.0 ± 6.4 cm, mass = 83.7 ± 15.8 kg, athletic training experience = 7.5 ± 8.3 yrs; 16 females: age = 28.6 ± 6.0 yrs, height = 161.9 ± 6.4 cm, mass = 69.0 ± 13.6 cm, athletic training experience = 5.3 ± 5.5 yrs). **Intervention(s):** A model outfitted in properly-fitted football equipment lay supine on the floor, wearing one of two helmet styles (Riddell 360 or Riddell VSR4). Three-dimensional accelerometers were secured to a mouthpiece and the sternum. Participants performed four randomly assigned trials of helmet removal in each condition (360 FM-on, 360 FM-off, VSR4 FM-on, VSR4 FM-off). Acceleration data were collected in the sagittal, frontal, and transverse planes. Trial time was determined with a digital stopwatch. A modified Borg CR-10 RPE scale was used to record difficulty following each trial. The independent variables were helmet (360 and VSR4) and removal technique

(FM-on and FM-off). **Main Outcome Measure(s):** Dependent variables were peak acceleration in three planes (sagittal, frontal and transverse), trial time and difficulty. For each dependent variable, a 2x2 factorial RMANOVA was performed with Bonferroni adjusted Pairwise post-hoc comparisons. (Alpha level = $p < 0.05$). **Results:** Main effects were detected in sagittal plane acceleration for helmet ($F_{1,13}=18.015$, $p=0.001$) and technique ($F_{1,13}=18.534$, $p=0.001$). The 360 (5.19 ± 1.6 m/s/s) was greater ($p=0.001$) than the VSR4 (3.1 ± 0.67 m/s/s) and FM-on (4.76 ± 1.1 m/s/s) was greater than FM-off (3.52 ± 0.80 m/s/s). There was a main effect in the transverse plane for helmet ($F_{1,13}=17.009$, $p=0.001$) and technique ($F_{1,13}=10.075$, $p=0.007$). The 360 (4.87 ± 1.6 m/s/s) was greater than the VSR4 (2.8 ± 0.78 m/s/s) and FM-on (4.33 ± 1.1 m/s/s) was greater than FM-off (3.34 ± 0.93 m/s/s). A main effect ($F_{1,13}=5.801$, $p=0.032$) in frontal plane acceleration was detected. The 360 (2.71 ± 0.92 m/s/s) was greater than the VSR4 (1.94 ± 0.43 m/s/s). For time, there was a main effect for helmet ($F_{1,13}=49.165$, $p<0.001$) and technique ($F_{1,13}=21.956$, $p<0.001$). The VSR4 (91.2 ± 18.8 s) took longer than the 360 (50.2 ± 11.1 s) and FM-off (82.5 ± 13.8 s) took longer than FM-on (59.0 ± 15.0 s). For difficulty, there was a main effect for helmet ($F_{1,13}=5.746$, $p<0.032$). The VSR4 was more difficult (2.67 ± 0.83) than the 360 (2.31 ± 0.73). An interaction ($F_{1,13}=6.471$, $p<0.024$) revealed the VSR4 as being more difficult with FM-off, but the 360 more difficult with FM-on. **Conclusions:** While removal of the facemask limited acceleration at the head, the removal process increased the time for the task for both helmets (360 and VSR4) and increased difficulty with the VSR4. Future research analyzing induced motion is warranted.

The Role Of Practice On Lacrosse Helmet Facemask Removal Time

Martinez DC, Bowman TG, Boergers RJ: Lynchburg College, Lynchburg, VA, and Seton Hall University, South Orange, NJ

Context: Expedient response to a catastrophic injury can be the difference between life and permanent injury or death. Face mask removal (FMR) is crucial to immediate treatment of the helmeted athlete. It remains unknown if practice consistently improves lacrosse helmet FMR efficiency.

Objective: To determine the effect of regular practice on the time required to remove a lacrosse helmet facemask using two FMR tools. **Design:** Randomized, crossover trial design.

Setting: Athletic Training laboratory.

Patients or Other Participants: Seven certified athletic trainers (4 males, 3 females; height = 174.53±6.17 cm; mass = 74.54±10.89 kg; 6 right handed, 1 left handed) and fifteen athletic training students (3 males, 12 females; height = 168.34±10.35 cm; mass = 76.60±13.09 kg; 14 right handed, 1 left handed) volunteered for this research study. **Intervention(s):** We asked participants to remove the facemasks of 2 different lacrosse helmet models (Cascade CPXR and Warrior Trojan) during 4 data collection sessions over 4 weeks. Each participant was randomly assigned one of 2 tools (cordless screwdriver or pruner) for the duration of the study and performed FMR on both of the helmets during each data collection session. We separated each of the data collection session by 7 days and provided standardized instructions to the participants for all data collection sessions. We also alternated the order of the 2 helmets on which each participant performed FMR week to week. We used removal method as the independent variable. **Main Outcome Measure(s):** We chose FMR time measured to the

nearest hundredth of a second as the dependent variable. Timing started when the participant picked up the removal tool and ended when the facemask was completely removed from the helmet. We explored the differences between removal tools across the four weeks using a split-plot repeated measures ANOVA. **Results:** The participants successfully completed all 180 FMR trials. We found a significant interaction for removal tool and time ($F_{3,60} = 9.81$, $P < .001$). We also uncovered significant main effects for time ($F_{3,60} = 22.63$, $P < .001$) and tool ($F_{1,20} = 22.73$, $P < .001$). **Conclusions:** The use of a cordless screwdriver was faster than the pruner. The participants became significantly faster at FMR across the 4 weeks of data collection with the sharpest decreases in time occurring between the first 2 weeks, especially when using the pruner. Further, the time required for FMR reduced more substantially overall when using the pruner compared to the cordless screwdriver over the 4 weeks of data collection. We recommend regular practice to improve FMR speed until FMR time plateaus, particularly when using a cutting tool.

Force Attenuation Of New And Used Lacrosse Helmets

Bowman TG, Breedlove KM, Breedlove EL, Dodge TM, Nauman EA: Lynchburg College, Lynchburg, VA; Purdue University, West Lafayette, IN; Springfield College, Springfield, MA

Context: The National Operating Committee on Standards for Athletic Equipment (NOCSAE) has developed force attenuation thresholds that protective helmets worn in sport must meet to be commercially available. The thresholds are set at such a level to help distinguish between impacts that are likely to cause severe injury from those that are less serious. It remains unknown how normal helmet use in athletic activity alters the force attenuation ability of lacrosse helmets. **Objective:** To determine how new and used lacrosse helmets perform on NOCSAE drop tests. **Design:** Cross-sectional study. **Setting:** Biomechanics laboratory with NOCSAE compliant drop tower. **Patients or Other Participants:** We tested 3 new and 3 randomly selected used helmets that had never been refurbished from 2 popular lacrosse models (Cascade Pro7, Cascade CPXR). All used helmets had been worn for three full traditional seasons prior to testing. **Intervention(s):** We tested the helmets using a drop test with the 3 prescribed impact velocities of 3.46 (low), 4.89 (medium), and 5.47 (high) meters per second according to the NOCSAE standard relevant to lacrosse helmets. The headforms and data collection equipment were certified for compliance prior to use. We also re-calibrated the accelerometer using a calibration shaker (PCB Piezotronics, Model 394C06) which provides a known acceleration and allows for high precision calibration exceeding NOCSAE requirements. We used helmet age (new or used), brand (Pro7 or CPXR), and drop location (front, top, rear, and side) as the independent variables. **Main Outcome Measure(s):**

We recorded and compared the Gadd Severity Index (GSI) scores between the helmets across the independent variables. **Results:** All 12 helmets passed the NOCSAE GSI threshold at all 3 velocities at each of the 4 drop locations. For the low velocity drops, we found a significant main effect for helmet age ($F_{1,32}=13.16$, $P=.001$, $\eta^2=.29$, $1-\beta=.94$) and drop location ($F_{3,32}=72.97$, $P<.001$, $\eta^2=.87$, $1-\beta=.99$). We discovered a three-way interaction between helmet age, helmet brand, and drop location at the medium velocity ($F_{3,32}=5.12$, $P=.01$, $\eta^2=.32$, $1-\beta=.87$) and at the high velocity ($F_{3,32}=7.31$, $P=.001$, $\eta^2=.41$, $1-\beta=.97$). **Conclusions:** Interestingly, all of the helmets passed the NOCSAE standard suggesting they can still adequately attenuate blows to the head, even after 3 years of use without reconditioning. However, at several locations, the force attenuation ability of the used helmets deteriorated especially during medium velocity drops, while at other locations it improved particularly during high velocity drops. We suspect that helmet use can degrade materials under some conditions, but improve performance in others due to change in helmet composition due to use (i.e., breaking in). The clinical implications of the differences in GSI scores noted remain unclear.

Force Attenuation Of Football And Lacrosse Helmets

Breedlove KM, Breedlove EL, Bowman TG, Sanghani SP, Nauman EA: Purdue University, West Lafayette, IN, and Lynchburg College, Lynchburg, VA

Context: The National Operating Committee on Standards for Athletic Equipment (NOCSAE) has developed force attenuation thresholds for protective helmets worn in sport. These thresholds are the same for lacrosse and football and the testing protocols are similar. However, it remains unknown how the force attenuation capabilities of football and lacrosse helmets compare to each other.

Objective: To determine the comparative force attenuation abilities of football and lacrosse helmets. **Design:** Cross-sectional study. **Setting:** Biomechanics laboratory with NOCSAE compliant drop tower.

Patients or Other Participants: We tested 3 helmets from each of the following 3 football models (Riddell Revolution, Schutt Ion4, and Xenith X1) and 3 helmets from 6 models of lacrosse helmets (Cascade CPX, Cascade Pro7, Cascade CPX-R, Cascade R, Warrior Trojan, and Warrior Venom). All helmets had never been used in sport activity.

Intervention(s): We tested helmets using a NOCSAE-compliant drop test relevant to each helmet's sport (football or lacrosse). Helmets were dropped at the prescribed impact velocities of 3.46 (low), 4.89 (medium), and 5.47 (high) meters per second as defined by NOCSAE. The headforms and data collection equipment were certified for compliance prior to use, and the accelerometer was calibrated using a high precision calibration device. **Main**

Outcome Measure(s): We recorded and compared the Gadd Severity Index (GSI) scores between football and lacrosse helmets, between the helmet models within each sport, and across the 4 different drop locations (front, top, rear, and side). **Results:** Two or more

Cascade CPX, Cascade R, and Warrior Trojan helmets failed the NOCSAE test by exceeding the NOCSAE GSI threshold for at least one impact. All other helmets passed the NOCSAE GSI threshold at all 3 velocities at each of the 4 drop locations. We discovered a significant interaction between model and location at the low ($F_{19,60}=7.04$, $P<0.001$), medium ($F_{19,60}=11.63$, $P<0.001$), and high ($F_{19,60}=12.65$, $P<0.001$) velocities. We uncovered a significant interaction of sport and location at the low ($F_{3,60}=15.72$, $P<0.001$), medium ($F_{3,60}=34.92$, $P<0.001$), and high velocities ($F_{3,60}=23.89$, $P<0.001$). We also found a significant main effect for helmet model at the low ($F_{7,60}=10.53$, $P<0.001$), medium ($F_{7,60}=36.68$, $P<0.001$), and high velocities ($F_{7,60}=25.03$, $P<0.001$). Additional main effects were identified for sport and location at all three velocities ($P<0.001$). **Conclusions:** Force attenuation capability, measured by GSI, varied across helmet models according to drop location after accounting for differences in sport. Overall, football helmets performed better than lacrosse helmets, and we found a wide variety of GSI scores among the different brands within each sport. Although lacrosse helmets are manufactured for a different athletic context, it may be possible for aspects of football helmet technology to be adapted to lacrosse helmets in the future in order to improve force attenuation performance.

Emergency Planning For Sudden Cardiac Events In Michigan High Schools

Ranucci AC, Griffes LS, Katch RK, Berry DC: Saginaw Valley State University, University Center, MI

Context: Sudden death in sports has a variety of causes and is a public and emotional event with long-lasting effects on athletic teams and the community. Emergency preparedness and providing prompt care is critical to patient survival; including having access to an emergency action plan (EAP) and automated external defibrillator (AED). **Objective:** Evaluate the state of high school emergency planning in Michigan, focusing primarily on the existence and characteristics of EAPs and AEDs for rapid response to sudden cardiac arrest (SCA). **Design:** Cross-sectional, descriptive survey. **Setting:** Michigan public/private high schools. **Patients or Other Participants:** Completed surveys were received from 14.3% (101/705) of schools associated with the Michigan High School Athletic Association (MHSAA). All divisions were represented; Class-A (n=26, 25.7%), Class-B (n=29, 28.7%), Class-C (N=27, 26.7%), and Class-D (n=19, 18.8%). **Intervention(s):** Athletic directors (n=705) from the 2013-2014 MHSAA online directory were invited to complete an IRB approved electronic survey (Snap Survey, Portsmouth, NH). Follow-up emails were sent 7 and 15 days later. The survey replicated a previous study (with permission) examining SCA in North Carolina using the National Athletic Trainers' Association (NATA) Inter-association Task Force on SCA as the theoretical model to assess measurable aspects of emergency planning, including: (1) documented, visible, and practiced plan incorporating an AED; (2) time-based resuscitation goals; (3) first responders training; and (4) efficient communication system between providers. **Main Outcome Measure(s):** Descriptive

statistics (eg., means, frequencies) were calculated for dependent variables (eg., EAP, AED characteristics); independent variable was athletic division. Pearson chi-square testing compared proportions of responders to non-responders to determine if athletic division was associated with the presence of an EAP and AED and their characteristics (eg. time-based resuscitation goals). Significance was set a-priori at $\alpha=0.05$. **Results:** EAPs were available in 40 (39.6%) schools. Class-A (OR 31.8, 95% CI:3.5, 285.3, $p<.001$), Class-B (OR 17.0, 95% CI:1.9, 147.1, $p=.002$), and Class-C (OR 12.4, 95% CI:1.4, 108.1, $p=.007$) schools were more likely to have an EAP compared to Class-D schools (reference). EAPs included aims to initiate CPR within one-minute (65%), and target to defibrillate within three-five minutes (82.5%) as recommended by NATA guidelines. AEDs were present in 98% (n=99) of schools; 71.6% reporting 2-5 AEDs. AEDs were locked up in 14 schools (14.1%); one school was unsure who had keys to access the device. **Conclusions:** Many schools demonstrated room for emergency planning improvement. Less than half of the schools possessed an EAP; however, more than two-thirds of school's EAPs did include aims to achieve recommended time-based resuscitation goals. Schools with EAPs should consider practicing them more frequently and improving coordination with EMS; while schools without plans need to work with local healthcare providers to establish EAPs that meet time-based resuscitation goals to improve patient outcomes during SCA.

Characteristics Of Football Helmets Associated With The Incidence Of Sport Related Concussion In High School Football Players

McGuine TA, Brooks MA, Hetzel S, Rasmussen J: University of Wisconsin, Madison, WI

Context: Sport Related Concussions (SRC) are a growing concern in high school football. There is limited data that examines the role that the type of helmet (brand, age) have on the incidence of SRC in high school football players. Football helmet manufacturers often claim that players wearing their helmets are less likely to sustain a SRC compared to players wearing other helmet brands. There are also claims that newer helmets offer better protection against SRC than older helmets. **Objective:** To determine if the type of football helmet affects the incidence and severity of SRC in high school football players. **Design:** Prospective cohort study. **Setting:** Data were collected in Wisconsin during the 2012 (36 schools) and 2013 (18 schools) high school football seasons. **Patients or Other Participants:** A convenience sample of 2,288 (grades 9 – 12) players (age = 15.9 ± 1.2 yrs.) enrolled in this study. **Intervention(s):** Licensed Athletic Trainers (ATs) at each school recorded the helmet brand (Riddell, Schutt and Xenith) and purchase year (2003-2013) worn by each subject and recorded the incidence and severity (days lost) for each SRC. **Main Outcome Measure(s):** The dependent variable was the incidence of SRC. Chi-square tests were used to compare the incidence of SRC between the helmet brands and helmet age (seasons of service). Wilcoxon Rank Sum tests were used to determine if there were differences in the severity (days lost) of SRC [Median: 25th, 75th IQR] for helmet brands and years in service. **Results:** A total of 204 players (8.9%) sustained 208 SRC causing them to miss a median of 14 (10.1, 20.2)

days. There was no difference ($p = 0.773$) in the incidence of SRC [SRC/helmets, (%: 95% CI)] for players wearing Riddell [108/1172 (9.2%: 7.7,11.1)], Schutt [56/678 (8.3%: 6.4,10.7)], Xenith [40/438 (9.1%: 6.7,12.3)] helmets. There was no difference ($p = 0.365$) in the incidence of SRC for helmets that were used for their first and second seasons, [47/463, 10.2%: 7.6,13.4], third and fourth seasons, (72/904, 8.0%: 6.3,10.0) or five or more seasons (83/895, 9.3%: 7.5,11.0). There was no difference ($p = 0.249$), in the severity of SRC for players wearing Riddell [13.0: 9.0,19.0], Schutt [14.0: 10.5,23.0] and Xenith [14.5: 11.8,19.0] helmets. There was no difference ($p = 0.239$) in the severity of SRC for helmets that were used in their first and second seasons [16.0: 11.0,19.5], third and fourth seasons [12.0: 8.0,21.0] or five or more seasons [13.5: 10.0,19.0]. **Conclusions:** Despite manufacturer's claims, there was no difference in the incidence or severity of SRC based on the helmet brand or helmet age. ATs need to be aware that factors other than the type of football helmet may affect the risk of high school players sustaining a SRC.

Free Communications, Thematic Poster Presentations: Characterizing Clinical Practice and Use of Patient Outcome Measures

Friday, June 27, 2014, 10:00AM-11:30AM, Room 203/204; Moderator: Sarah Manspeaker, PhD, ATC
14410DOTE 14340SOMU

Clinical Practice Patterns And Beliefs Of Athletic Trainers In The Management Of Hamstring Strain Injuries

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Context: Hamstring strain injuries (HSI) are among the most commonly occurring injuries in athletics and remain a challenge to the athletic trainer (AT). The alarmingly high re-injury rate (12-31%) suggests that current management is inadequate, return-to-play occurs too soon, or evidence-based practice (EBP) is not being employed. **Objective:** To assess the clinical practice patterns (treatment, rehabilitation) and beliefs (confidence, satisfaction) of ATs in the management of HSI, and to determine if the limited evidence in the literature regarding HSI management is being practiced. **Design:** Cross sectional original survey. **Setting:** A population based study of 2013 NATA Annual Meeting registrants. **Patients or Other Participants:** Certified ATs from the registrant list were invited to participate (n=1,356, male = 691, female = 665, age = 35.44+10.45 years, years certified = 11.92+9.75 years, HSI evaluated per year = 16; median = 10; skew = .068). Response rate = 17%. **Intervention(s):** A 71-item survey was electronically distributed to 7,274 registrants and 700 in-person surveys were randomly distributed at the Annual Meeting. A table of specifications and expert panel established construct and content validity, while pilot testing established reliability ($\alpha = .92$). **Main Outcome Measure(s):** ATs rated clinical practice patterns (treatment and rehabilitation method use) on a 3-point scale (always=1, sometimes=2, never=3), and beliefs on a 5-point Likert scale (strongly agree=1 to strongly disagree=5). Exploratory factor analysis uncovered survey structure and dimensionality. Principal axis factor analysis was employed. Descriptive

statistics assessed clinical practice patterns. **Results:** A two-factor solution was accepted for factor analysis ($r = 0.76$, $r = 0.70$). Variables of factor 1 described high levels of modern techniques (contemporary management style), while factor 2 was defined by appreciable loadings from standard practices (traditional management style). A majority rating of “always” was reported for evidence-based methods of eccentric strengthening (79.2%, 1041/1314, 1.22+0.44) and progressive agility (80%, 1046/1307, 1.21+0.43), while core strengthening (55.8%, 730/1308, 1.49+0.60), neural flossing (10.7%, 138/1289, 2.49+0.68), and muscle activation exercises (47.5%, 616/1298, 1.65+0.69) had lower usage rates. Belief ratings of “strongly agree” to being very confident a re-injury would not occur following return-to-play (8.7%, 118/1351, 2.40+0.82), believing research guidelines are very useful (3.9%, 52/1350, 2.77+0.76), and satisfaction with current management plan (12.6%, 170/1350, 2.20+0.73) were reported. **Conclusions:** Results indicate that ATs lean towards either a contemporary or traditional management style. The research has been overwhelming inconclusive with regard to HSI, but there are some methods that have been shown to be effective. While certain methods are being utilized by ATs, results show that the overall practice patterns of ATs are not fully representative of EBP. Current re-injury rates are not suggestive of successful management, but employing more of these contemporary methods could be an effective way to decrease HSI reoccurrence while also improving confidence and satisfaction.

Functional Performance Differences Between Gender And Grade Level In High School Athletes: The Functional Pre-Participation Physical Evaluation (FPPE) Project

Starkel C, Grooms D, Miller M, Schussler E, Onate J: Ohio State University, Columbus, OH

Context: The 4th edition of the Pre-Participation Physical Evaluation (PPE) recommends functional testing for the musculoskeletal portion of the examination. However, data for lower extremity functional tests are quite limited across gender and education levels. **Objective:** To compare lower extremity functional performance between genders and across grade levels in healthy high school athletes for establishment of functional physical evaluation baseline data. **Design:** Cross-sectional study. **Setting:** High school athletic training facilities. **Patients or Other Participants:** 148 female high school soccer and lacrosse athletes (15.5 ± 1 years, 1.62 ± 0.07 m, 59.3 ± 11.7 kg) and 340 male high school soccer, lacrosse and football athletes (15.7 ± 1.2 years, 1.78 ± 0.09 m, 78.8 ± 16.3 kg). **Intervention(s):** A functional performance assessment was completed prior to the start of the respective seasons consisting of single leg anterior reach (SLAR) and single leg hop (SLHOP). The SLAR evaluates dynamic balance by measuring the distance an individual is able to reach their contralateral foot while maintaining a single leg balance position. The SLHOP evaluates single leg power and landing control by measuring the distance an individual is able to jump on one leg while maintaining control of the landing. All reach and hop distances were normalized to leg length (measured from ASIS to medial malleolus). **Main Outcome Measure(s):** A two-way ANOVA (a-priori $p < 0.05$) was conducted to examine the effect of gender and grade level on right leg SLAR and SLHOP performance. Tukey post-hoc comparisons were examined

to determine the grade levels in which differences existed. **Results:** SLHOP performance was significantly different between genders (males = $182.9\% \pm 35.5\%$, females = $151.4\% \pm 28.9\%$, $p < .001$), but no significant differences were found for SLAR performance (males = 68.1% , females = 67.9% , $p = .871$). No interaction effect was found between gender and grade level. Statistically significant differences existed for SLHOP and SLAR performance between grade levels. The post-hoc test revealed SLHOP performance was significantly better for athletes in grades 11 ($168.7\% \pm 3.3\%$, $p = .016$) and 12 ($179.3\% \pm 3.6\%$, $p < .001$) compared to athletes in grade 9 ($157.6\% \pm 3.2\%$). SLAR performance was significantly better for athletes in grades 11 ($70.2\% \pm 0.77\%$, $p = .027$) and 12 ($71.3\% \pm 0.84\%$, $p = .002$) compared to athletes in grade 9 ($67.8\% \pm 0.76\%$). There were no statistically significant differences for SLAR and SLHOP symmetry between grade levels (SLAR $p = .065$; SLHOP $p = .753$). **Conclusions:** SLAR and SLHOP performance improves with increasing high school grade level. These results indicate power performance differs between genders while dynamic balance does not. Functional pre-participation exams should consider grade and gender norms when analyzing PPE outcomes.

Athletic Training Services Provided During Daily Patient Encounters In The Secondary School Setting: A Report From The Athletic Training Practice-Based Research Network

Stobierski L, Snyder Valier AR, Lam KC, Anderson BE, Welch CE, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Athletic trainers (ATs) have a unique role in the healthcare system, treating patients on a regular and often daily basis. These include services for injury prevention and performance enhancement such as taping and wrapping, stretching, various modalities, and exercise prescription that are often unaccounted for in traditional documentation. Thus, there is little description of daily patient encounters to characterize practice and the role of athletic training in healthcare of secondary school athletes. **Objective:** To characterize daily athletic training services provided by secondary school ATs from the Athletic Training Practice-Based Research Network (AT-PBRN). **Design:** Descriptive study. **Setting:** Secondary school athletic training clinics within the AT-PBRN. **Patients or Other Participants:** Adolescent patients ($n=4,341$; age= 16.4 ± 1.3 years) seeking care from ATs affiliated with the AT-PBRN. **Intervention(s):** A web-based electronic medical record was used to obtain patient characteristics via de-identified data between December 1, 2010-October 31, 2013. **Main Outcome Measure(s):** Descriptive data regarding practice characteristics from patient encounter forms were analyzed and reported as percentages and frequencies. **Results:** The AT-PBRN documented 30,757 patient encounters (mean 7.1 ± 10.6 encounters per patient) among 2,577 male and 1,764 female patients. The largest contribution to patient encounters were from football (44.9% , $n=13,814$), followed by basketball (15.9% , $n=4,902$), soccer (9.1% , $n=2,800$), track (8.3% , $n=2,547$), and volleyball (7.3% , $n=2,275$). All other sports accounted for less than 4% of

patient encounters each. Most encounters were for preventative services (56.0% , $n=17,211$), followed by care for a current injury (34.0% , $n=10,460$) and care for new injuries (10.0% , $n=3,086$). These patient encounters were primarily for preventative services or injury care for the ankle (31.3% , $n=9,635$), knee (12.1% , $n=3,721$), wrist (9.3% , $n=2,859$), calf (6.2% , $n=1,899$), and shoulder (5.7% , $n=1,754$). Of the preventative encounters, taping was the most common service provided (60.3% , $n=10,381$), followed by ice/hot pack application (27.8% , $n=4,785$), and treatment (11.5% , $n=1,971$). Regarding care for current injury, taping was also the most common (40.1% , $n=4,196$), followed by treatment (38.1% , $n=3,990$), and ice/hot pack application (36.5% , $n=3,823$). The most common service for a new injury was evaluation (67.2% , $n=2,075$), followed by ice/hot pack application (46.4% , $n=1,431$), and treatment (26.0% , $n=803$). **Conclusions:** These findings describe daily athletic training services provided by secondary school ATs within the AT-PBRN, highlighting the important and unique nature of athletic training services, especially in the area of preventative activities. It is imperative that ATs document these daily patient encounters to accurately describe a valued area of athletic training practice. Future research aimed at capturing the value of these routine services, through cost analyses, is essential in promoting the important role of ATs in the healthcare of secondary school athletes. The athletic training profession should embrace this prevention role in advocacy efforts, especially in secondary schools.

Determination Of The Functional Movement Screen To Predict Musculoskeletal Injury In Inter-Collegiate Athletics

Wiese BW, Boone JK, Mattacola CG, McKeon PO, Uhl TL:

University of Kentucky, Lexington, KY; East Carolina University, Greenville, NC; University of Delaware, Newark, DE; University of Kentucky, Lexington, KY; Ithaca College, Ithaca, NY

Context: Participation in sport increases risk of injury. Identification of risk factors for injury is often accomplished through the pre-participation exam. Functional movement insufficiencies may place an individual at increased risk of injury. The Functional Movement Screen (FMS) is a clinical tool used to identify movement insufficiencies and/or asymmetries. A cut off score of 14 or less has been reported to indicate a higher risk of injury in the NFL; however little research has been done to validate this cutoff for NCAA Division I football. **Objective:** To investigate the utility of the FMS as a screening tool to predict musculoskeletal injury in NCAA Division I football. **Design:** Prospective cohort study. **Setting:** Collegiate athletic training room/clinic. **Patients or Other Participants:** 144 NCAA Division I football athletes participated (age: 18.9±1.3 years, height: 187.2±6.9 cm, mass: 102.4±19.9 kg). **Intervention(s):** FMS scores were obtained prior to the start of the NCAA football season. Participants were tracked prospectively over the course of a single season and all sport related injuries were evaluated, documented, and tracked by an AT. The independent variable was group (injured vs. non-injured) and the dependent variable was composite FMS score. Groups were self-allocated depending on if they suffered an injury or not during the season. An injury was defined as removal from play or at least one days' time loss from team activities. **Main Outcome Measure(s):**

Upon completion of the NCAA football season, the FMS composite score at preseason was compared between the injured and non-injured groups using a Receiver Operator Characteristic (ROC) curve to determine the optimal cut score for group membership. Sensitivity, specificity, positive likelihood ratios, and odds ratios were calculated to determine the optimal cut-off score that best discriminates between the injured and non-injured groups. **Results:** Across the entire season, 93 players sustained an injury whereas 51 players did not. The vast majority of the injuries were associated with the lower extremity. The true positive rate and the false positive rate were .491 and .495, respectively for the optimal cut-off score of 17. Odds ratio of 1.425 (95% CI: .6-3.2) and a positive likelihood ratio of 1.154 were found for individuals that scored a 17 or below on the FMS. The ROC curve was not significant with a value of $P=.854$ (95% CI: .389-.592). **Conclusion:** These results suggest that the FMS was not predictive of injury for NCAA Division I football athletes. Our results indicate that the FMS captures elements of functional insufficiencies, yet did not provide a clear delineation for those who would be positive for sustaining an injury.

The Impact Of Sport And Sex On Sport-Related Injury Patterns: A Report From The Athletic Training Practice-Based Research Network

Fayson SD, Lam KC, Snyder Valier AR, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Understanding athletic training practice characteristics (eg, injury characteristics) can provide insight into current clinical practice patterns and help guide educational and scientific initiatives. Although current evidence suggests that sport-related injury patterns vary due to skill level, level of conditioning, frequency, and duration of activity, little is known of the impact of sport and sex. **Objective:** To describe common injuries from the Athletic Training Practice-Based Research Network (AT-PBRN) based on sport and sex. **Design:** A retrospective analysis of electronic medical records. **Setting:** Athletic training clinics in secondary school (81.8%) and collegiate (18.2%) settings across 13 states (AK, AZ, CA, KS, MA, MN, NC, NH, NJ, NY, UT, VA, WI) within the AT-PBRN. **Patients or Other Participants:** Medical records of 5,179 patients (male=3,004, age=17.1±2.2 years, height=174.4±12.1 cm, mass=76.6±16.8 kg; female=2,175, age=17.0±2.2 years, height=164.3±10.2 cm, mass = 59.8 ± 9.2 kg) who were diagnosed with a sport-related injury by an athletic trainer (AT) within the AT-PBRN. **Intervention(s):** Medical records of patients who were diagnosed with a sport-related injury between October 2009-October 2013 were reviewed. All medical records were created by an AT utilizing a web-based electronic medical record with ICD-9 diagnostic codes. **Main Outcome Measure(s):** Summary statistics were calculated for injury data based on sport and sex, and were reported as percentages and frequencies. **Results:**

A total of 7,534 sport-related injuries (male = 4,260, female = 3,274) were documented during the study period. Most injuries in male sports occurred in football (51.9%, n=2,210), basketball (9.4%, n=401), and soccer (7.9%, n=338). In female sports, soccer (20.4%, n=669), basketball (16.5%, n=542), and volleyball (11.3%, n=423) resulted in the most injuries. Concussion (ICD-9:850.9, 850.0, 850.5), ankle sprain/strain (ICD-9:845, 845.01, 845.03, 845.09), and knee sprain/strain (ICD-9:843.9, 844, 844.1, 844.2, 844.9) were documented as the top three injuries, in varying rank order, for football (concussion:19.6%, n=434; ankle sprain/strain:11.4%, n=251; knee sprain/strain: 9.7%, n=215), male basketball (ankle sprain/strain:34.9%%, n=140; concussion:9.7%, n=39; knee sprain/strain:6.0%, n=24), female soccer (ankle sprain/strain:17.0%, n=114; sprain/strain of the knee:14.1%, n=94; concussion: 13.0%, n=87), female basketball (ankle sprain/strain:18.6%, n=101; knee sprain/strain:14.6%, n=79; concussion:9.2%, n=50), and female volleyball (ankle sprain/strain:20.3%, n=86; knee sprain/strain:10.2%, n=43; concussion:9.0%, n=38). The most common injuries for male soccer were ankle sprain/strain (16.6%, n=56), thigh/hip/groin sprain/strain (ICD-9: 843.90) (14.2%, n=48), and concussion (11.5%, n=39). **Conclusions:** Regardless of sport or sex, ankle sprains/strains, knee sprains/strains, and concussions appear to be common sport-related injuries that athletic trainers evaluate, diagnosis, and manage during daily clinical practice. These results corroborate with previous epidemiological studies and suggest that educational and scholarly efforts should be targeted for these body regions and conditions, with special emphasis on injury prevention and treatment intervention. Future investigations should include comparative effectiveness research studies to identify effective treatment strategies for these common sport-related injuries.

Treatment Characteristics And Estimated Direct Costs Of Care Provided By Athletic Trainers For Lower Extremity Injuries: A Report From The Athletic Training Practice-Based Research Network

Lam KC, Welch CE, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Lower extremity injuries (LEI) are common during sport participation. While epidemiological studies provide insight into patient and injury characteristics, there are limited data regarding treatment characteristics and estimated direct costs of care (DCC) for athletic training services (ATS) related to LEI. **Objective:** To describe treatment characteristics and estimated DCC for ATS associated with LEI. **Design:** Retrospective analysis of electronic medical records. **Setting:** Athletic training clinics across 13 states within the Athletic Training Practice-Based Research Network. **Patients or Other Participants:** Medical records of 3,321 patients (male=1,778, female = 1,543, age = 17.1 ± 2.1 years, height = 169.5 ± 12.6 cm, mass = 68.1 ± 16.2 kg) diagnosed with a LEI by an athletic trainer (AT). **Intervention(s):** Medical records of patients who received ATS between October 2009-October 2013 for a LEI were identified using ICD-9 diagnostic codes. All medical records were created by an AT via a web-based electronic medical record. **Main Outcome Measure(s):** 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 (number of documented patient encounters), and type of ATS provided (CPT codes). DCC were estimated by applying the 2013 Centers for Medicare and Medicaid Services Physician Fee Schedule (MPFS) national payment amount. The MPFS online database was utilized to determine the non-facility (ie, non-hospital) price for each CPT code. Codes were priced

in accordance with the number of units recorded and the DCC for each EOC were estimated. **Results:** A total of 4,215 LEI were identified during the study period. LEI most frequently occurred during football (23.0%), soccer (16.8%), and basketball (13.7%), and in the body regions of the ankle (32.7%), knee (29.6%) and thigh/hip/groin (13.6%). The most common diagnoses by body region were sprain/strain of the ankle/foot (ICD-9:845; 56.7% of ankle injuries), knee pain (ICD-9:719.46; 18.5% of knee injuries), and sprain/strain of the thigh/hip/groin (ICD-9:843.90; 75.9% of thigh/hip/groin injuries). The most frequently utilized treatment was hot or cold pack (CPT 97010; 32.4%), followed by therapeutic exercise (CPT:97110; 22.3%), therapeutic activities (CPT:97530; 8.5%), electrical stimulation (CPT:97032; 6.8%), and strapping of the ankle/foot (CPT:97035; 6.7%). The average duration of care was 15.1 ± 42.3 days across an average of 6.2 ± 10.0 EOC per injury. The average number of treatments provided per EOC was 1.79 ± 0.86 . The average total cost of care was $\$202.38 \pm 374.88$ per injury and the average cost per EOC was $\$67.11 \pm 39.69$. **Conclusions:** In conjunction with epidemiological findings, our results provide a more comprehensive perspective on athletic training practice patterns as they relate to LEI. Understanding clinical practice patterns may offer guidance for future educational, clinical, and scholarly efforts. Although ATS are not currently reimbursable, estimating DCC for these services can help begin to demonstrate the value and potential healthcare costs saving of athletic trainers.

Clinicians Are Unfamiliar And Infrequently Implement Clinical Decision Rules

Hankemeier DA, Popp JK, Walker SE: Ball State University, Muncie, IN

Context: Clinical Decision Rules (CDR) are decision making tools widely used in healthcare to aid in the diagnosis of orthopedic conditions and illnesses. These CDRs are validated and have high diagnostic accuracy yet previous research has indicated that athletic trainers (ATs) do not implement CDRs in daily clinical practice. **Objective:** To determine the familiarity of CDRs among ATs and also to determine the frequency that ATs apply CDRs with applicable patient cases. **Design:** Cross-sectional descriptive study. **Setting:** Online survey instrument. **Patients or Other Participants:** A total of 3400 ATs were randomly selected to receive a link to the online survey. Responses from 340 ATs (152 males, 188 females; 33.73 ± 9.71 yrs of age; 10.63 ± 8.63 years AT experience) representing all NATA districts and clinical settings were collected (10.0% response rate). **Intervention(s):** An online survey consisting of demographics, Likert scale items investigating familiarity and application of 14 CDRs was developed via Qualtrics. The survey instrument was validated by a panel of experts for content. Reliability of this type of survey is not warranted. Participants received an email with the purpose of the study and a link to the survey; reminder emails were sent at 2 and 4 weeks after the initial email. To improve the response rate, participants were emailed two additional reminders approximately one month later. **Main Outcome Measure(s):** Percentages of ATs familiarity with Ottawa Ankle Rules, Buffalo Modification to Ottawa, Pittsburgh Knee Rules, Ottawa Knee Rules, Canadian C-Spine Rules, Canadian CT Rules, New Orleans Criteria, Walsh Criteria, Wells Score-DVT, Wells Score-Pulmonary Embolism, Upper

Extremity-DVT, NEXUS, NEXUS II, and the Revised Geneva Score were collected. If ATs reported that they were moderately or extremely familiar with a CDR, percentages were collected on how often they implement the CDR with applicable patient cases. Information regarding educational experiences was also gathered. **Results:** The Ottawa Ankle Rules was “extremely” or “moderately” familiar to 60.9% while 39.1% were “not at all familiar”. Of participants who were familiar with the Ottawa Ankle Rules, only 22.6% applied them in “more than 75% of all applicable patient cases” while 13.2% did so in “less than 25% of all applicable patient cases”, and 7.4% never applied the CDR. All other CDRs were “not at all familiar” to at least 73.2% of participants. A majority of participants had never been formally instructed (80.8%) or had continuing education (88.8%) in CPRs. **Conclusions:** ATs are not familiar with the majority of highly validated CDRs that could improve effectiveness and consistency of patient care. Even when ATs are familiar with a CDR they do not commonly apply them in patient care. Future research and initiatives should investigate how to increase use of CDRs and focus on improving AT awareness of these decision making tools.

Familiarity And Use Of Patient-Rated Outcome Measures Among Athletic Trainers

Popp JK, Hankemeier DA, Walker SE: Ball State University, Muncie, IN

Context: Patient-rated outcome measures (PROMs) are questionnaires that inquire about a patient’s health status and contain a wide range of factors, including physical function, symptoms, and social well-being. PROMs enable athletic trainers (AT) to track outcomes associated with therapeutic interventions, as well as ensure they are providing comprehensive patient care based on deficiencies identified by patients. **Objective:** To determine ATs familiarity and usage of PROMs. **Design:** Cross-sectional descriptive study. **Setting:** Online survey. **Patients or Other Participants:** A sample of 3400 ATs was randomly selected to receive a link to the online survey. A total of 246 ATs (115 males, 131 females; 34.11 ± 9.00 yrs of age; 11.15 ± 8.60 years of experience) completed the survey for a response rate of 7.2%. Participants represented each NATA district and clinical setting. **Intervention(s):** The survey, administered by Qualtrics, consisted of demographic and Likert-scale items related to the use and familiarity of PROMs. The survey was validated for content by a panel of experts. Reliability of this type of survey is not warranted. Participants received an email with the purpose of the study and a link to the online instrument. Reminder emails were sent in 2-week intervals over 4 weeks. Two additional reminders were emailed one month later to improve response rate. **Main Outcomes Measures:** ATs familiarity on generic (e.g. Medical Outcomes Study 36-Item Short-Form Health Survey) and specific (e.g. Foot and Ankle Ability Measure) PROMs was identified. When participants reported that they were moderately or extremely familiar with a PROM, frequencies were collected on how often that PROM was implemented with applicable patient

cases. Previous education on PROMs was also gathered. **Results:** 86.6% of ATs indicated that they are extremely/moderately familiar with the Sport Concussion Assessment Tool 2, but only 53.3% of ATs implement this instrument in more than 75% of applicable patient cases. 35.0% of ATs were extremely/moderately familiar with the Lower Extremity Functional Scale, but only 7.3% implement this instrument in more than 75% of applicable patient cases. All generic PROMs were “not at all familiar” to at least 68.3% of ATs surveyed, while all specific PROMs were “not at all familiar” to at least 65.0%. The majority of ATs had not received educational preparation (68.6%) or continuing education (71.5%) related to PROMs. 41.4% indicated that PROMs are used in their workplace, but 71.5% reported that employers do not require the tracking of patient outcomes. **Conclusions:** ATs are not familiar with the majority of PROMs designed to improve patient care. Even when ATs are extremely or moderately familiar with a PROM, they are not consistently utilized to evaluate the effectiveness of an intervention. ATs need continuing education on the benefits of using PROMs, and how PROMs should be incorporated into clinical practice to deliver patient-centered care.

Free Communications, Rapid Fire Poster Presentations: Health and Safety in the Secondary School Setting

Saturday, June 28, 2014, 8:00AM-10:00AM, Room 203/204; Moderator: Rebecca Stearns, PhD, ATC, PES

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Implementing Health And Safety Policy Changes In The High School Setting From A Leadership Perspective

Pagnotta KD, Mazerolle SM, Raso SR, Pitney WA, Casa DJ: University of Connecticut, Storrs, CT, and Northern Illinois University, DeKalb, IL

Context: Every year high school athletes die or are injured while participating in sports. Several policies can be implemented by high school athletic associations (HSAA) to reduce the incidence of sudden death in sport. While these policies may not prevent incidences, they certainly reduce the risk associated with sport. There are consensus statements and recommendations made by professional organizations such as the National Athletic Trainers' Association (NATA), however nothing is mandated, allowing each state the freedom to create, implement and adapt policies, as they deem necessary. An example of a recommended policy is heat acclimatization for the reduction in exertional heat illnesses. Anecdotal evidence suggests variability in implementation of this policy despite its endorsement and impact on reduction of sudden death related to heat stroke.

Objective: Retroactively examine why and how 3 states were able to facilitate the successful creation and adoption of heat acclimatization guidelines. **Design:** Case study design utilizing semi-structured phone interviews. **Setting:** HSAA in Arkansas, Georgia, and New Jersey. **Patients or Other Participants:** A gatekeeper from each state identified members of the HSAA or sports medicine advisory committee (SMAC) who were instrumental in the change process. Seven males, 3 females (n = 10) (5 athletic trainers (ATs), 2 members of HSAA, 2 parents, 1 physician) participated. Participant recruitment ceased when data saturation was reached. **Data Collection and Analysis:** All phone interviews were digitally recorded and transcribed verbatim. A grounded theory approach guided analysis, while

multiple analysts and peer review were used to establish credibility. **Results:** The catalyst to implementing the policy was different for each state (student athlete death, empirical data and proactivity). Once the decision to implement change was made, the states had two similarities: strong professional relationships and open communication between the SMAC and the leadership of the HSAA. Each state's SMAC, which included an AT as a key member, utilized the recommendations from the NATA when developing the state's proposed guidelines. The SMAC then presented the proposed guidelines to the members of the HSAA allowing for open dialogue about the policies. This open communication allowed the policies to be implemented with little resistance. The adoption of the policy by each state reflects the institutional change theory which individuals can help foster change. **Conclusions:** While the initiating factor that spurred the change can vary, professional relationships and communication fundamentally allowed for successful adoption of the policy. SMACs, specifically the ATs, were influenced by the recommendations from national governing bodies, which aligns with the institutional theory on change. As more states begin to examine and improve their current health and safety policies this information could serve as a valuable resource for ATs on SMACs within other states, and future health and safety initiatives.

Sport-Related Emergency Action Plan Creation And Implementation In The Secondary School Setting

Dhesse MF, Pitney WA, Mazerolle SM: Northern Illinois University, DeKalb, IL, and University of Connecticut, Storrs, CT

Context: The NATA position statement for Emergency Action Planning has been in place for over 10 years. The implementation of emergency action plans (EAPs) is a mainstay for various other position statements (eg, preventing sudden death in sports). **Objective:** survey Athletic Trainers (ATs) in order to: 1) examine the extent to which Sport-related EAPs are implemented in secondary schools, 2) identify which recommendations from the NATA position statement is commonly missing, and 3) determine the perceived barriers to implementing EAPs. **Design:** Cross sectional. **Setting:** Secondary school. **Patients or Other Participants:** 954 ATs of which 485 (50.8%) were female and 457 (47.9%) were male (12 (1.3%) undisclosed) aged 36.7 ± 11.2 years with 10.9 ± 9.3 years of experience in the secondary school setting. **Intervention(s):** Data were collected with an online instrument adapted from the NATA position statement on EAPs and was created specifically for this study. The instrument provided participants with categorical response options (yes or no) for whether they had an EAP in place and whether each guideline from the position statement was addressed in the EAP. The instrument also contained an open-ended question related to the barriers for implementing EAPs. The instrument's face and content validity was established with a panel of 6 experts (4 AT practitioners and 2 AT researchers with expertise in survey methods). The survey was distributed to 4,607 ATs with responses from 954, for a 20.7% response rate. **Main Outcome Measure(s):** Descriptive statistics, specifically frequencies and percentages, were calculated to determine

the extent to which EAPs are implemented and whether all components were addressed. An inductive content analysis was used to identify emergent themes from the open ended comments. **Results:** 854 (89.5%) ATs reported having an EAP in place, while 100 (10.5%) indicated not having an EAP in place. Of those with EAPs in place, only 33 (3.9%) had EAPs that addressed all of the position statement guidelines. Of the 12 NATA position statement recommendations for EAPs, the 2 most frequently addressed were having a clear mechanism for communication to emergency care providers and identifying personnel involved with carrying out the emergency plan. The two recommendations most commonly not addressed included having the EAP reviewed by the administration and legal counsel and working with personnel from the emergency care facilities when developing the EAP. The emergent themes pertaining to primary barriers to creating EAPs were: 1) lack of personnel cooperation (both administration and coaches), and 2) facility challenges (multiple facilities, location of facilities). **Conclusion:** Despite the necessity of having an EAP to effectively manage emergency situations, not all secondary schools have implemented these plans. The lack of cooperation between all personnel involved with the organization is concerning and needs to be addressed to prevent sudden death in sport.

The Impact Of Concussion Education On The Knowledge And Perceived Expertise Of Novice Healthcare Professionals

Hunt TN, Harris LL, Way DP: Ohio State University, Columbus, OH

Context: Implementation of concussion legislation mandates healthcare providers have expertise in concussion management to evaluate, care and make return to participation decisions. Unfortunately, the method and determination of expertise for concussion education in healthcare providers is currently ambiguous. **Objective:** This study aimed to 1) determine if an educational intervention would increase knowledge and perceived expertise; 2) examine the correlation between experience and knowledge and perceived expertise in novice healthcare providers (athletic training and medical dietetics students). **Design:** Cohort study. **Setting:** Classroom setting. **Patients or Other Participants:** Novice healthcare providers were divided into two groups: intervention (n=16) athletic training students (ATS) and control (n=19) medical dietetics students (MDS). **Intervention(s):** Both groups took a knowledge questionnaire before the first class of spring quarter (Time 1) and again six months later (Time 3). The intervention group completed a didactic seminar on concussion management and completed the questionnaire at the end of the quarter (Time 2). **Main Outcome Measure(s):** The concussion education questionnaire consisted of questions in three major domains: demographics, knowledge, and perceived expertise scores, with knowledge and expertise serving as main outcome measures. A 2x2 repeated measures ANOVA and two-tailed correlations were calculated to assess specific aims using SPSS 21.0. Significant levels were set a priori at $p > 0.05$. **Results:** 16 ATSs and 19 MDSs were enrolled in the study by completing questionnaires at respective time points. There was a statistically significant group main effect ($F_{(1,33)} = 5.40$; $p =$

0.026; Cohen's $D = .664$) where the ATS knowledge scores declined over time. However, there was not a statistically significant interaction between groups on knowledge scores across time ($p = 0.10$). Statistically significant interactions existed between group and time for both self-efficacy ($F_{(1,33)} = 86.38$; $p < .001$) and experience ($F_{(1,33)} = 14.2$; $p < .001$) with the ATS group demonstrating significant increases in scores over time. There was a statistically significant correlation between the number of concussions evaluated and perceived expertise ($r^2 = 0.630$, $p < .001$). As ATSs evaluated more concussions, they gained experience and reported an improved perceived expertise. **Conclusions:** ATSs and MDSs scored very high on the knowledge pre-test, demonstrating that they knew a lot about concussions before taking the class. This corresponds to mass media attempts to educate the public about the seriousness of concussion. The increase of concussion evaluations (experience) during ATSs clinical time contributed to their perception of expertise. This study found that more discriminating knowledge assessment instruments are needed to differentiate between trained and non-trained healthcare professionals to evaluate knowledge and retention. Educators need to implement the best educational practices possible to maximize knowledge and expertise. While it appears that clinical experience may supersede didactic education, a combination of both will encourage higher level thinking and implementation of knowledge.

The Collaborative Relationship Between Athletic Trainers And School Nurses For Managing Sport-Related Concussion

Minthorn LM, Welch CE, Weber ML, Mayfield RM, Valovich McLeod TC: A.T. Still University, Mesa, AZ, and University of Michigan, Ann Arbor, MI

Context: In the secondary school setting, athletic trainers (AT) and school nurses (SN) are the primary healthcare professionals involved in concussion management. ATs and SNs play a key role in integrating concussed student-athletes back to academia and sports. However, it is unknown how both of these healthcare professionals interact for concussion management. **Objective:** To describe the collaborative relationship between ATs and SNs regarding the management of sport-related concussions in the secondary school setting. **Design:** Cross-sectional design. **Setting:** Self-reported online survey. **Patients or Other Participants:** 851 ATs (25.9% response rate; 308 males, 376 females, 167 missing, age = 37.28 ± 10.13) and 1,119 SNs (14.0% response rate; 6 males, 809 females, 304 missing, age = 52.52 ± 8.37) practicing in the secondary school setting. **Intervention(s):** Participants were solicited via email to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC) survey. The BAKPAC consisted of several multipart questions to assess participants' collaboration with other healthcare providers for the management and care of student-athletes following a concussion in the secondary school. Separate versions of the survey were tailored to ATs (BAKPAC-AT) and SNs (BAKPAC-SN), respectively. **Main Outcome Measure(s):** Descriptive statistics (means, SD, percentages, frequencies) were reported to describe the collaborative relationship between ATs and SNs. **Results:** Only 50% of SNs collaborate with an AT at the secondary school. Of those SNs that collaborate care with an AT, only 21% interact with ATs on a daily basis, with

23% of SNs interacting with ATs 2-3 times per week and 43% only interacting with ATs as needed. Interestingly, 53% of ATs reported they interact with the SN on a daily basis. The most common method of communication between ATs and SNs was email (77%), followed by in-person (69%), phone (56%) and text-messaging (13%). Regarding concussion management, 79% of ATs and 65% of SNs reported they collaboratively manage concussions with the other healthcare provider. While 31% of ATs indicated they are the primary provider of care following a sport-related concussion, 50% indicated they share concussion management with SNs and 11% indicated SNs evaluate the concussed student-athlete during school hours. SNs reported they always (55%) and almost always (10%) refer student-athletes with sport-related concussion to an AT, while 13% reported they never refer to an AT. **Conclusions:** Only half of SNs with an AT at their secondary school have an established professional relationship. These data suggest that ATs and SNs collaborate during concussion management, but the extent and perception of collaboration is varied between healthcare professionals. Our findings highlight the need for improved collaborative efforts between ATs and SNs on concussion management. ATs should reach out to SNs to help foster this relationship, including referral to each other that can ultimately improve patient outcomes following a concussion in secondary school student-athletes.

The Influence Of Athletic Training Experience In The Secondary School Setting On Concussion Management, Referral And Familiarity Of Academic Accommodations

Valovich McLeod TC, Welch CE, Mayfield RM, Weber ML, Parsons JT: A.T. Still University, Mesa, AZ, and University of Michigan, Ann Arbor, MI

Context: Clinical experience can improve the knowledge, skill, and confidence of healthcare providers, including athletic trainers (AT). However experience can also represent a period of deskilling caused by a reliance on dated, habitual practices not informed by contemporary literature. This is especially true for providers in solitary practice, without access to contemporary research, and with limited professional development budgets, such as secondary school ATs. For topics in which the literature rapidly proliferates, such as with concussion assessment and management, experience can be counterproductive to quality patient care. **Objective:** To determine whether secondary school setting experience influences concussion management and referral practices and familiarity with academic accommodations (AA). **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 851 ATs (25.9% response rate) practicing in the secondary school setting (308 males, 376 females, 167 missing, age = 37.28 ± 10.13). **Intervention(s):** Participants were solicited via email to complete the Athletic Trainers' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-AT) survey. The BAKPAC-AT consists of several multipart questions to assess ATs' concussion management, referral patterns, and familiarity with AA. Independent variables included AT secondary school experience (<10yrs, >10yrs). **Main Outcome Measure(s):** The dependent variables were participants' responses to questions about management, referral, and AA. Descriptive statistics reported

overall practices. Relative risk ratios (RR) with confidence intervals (CI) and Mann-Whitney U Tests ($P < .05$) were used to assess differences regarding assessment tool use, collaborative management, and AA between groups. **Results:** Respondents were 361 ATs with < 10 yrs and 323 with > 10 yrs of secondary school experience. ATs who have practiced < 10 years were 4.4% more likely to employ following-up concussion testing ($RR = 1.044$; $CI = 1.00-1.09$; $P = .048$); 21.6% more likely to use graded symptom checklists ($RR = 1.216$; $CI = 1.01-1.46$; $P = .022$); 49.3% more likely to use balance assessments ($RR = 1.439$; $CI = 1.11-1.87$; $P = .003$), and 40.7% more likely to use sideline assessments ($RR = 1.407$; $CI = 1.19-1.66$; $P < .001$) during post-concussion testing compared to the more experienced group. However, ATs with < 10 years are 13.9% less likely ($RR = 1.139$; $CI = 1.00-1.30$; $P = .027$) to collaboratively manage concussions with a school nurse than those that have practiced > 10 years. Respondents with > 10 years experience were “minimally” to “moderately” familiar with IEPs ($2.88 \pm .97$, $P < .001$) and 504 plans ($2.57 \pm .97$, $P < .001$), while respondents < 10 years experience were only “minimally” familiar with IEP ($2.34 \pm .97$) and 504 plans (1.93 ± 1.07). **Conclusions:** ATs with < 10 years of experience are significantly more likely to employ objective follow-up concussion assessment tools; however, these same ATs are less likely to collaborate with school nurses and are less familiar with AA for concussed student-athletes. Overall these findings suggest that ATs with contemporary training in objective concussion assessment tools do employ these tools. However, experience is important for building those collaborative relationships with peer healthcare professionals and understanding the intricacies of concussion management, which includes AA.

Assessing Sex Differences In High School Student Athletes' General Knowledge, Awareness, And Reporting Behaviors Of Concussion

Wallace JS, Covassin T: Michigan State University, East Lansing, MI

Context: Knowledge and understanding of the signs and symptoms of concussion is important in the decision to report a potential concussive injury. High school student athletes that participate while experiencing symptoms are more susceptible to subsequent injury and/or catastrophic brain injury. **Objective:** To identify sex differences in knowledge of concussion by recognizing associated signs and symptoms of concussion, as well as identify why a high school student athlete would or would not report a potential injury. **Design:** Cross-sectional study. **Setting:** Participants completed a survey on paper or online through a link. **Patients or Other Participants:** A total of 188 high school athletes (65 females, 123 males) participating in football, volleyball, boy's and girl's basketball, boy's and girl's soccer, gymnastics, cheerleading, and wrestling (response rate = 47%). **Intervention(s):** A knowledge of concussion survey was developed by certified athletic trainers to determine face/content validity. The survey consisted of 24 questions including concussion history, concussion knowledge, scenario questions, signs and symptoms of a concussion and reasons why an athlete would not report their concussion. The independent variable was sex (male/female). Frequency statistics and independent t-tests were conducted to analyze data. **Main Outcome Measure(s):** We examined the proportion of athletes who correctly identified signs and symptoms of concussion and compared knowledge across sex. Additionally, we examined reasons why high school student athletes would not disclose a potential concussive injury. Statistical significance was set

aprior at $p = .05$. **Results:** Approximately 70% of the athletes self-reported having an understanding of the signs and symptoms of concussion. Again, 70% self-reported understanding the dangers of concussion; however, approximately 30% agreed that it is okay to continue playing their sport after losing consciousness. Scores for correctly identifying the signs and symptoms of concussion were higher in females than males; however, results were not significant. ($M = 16.65 \pm 2.63$, $t(1,186) = -1.67$, $p = .082$). Results indicated that 53.2% of the participants reported not informing anyone of a potential concussion; 71.8% reported not telling anyone because they did not think the injury was serious enough to warrant medical attention, 59.6% did not want to lose playing time, and 53% did not want to let their team down. **Conclusions:** In the past decade, with all the attention given to concussion in the media, we have not seen a change in knowledge and reporting behaviors in high school athletes. The knowledge and underreporting observed in this study was at high schools with athletic trainers, which makes it worrisome as to what high school athletes at schools without an athletic trainer know about concussion and how potential injuries are being reported. Concussion education needs to be a priority for high school athletic programs for student athletes, coaches, parents, and administrators.

Influence Of Demographic Factors And Personal Concussion History On Concussion Knowledge And Attitudes Among Parents Of Youth Athletes

Register-Mihalik JK, Valovich McLeod TC, Marshall SW, Mayfield RM, Linnan LA, Mihalik JP, De Maio VJ, Guskiewicz KM: WakeMed Health & Hospitals, Raleigh, NC; A.T. Still University, Mesa, AZ; University of North Carolina, Chapel Hill, NC; University of Michigan, Ann Arbor, MI

Context: Young athletes' parents are key stakeholders in addressing the concussion problem in sport. **Objective:** To examine demographics associated with concussion knowledge and attitudes among parents of youth athletes. We hypothesized that male parents, older parents, those with a personal concussion history and those with previous concussion education would have higher knowledge and attitude scores. We expected no relationship between parent knowledge and attitudes. **Design:** Cross-sectional survey in North Carolina and Arizona. **Setting:** Classroom. **Patients or Other Participants:** A convenience sample of parents (n=213; age=44.1±6.5 years; 131 females) whose children participated in youth football, boys/girls soccer, boys/girls lacrosse, and/or boys/girls ice hockey (response=100% of meeting attendees). **Intervention(s):** Parents attended a meeting as part of a larger study and completed a pre-validated paper survey (n=213; age=44.1±6.5 years; 131 females). Kappa agreement was 0.6-0.9 for all questions. Criterion variables were sex (female vs. male parents), age (median split: <44 vs. 44+ years), previous concussion education (no vs. yes), geography (North Carolina vs. Arizona), and personal concussion history (no vs. yes). **Main Outcome Measure(s):** Outcomes included knowledge and attitude scores. Knowledge score was the total correct of 28 knowledge questions; Attitude score was the sum of nine, 7-point Likert scale responses (max=63; higher=better attitudes). Two multivariate

regression models (clustered by league) were used to understand the influence of demographics on knowledge and attitudes (mean difference (MD) estimate). A simple correlation was used to examine the knowledge and attitudes relationship (a priori $\alpha=0.05$). **Results:** Knowledge and attitude scores were moderate (knowledge: 23.3 ±2.5; attitudes: 49.4±3.7). Younger parents had slightly better knowledge than older (MD = 0.6; 95% CI: 0.1,1.2; P = .034). There were no significant knowledge differences between females and males (MD = -0.6, 95% CI: -1.8,0.4; P = .273), parents from North Carolina and Arizona (MD = -0.4; 95% CI: -0.3,1.1; P = .219), parents with and without a concussion history (MD = -0.8; 95% CI: -1.9,0.2; P = .123) or, with and without concussion education (MD = -0.6; 95% CI: -1.8,0.6; P = .325). Younger parents had lower attitude scores than older (MD = -1.5; 95% CI: -2.5,-0.6; P = .001) and those without a concussion history had lower attitude scores than those with (MD = -1.2; 95% CI: -2.2,-0.3; P = .010). No significant attitude differences were observed between females and males (MD = -0.6; 95% CI: -1.9,0.6; P = .301), parents with and without concussion education (MD = -0.3; 95% CI: -0.2,1.9; P = .671), or parents from North Carolina and Arizona (MD = 0.6; 95% CI: -0.3,1.6; P = .214). No correlation was observed between knowledge and attitudes ($r=0.134$; P=.091). **Conclusions:** Knowledge and attitudes were moderately low highlighting the need for more directed interventions. Since few demographic factors explained differences in knowledge or attitudes, additional factors such as league policies may also influence these outcomes. The disconnection of knowledge and attitudes clarifies that increasing knowledge alone is unlikely to change behaviors since attitudes are closely linked to behaviors. Athletic Trainers should consider these factors when educating parents about concussion. This study was funded by the National Operating Committee on Standards for Athletic Equipment.

School Nurse Concussion Management: Collaborative Professional Relationships And Concussion Policy Knowledge In The Secondary School Setting

Mummert DK, Welch CE, Weber ML, Kasulke AJ, Parsons JT, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Comprehensive concussion management in secondary schools requires that care be available both during and after school. This is best accomplished by a collaborative, interdisciplinary team composed of athletic trainers (AT), school nurses (SN) and other healthcare providers (HCP) working together on an existing concussion policy. However, little is known about SNs relationships with HCPs and their concussion referral patterns, including those to an AT. **Objective:** To determine SNs' healthcare relationships, referral patterns, and concussion policy knowledge. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 1,119 SNs (14.1% response rate) practicing in the secondary school setting (6 males, 809 females, 304 missing, age = 52.52 ± 8.37). **Intervention(s):** Participants completed the School Nurses' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-SN) survey. The BAKPAC-SN consists of multipart questions to assess SNs' referral practices following sport-related concussion, and relationships with HCPs. **Main Outcome Measure(s):** The dependent variables were participants' responses to the referral and relationship questions. Descriptive statistics reported overall referral practices. Separate forward-stepwise binary logistic regression analyses ($P < .05$) determined whether any personal (SN years experience) or school (enrollment, type, presence of football) factors predicted SNs' relationship with an AT. **Results:** 53.7% of SNs (n = 601) reported their school has a concussion policy, but only 36.2% (n = 405) had

a role in the policy. 10.8% of SNs (n = 121) were unaware if a policy existed and 30% were unaware if their state had a youth sports concussion law. The HCP with which SNs' most frequently had a relationship was ATs (41.6%, n = 466), and the presence of football (P < .001), enrollment (P = .002), and school type (P < .001) were significant predictors of SNs' relationship with ATs. More than half of these respondents (55%, n = 257) indicated they refer 100% of concussion cases ("always") to ATs. Besides ATs, SNs have relationships with speech therapists (29.8%, n = 334), physical therapists (25.2%, n = 282), and occupational therapists (21.8%, n = 244). Only 16.2% reported having a relationship with a sports medicine (16.2%, n = 181) or physical medicine and rehabilitation physician (8.8%, n = 99), and 25% of respondents (n = 280) do not have a relationship with other HCPs. Interestingly, only 7.3% of SNs (n = 81) with a physician relationship "always" (3.5%, n = 39) or "almost always" (3.8%, n = 42) referred concussed patients. **Conclusions:** It is concerning that 11% of SNs were unaware of an existing concussion policy and 30% were unsure whether their state had a concussion law, which could suggest poor policy awareness by SNs, but may also suggest SNs are being overlooked by those responsible for concussion policy. Interestingly, of those who were aware of their school's concussion policy, few indicated they had a role in the policy. Both of these findings highlight the need for improved education of SNs regarding concussion policies and the need for ATs to reach out to SNs to collaborate on concussion care.

The Impact Of Athletic Trainer Employment On School Nurses' Concussion Management Practices For Student-Athletes With Sport-Related Concussions
Weber ML, Welch CE, Parsons JT, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Along with athletic trainers (AT), schools nurses (SN) play an integral role in concussion management at secondary schools. Prior studies have investigated the management practices of ATs, but little is known of SNs' role in concussion management, including which assessment tools are utilized. **Objective:** To determine concussion management practices of secondary school SNs. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 1,119 SNs (14.1% response rate) from a convenience sample of nurses that were currently practicing in the secondary school setting (6 males, 809 females, 304 missing, age = 52.52 ± 8.37). **Intervention(s):** Participants were solicited via email to complete the School Nurses' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-SN) survey. The BAKPAC-SN consisted of several multipart questions to assess SNs' current concussion management practices regarding administration and involvement in baseline and follow-up concussion testing and the assessment tools utilized. The independent variable was the presence or absence of an employed AT. **Main Outcome Measure(s):** The dependent variables were participants' responses to questions regarding concussion management/assessment tool use. Descriptive analyses (mean ± SD, frequencies, percentages) and Mann-Whitney U tests were utilized to determine differences regarding participation roles in baseline and follow-up concussion testing. **Results:** SNs annually manage 10.74 ± 17.32 concussion cases. Significant differences (P < .05) existed between respondents

with an employed AT (n = 571) and those without (n = 434) regarding the administration of, and SN involvement in, both baseline and post-concussion testing. 62% of SNs (n = 354) whose school employs an AT reported the school conducts baseline concussion testing, compared to 18% (n = 78) of SNs whose school does not employ an AT. Regardless of AT employment, only 6.9% (n = 77) of SNs participate in the administration of baseline testing, while 16.8% (n = 188) reported not knowing if baseline testing was conducted. 61.8% of SNs (n = 353) whose schools employ an AT reported post-concussion testing is conducted, compared to 18.4% (n = 80) without an AT. Regardless of AT employment, only 8% (n = 89) of SNs participate in the administration of post-concussion testing. The most common tool utilized for concussion testing was: neurocognitive tests (25.2%, n = 282), sideline assessment (14.5%, n = 162) and graded symptom checklists (11.7%, n = 131). However, 26.5% (n = 297) of SNs reported not knowing which assessment tools were utilized and 17.2% (n = 193) reported baseline and post-concussion testing is not conducted. **Conclusions:** When an AT is employed at the secondary school setting with an SN, baseline and follow-up concussion testing are typically conducted. However, few SNs participate in the administration of the testing. The most frequently used concussion assessment tools included neurocognitive tests (eg, ImPACT). As primary healthcare providers at the secondary school, it is essential for the ATs and SNs to collaborate in concussion management and testing. ATs should utilize SNs to assist with concussion testing at the secondary school.

The Comparison Of Athletic Trainers' And School Nurses' Familiarity And Perceptions Of Academic Accommodations Following Sport-Related Concussion

Kay MC, Welch CE, Weber ML, Mayfield RM, Parsons JT, Valovich McLeod TC: A.T. Still University, Mesa, AZ, and University of Michigan, Ann Arbor, MI

Context: Athletic trainers (AT) and school nurses (SN) are the key healthcare providers in secondary schools. A part of their role involves the collaborative management of sport-related concussions, especially when academic accommodations (AA) are warranted. However, effective collaboration requires that ATs and SNs are similarly informed about AA and its role following sport-related concussion.

Objective: To compare ATs and SNs familiarity and perceptions of 504 plans, individualized education programs (IEP), and each profession's role in AA for student-athletes following sport-related concussion.

Design: Cross-sectional design. **Setting:** Self-reported online survey.

Patients or Other Participants: 851 ATs (25.9% response rate; 308 males, 376 females, 167 missing, age=37.28±10.13) and 1,119 SNs (14.0% response rate; 6 males, 809 females, 304 missing, age = 52.52 ± 8.37) practicing in the secondary school setting. **Intervention(s):** Participants were solicited via email to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC) survey. The BAKPAC consisted of several multipart questions to assess participants' familiarity and perceptions regarding 504 plans, IEPs, and their role in returning student-athletes back into the classroom. Separate versions were tailored to ATs (BAKPAC-AT) and SNs (BAKPAC-SN), respectively. Independent variables included healthcare role (AT vs. SN). **Main Outcome Measure(s):** The dependent variables were participants' responses to the AA

questions. Descriptive statistics (mean ± SD, percentages) were reported. Mann-Whitney U tests ($p < .05$) were used to identify differences. **Results:** On average, ATs manage 16.73 ± 17.65 concussions per year and SNs manage 10.74 ± 17.32 . Both ATs (71.4%) and SNs (55%) have had student-athletes under their care receive AA following a concussion, and have encountered student-athletes with a decline in academic performance due to concussions (AT = 64.5%; SN = 51.7%). SNs were moderately to extremely familiar with 504 plans (3.55 ± 0.72 , $p < .001$) and IEPs (3.55 ± 0.70 , $p < .001$), while ATs were not familiar to minimally familiar with 504 plans (1.81 ± 1.34) and minimally familiar with IEPs (2.11 ± 1.35). SNs agree to strongly agree (3.84 ± 0.55 , $p < .001$) and ATs agree (3.17 ± 1.56) that concussions can affect performance. SNs agree (3.32 ± 0.80 , $p < .001$) that student-athletes with active concussions should be eligible to receive AA, while only 67.6% of ATs agree (2.60 ± 1.40). Only 27% of SNs and 36.2% of ATs indicated their secondary school has an established AA support team. Both SNs (2.98 ± 0.91) and ATs (3.00 ± 1.52) moderately agree that an AT should play a role in the implementation of AA in the secondary school setting. **Conclusions:** While ATs and SNs are not always familiar with their specific role in the AA process, they agree AA are a necessary part of concussion management practices. As the primary healthcare providers in the secondary school, it is vital ATs and SNs understand their individual and collaborative roles to successfully return concussed student-athletes to the classroom. These data suggest that SNs and ATs work together to develop appropriate AA support teams at their schools.

Athletic Directors' Barriers To Hiring Athletic Trainers In Secondary Schools

Raso SR, Mazerolle SM, Pagnotta KD, Casa DJ: University of Connecticut, Storrs, CT

Context: More than 7 million high school students currently participate in organized sports, which result in an estimated 1.4 million sports-related injuries each year. While most athletic related injuries are relatively minor, potentially limb- or life-threatening emergencies can occur. The Inter-Association Task Force for Preventing Sudden Death in Secondary School Athletics: Best Practice Recommendation urges all high schools to have a certified athletic trainer (AT) on staff to take charge of emergency situations and provide care for student-athletes. Despite the recommendation not all high schools employ an AT, however there is limited knowledge regarding barriers to employment of the AT in this practice setting. The recent CATCH-ON study polled public high schools to examine the extent of medical coverage, and reasons why some schools are not utilizing the services of an AT. The study found that 64% of schools have access to an AT. Of those schools that do not employ an AT cost appeared to be the major limiting factor. **Objective:** Gain a better understanding of the barriers regarding hiring ATs in public high school from the Athletic Director perspective (AD). **Design:** Basic qualitative design utilizing semi-structured phone interviews. **Setting:** Full-time ADs in public high schools from multiple regions of the US. **Patients or Other Participants:** Twenty public high school ADs (M = 17, F = 3) divided into geographical regions (North = 6, South = 4, Midwest = 4, West = 6). Seventeen schools reported sponsoring football teams. Data saturation guided the total number of participants. **Data Collection and Analysis:** All participants completed phone interviews guided by a

semi-structured questionnaire. Interviews were audio recorded and transcribed verbatim. Multiple analyst triangulation, field notes, and peer review were included as steps to establish data credibility. The data was analyzed using the principles of general inductive approach. **Results:** The emergent themes included decision making, budget and non-budget issues. Decision-making represented the lack of power of an AD to hire an AT; a responsibility that was perceived to fall on the superintendent and school board. Budget issues pertained to the funding allocated to specific resources within a school, which often did not include an AT. Non-budget issues incorporated rural locations without clinics or hospitals nearby, misconceptions of the roll of an AT which leads to the belief that first aid trained coaches are appropriate medical providers, and community support from local clinics, hospitals and volunteers. **Conclusions:** Many ADs understand the role and importance of the AT. While there are many reasons schools may have difficulty employing an AT, it seems that the hiring and budgeting decisions are controlled by superintendents and school boards. With this in mind, it may be necessary to create informational programs targeted to administration with the correct level of organizational power within school districts.

Free Communications, Thematic Poster Presentations: Injury Prevention

Saturday, June 28, 2014, 10:30AM-12:00PM, Room 203/204; Moderator: Christopher Kuenze, PhD, ATC
14379MOIN 14383OONE

Risk Factors Of Anterior Cruciate Ligament Injury: A Meta-Analysis

McCullough MM, Gabler CM, Howard JS, Medina McKeon JM: University of Kentucky, Lexington, KY, and Ithaca College, Ithaca, NY

Context: Risk factors associated with anterior cruciate ligament (ACL) injury have been investigated at length; however, few studies prospectively assess risk factors prior to an actual ACL injury. **Objective:** To systematically review and synthesize the literature to determine the extent to which modifiable risk factors are directly linked to ACL injury. **Data Sources:** PubMed (1984-March 2013); CINAHL (1984-March 2013), MEDLINE (1984-March 2013), and SPORTDiscus (1984-April 2013); and Web of Science (1994-April 2013). Keywords were “anterior cruciate ligament” and “risk factor”. **Study Selection:** Criteria for inclusion were: (1) prospective, (2) evaluated risk factors of ACL injury regarding body composition or neuromuscular/biomechanical function, and (3) provided means and standard deviations for injured and non-injured cases. **Data Extraction:** Methodological quality was assessed with the modified Downs and Black (mD&B) scale. Three primary categories of modifiable risk factors were identified: (1) body mass index (BMI), (2) biomechanical alterations (BIOMECHANICAL), and (3) muscle function surrounding the knee (MUSCLE). Variables included in BIOMECHANICAL were related to hip or knee flexion angles, landing errors, and knee abduction moment during landing or cutting. Variables included in MUSCLE were strength, preactivity, force, or power for the quadriceps or hamstrings. Means and standard deviations for these variable categories were extracted. The quality of evidence was assessed using the Centre for Evidence-Based Medicine (CEBM)–Levels of Evidence. Bias-corrected Hedges g was used to calculate the effect size (ES) for each variable within each category. A separate random-effects meta-analysis was performed on each

category to calculate weighted effect [95% CI]. **Data Synthesis:** Inclusion criteria were met by 7 studies; 20 separate data points in these studies were analyzed. The mean mD&B was 16.1 out of 27 (range 13-19). For the CEBM, 2 studies were classified as Level 3 evidence, 5 were classified as level 2. The overall summary effect for all included data points was moderate (ES = 0.58 [0.33,0.81], $p < 0.001$) demonstrating more risk factor-related deficits for individuals subsequently injured compared to those who were not. Individually, all 3 meta-analyses also demonstrated similar risk increases. For BMI, 3 study points were included for a strong effect (ES = 0.87 [0.54,1.21], $p < 0.001$). For BIOMECHANICAL, 6 study points were included for a strong effect (ES = 0.70 [0.18, 1.22], $p = 0.008$). For MUSCLE, 8 study points were included for a weak effect (ES = 0.31 [0.06, 0.56], $p = 0.02$). **Conclusions:** Prospective studies are able to provide a direct cause and effect relationship between a risk factor and ACL injury. While ACL risk factors are heavily investigated, there are very few studies that provide that direct link. Even commonly accepted ACL risk factors such as knee flexion and abduction have not been evaluated in more than two studies meeting inclusion criteria. By summarizing those factors that have been prospectively investigated, we present three distinct categories of validated risk factors for further investigation.

Prophylactic Effectiveness Of Preventive Neuromuscular Training On Anterior Cruciate Ligament Injury Reduction By Exercise: Sub-Group Analyses

Sugimoto D, Myer GD, Barber Foss KD, Hewett TE: Cincinnati Children's Hospital Medical Center, Cincinnati, OH; The Micheli Center for Sports Injury Prevention, Waltham, MA; Boston Children's Hospital, Boston, MA; Ohio State University, Sports Health & Performance Institute, Columbus, OH

Context: Consistent increases in the prevalence of anterior cruciate ligament (ACL) injuries and their associated long-term physical impact have resulted in the development and use of neuromuscular training (NMT) as a prophylactic intervention for female athletes. Recent meta-analysis reports demonstrate that NMT effectively reduces ACL injury in female athletic population. However, among reviewed studies, disparity of ACL injury reduction was observed, which may stem from the types of exercises implemented in the NMT. **Objective:** To systematically review and synthesize previously published studies to evaluate the type of exercises that enhance prophylactic effectiveness of NMT on ACL injury reduction in female athletes. **Data Sources:** A computerized search was performed using PubMed, CINAHL, MEDLINE, SPORTDiscus, (1995-2012) in May, 2012. Key words were “anterior cruciate ligament”, “ACL”, “prospective”, “neuromuscular”, “training”, “female”, and “prevention”. Abstracts and unpublished data were excluded. **Study Selection:** Criteria for inclusion required: 1) a prospective controlled design, 2) females included as participants, 3) NMT focused on injury reduction utilized as an intervention, 4) specific exercise types documented, and 5) number of ACL injury reported. **Data Extraction:** Study quality was assessed with the PEDro scale. Extracted data included number of ACL injuries and number of subjects in the NMT intervention and control

groups. The extracted data were further classified by specific types of exercise employed in order to perform a series of sub-group analyses to delineate the potential effects of types of exercise to the prophylactic effectiveness of NMT. Odds ratios(OR) were used to compare the ratios of ACL injuries between intervention and control groups using either balance, plyometric, strengthening and proximal control exercises. The quality of evidence was assessed using the Strength of Recommendation Taxonomy (SORT) – Levels of Evidence scale. **Data Synthesis:** Fourteen studies met inclusion and yielded average PEDro score of 4.8/10 (range: 2 to 7). Results are presented as OR [95% Confidence Intervals]. The sub-group analyses demonstrated greater ACL injury reduction in NMT that included plyometric(OR 0.39: [0.29,0.57]) strengthening(OR 0.32: [0.23,0.46]), and proximal control(OR 0.33: [0.23, 0.47]) exercises compared to NMT that did not include those three exercise components. Inclusion of balance exercises did not show greater ACL injury reduction. However, NMT with a combination of balance exercises and other exercise modalities(OR 0.32: [0.22, 0.46]) demonstrated significant ACL injury reduction compared with NMT with balance training alone(OR 1.15: [0.70, 1.89]). The SORT scale reached evidence level A. **Conclusions:** The prophylactic effectiveness of NMT on ACL injury reduction differed based on prescribed types of exercises. The current analysis indicates that plyometric, strengthening, and proximal control exercises in NMT, and balance in conjunction with these other exercise components to reduce ACL injury risk in female athletes.

Reduction Of Ground Reaction Forces After A Lower Extremity Injury Prevention Program

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

Context: Lower extremity injury prevention programs can reduce injury rates and improve landing technique. Limited knowledge exists about the effectiveness of these programs in military populations. Furthermore, it is unknown how long protective effects remain after a program completion. **Objective:** To evaluate the effects of a lower extremity injury prevention program on vertical ground reaction forces (VGRF) over time in a military setting. **Design:** Cluster-randomized controlled trial with a time-series panel. **Setting:** United States service academy. **Patients or Other Participants:** The population for this study was 1104 cadets (17-23 years old) entering a service academy. **Intervention(s):** Participants were cluster-randomized by military company (n = 8 companies) to either the Dynamic Integrated Movement Enhancement (DIME) injury prevention program or an active control group that performed the Army's Preparation Drill (PD). Both programs were performed 3-4 times per week for 10 minutes prior to physical training during a 6-week period. Both programs consisted of flexibility, strengthening, agility, and plyometric exercises; however, the DIME program placed additional emphasis on balance exercises and proper movement control. A random subsample of participants (n~150) completed three trials of a jump-landing task at each time point: immediately before the intervention period (PRE), immediately after (POST), and two (R1), four (R2), six (R3), and

eight months (R4) following completion of the intervention period. The jump-landing task required participants to jump forward from a 30-cm high box a distance of half their height, land with their right foot on a force plate, and jump for maximal height immediately upon landing. **Main Outcome Measure(s):** Peak VGRF (PVGRF) data were collected from a non-conductive force plate with a sampling frequency of 1000 Hz during the jump-landing task. The average PVGRF was normalized to body weight (%BW). We used a generalized linear model with generalized estimating equations to compare the PVGRF between groups (DIME, PD) and time (PRE, POST, R1, R2, R3, R4)($\alpha \leq 0.05$). **Results:** A significant interaction was observed (P = 0.003). PVGRF for the DIME group was significantly lower at R1 ($2.73 \pm 0.91\%$ BW), R2 ($2.89 \pm 0.64\%$ BW), and R3 ($2.82 \pm 0.83\%$ BW) compared with PRE ($3.42 \pm 1.17\%$ BW), POST ($3.50 \pm 0.89\%$ BW), and R4 ($3.40 \pm 1.11\%$ BW). PVGRF of the DIME group was lower than the PD group at R1, R2, and R3 (R1: $3.01 \pm 0.83\%$ BW, R2: $3.00 \pm 0.98\%$ BW, R3: $3.12 \pm 0.96\%$ BW). Neither group reduced PVGRF between PRE and POST (P > 0.05). **Conclusions:** Immediate reductions in PVGRF were not observed, but decreases were observed in the intervention group at 2, 4, and 6 months following intervention. These improvements in landing force attenuation remained until 9 months following the injury prevention program. The lack of improvement at the post intervention assessment was likely due to fatigue, which also corresponded with the end of basic training.

14F12MOBI

An Injury Prevention Program Warm-Up Acutely Improves Landing Technique And Sport Performance In Youth Athletes

Root HJ, Martinez JC, Casa DJ, Kraemer WJ, Trojian TH, DiStefano LJ: University of Connecticut, Storrs, CT

Context: Injury prevention programs (IPP) performed as a warm-up over the course of an athletic season improve injury rates, performance outcomes and jump-landing technique. Issues with program adoption exist. Identifying acute benefits of utilizing an IPP compared to other warm-ups may encourage IPP compliance. **Objective:** To examine immediate effects of three warm-up protocols (injury prevention program (IPP), dynamic warm-up (DWU), static warm-up (SWU)) on performance measures and jump-landing technique in youth athletes. **Design:** Randomized-controlled trial. **Setting:** School gymnasiums. **Patients or Other Participants:** Sixty male and 29 female youth athletes (age = 13 ± 2 yrs, height = 161.79 ± 12.60 cm, mass = 37.06 ± 13.50 kg) volunteered to participate in a single test session. **Intervention(s):** Participants were stratified by sex, age, and sport, then randomized into one protocol (IPP, DWU, SWU). The SWU included a 5-minute jog before 5 minutes of lower extremity (adductor, quadriceps, hamstring, and gastrocnemius-soleus) static stretching. The DWU consisted of 10-minutes of dynamic flexibility exercises targeting the lower extremity. The IPP was a 10-minute warm-up with dynamic flexibility, strengthening, plyometric, and balance exercises. Proper technique was stressed throughout the IPP. Participants were assessed for landing technique and performance measures immediately before (PRE) and after (POST) completing their warm-up. **Main Outcome Measure(s):** Participants performed a vertical jump (VJ), long jump (LJ), shuttle run (SR), and jump-landing task in a randomized order. VJ involved two trials of a full countermovement

standing jump task using a Vertec (Sports Imports, Columbus, OH). Participants performed two trials of a standing LJ where a single grader measured horizontal distance using a tape measure. Two trials of the SR were performed, where one trial equaled four consecutive 30-m sprints. SR time was recorded using TC-Speed Trap II Wireless Timing Gates (Gill Athletics, Champaign, IL). Three trials of a jump-landing task were videotaped with a digital video camera from the front and side. Participants jumped from a 30-cm box a distance of half his/her body height then rebounded vertically for maximal height. A single rater blinded to group assignment graded each jump using the Landing Error Scoring System (LESS), a valid/reliable clinical screening tool that evaluates the number of landing errors. The average of all trials was used to calculate change scores (post-pre) for all outcome measures. Separate one-way between-subjects (Group: IPP, DWU, SWU) analysis of variance tests were performed for each dependent variable ($\alpha < 0.05$). Separation of confidence intervals was used to evaluate any significant group differences. **Results:** LESS score significantly improved after IPP (change score \pm SD: -0.55 ± 1.25 errors) compared with DWU (0.16 ± 1.33 errors) and SWU (0.51 ± 1.39 errors) ($P = 0.01$). No other differences were observed ($P > 0.05$). **Conclusions:** An injury prevention program used as a team warm-up can improve jump-landing technique after a single session and is equally effective as a DWU or SWU in preparing an athlete for participation.

14288MONE

Associations Between Changes In Quadriceps Cortical Excitability And Sagittal Plane Jump-Landing Biomechanics Following A Four-Week Feedback Intervention

Lefevre CE, Luc BA, Ericksen HM, Thomas AC, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Jump-landing feedback is commonly conducted to teach participants to land in a manner that would theoretically decrease loading of joint structures and potentially prevent injury. Making alterations in jump-landing movement patterns likely requires neurological changes in the primary motor and motor association cortices of the cerebrum. It remains unknown if biomechanical changes from feedback interventions are associated with changes in excitability of the motor cortex. **Objective:** Determine associations between sagittal plane knee kinematics and kinetics and changes in corticospinal excitability of the quadriceps following a four-week jump-landing feedback intervention. **Design:** Descriptive observational study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four healthy females (19.96 ± 1.54 yrs, 158.50 ± 13.10 cm, 58.34 ± 7.77 kg). **Intervention(s):** The feedback intervention consisted of 12 sessions over 4-weeks, in which the participants were provided verbal and visual feedback for the purpose of altering jump-landing biomechanics. One of the specific feedback components was to land with increased bending in the knees and hips. **Main Outcome Measure(s):** Knee biomechanics were assessed during jump-landing using a three-dimensional motion capture system with integrated force plates. Participants performed three jump landings off a 30cm box placed at 50% of the participant's height away from the force plate. Upon landing, participants immediately

rebounded for maximum height. Peak knee flexion angles and internal knee extension moments were determined during the first 25% of stance phase using a standard inverse dynamics approach and were averaged across the three trials. Vastus lateralis corticospinal excitability was assessed with active motor thresholds (AMT) via Transcranial Magnetic Stimulation (TMS). Expressed as a percentage of total TMS output, AMT was determined as the lowest TMS intensity able to elicit a measurable motor evoked potential ($\geq 100\mu\text{V}$) in 5/10 consecutive trials. Pre-post intervention percent change scores were calculated for each variable and used for analysis. Pearson product moment correlations were used to determine the associations between changes in peak knee flexion angles and knee extension moments and changes in AMT over the 4-week intervention. **Results:** Changes in peak knee flexion angle significantly and negatively correlated with changes in AMT ($r = -0.642$, $P = 0.001$), while peak knee extension moment significantly correlated with changes in AMT ($r = 0.436$, $P = 0.033$). **Conclusions:** Following a four-week feedback intervention, greater increases in corticospinal excitability (as measured by lower AMT values) were associated with greater increases in knee flexion angles and decreases in the knee extension moments during jump landing. The current study provides evidence that alterations in corticospinal pathways may help to influence changes in movement strategies. Given the present association between changes in corticospinal excitability and jump-landing biomechanics, it seems that feedback is a clinically useful means of improving corticospinal excitability. Changing corticospinal excitability may be the driving mechanism behind feedback related changes in movement.

Jump Landing Feedback Decreases Vertical Ground Reaction Forces Without Negatively Affecting Vertical Jump Performance

Luc BA, Lefevre CE, Ericksen HM, Thomas AC, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Jump-landing feedback interventions aimed at altering kinetics to decrease injury risk have demonstrated success in decreasing vertical ground reaction forces (vGRF) during jump-landing. Lowering vGRF during jump-landing has generally been hypothesized to be a beneficial adaptation for the protection of lower-extremity structures. It remains unknown if prolonged training to decrease vGRF during jump-landing will negatively affect performance in power related activities. **Objective:** Determine if there is a change in vGRF during jump-landing and vertical jump height following a four-week jump-landing feedback intervention aimed at improving lower extremity biomechanics. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Forty-one females with no history of lower extremity injury were randomized into two groups including: 1) feedback ($n = 26$; $20.0 \pm 1.5\text{yrs}$; $158.1 \pm 13.0\text{cm}$; $58.5 \pm 7.6\text{kg}$), and 2) control ($n = 15$; $19.5 \pm 1.7\text{yrs}$; $158.8 \pm 11.4\text{cm}$; $60.2 \pm 8.5\text{kg}$). Randomization was weighted in favor of the feedback group. **Intervention(s):** Jump-landing feedback consisted of 12 supervised sessions over a 4-week period where each participant performed six sets of six jumps. After each set of jumps, participants completed self-analysis feedback and received expert provided feedback, consisting of visual and verbal cues on proper landing techniques, specifically to “land softly and evenly on both feet”. Control participants attended two testing sessions separated by

four weeks. **Main Outcome Measure(s):** vGrf was evaluated as participants performed 3 jump landings off a 30cm box, 50% of their height away from the target force plates, and immediately rebounded for maximum height. Three maximum vertical jumps were also performed at baseline and 4-weeks later. Maximum vertical jump height was determined by subtracting the standing reach height from the largest jump height measured with a Vertec Vertical Jump Measuring Device. Peak vGRF during the first 25% of stance was determined using a standard inverse dynamics approach and averaged over 3 trials. Separate, 2x2 (group x time) repeated measures ANOVAs were used to determine differences between groups over time. In the presence of a significant interaction, post hoc independent and dependent t-tests were used to determine between and within group effects, respectively. Alpha level was set a priori at $P \leq 0.05$. **Results:** There was a significant group by time interaction for vGRF ($F_{1, 39} = 28.52$, $P < 0.001$). The feedback group (Pre: 1.95 ± 0.45 , Post: 1.42 ± 0.36) demonstrated a decrease in peak vGRF following the 4-week feedback intervention compared to the control (Pre: 1.77 ± 0.32 , Post: 1.77 ± 0.36 , $P = 0.005$). No differences in vertical jump height were found between groups or over time (Feedback Pre: 13.9 ± 3.7 , Post: 14.6 ± 3.1 ; Control Pre: 13.2 ± 3.9 , Post: 14.1 ± 2.1). **Conclusions:** The 4-week feedback intervention was successful in decreasing landing forces and did not adversely affect vertical jump height performance. These data provide evidence that interventions that seek to lower injury risk by decreasing jump-landing vGRF will not adversely affect power related tasks linked to performance.

Self-Analysis Does Not Agree With Expert-Provided Feedback During An Intervention To Improve Jump-Landing Biomechanics

Dykyj CJ, Borden EC, LeVan TR, Ericksen HM, Pietrosimone BG, Thomas AC: University of Toledo, Toledo, OH, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Feedback interventions may successfully improve jump-landing biomechanics to reduce non-contact anterior cruciate ligament (ACL) injury risk. Varying modes of feedback delivery have shown success in changing landing biomechanics. Many interventions rely on trained clinicians or teammates to provide athletes feedback regarding their movement biomechanics. However, it remains unknown if individuals are able to self-analyze their own biomechanics and whether or not this analysis matches up with what an expert observes. **Objective:** To determine the agreement between self-analysis and expert-provided feedback following six feedback intervention sessions. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-seven recreationally active females with no history of lower extremity injury (age: 20.07 ± 7.81 years; height: 163.8 ± 0.08 cm; mass: 57.94 ± 7.81 kg) volunteered. **Intervention(s):** For each intervention session, participants completed six sets of 6 jump-landing trials off a 30cm box. Participants were provided a brief PowerPoint prior to the intervention that contained verbal and visual cues instructing them to land: 1) symmetrically; 2) with a neutral knee valgus/varus position; 3) with feet shoulder-width apart; 4) on your toes rocking back to your heels; 5) with increased knee and hip flexion; and 6) softly. A single investigator observed all jump-landing trials and provided expert feedback following each set of jumps. **Main Outcome Measure(s):** The participant and the investigator separately evaluated

landing performance. Participants were asked to indicate which of the six landing instructions they accomplished following each set of jumps by indicating “yes” or “no”. The investigator then provided expert feedback, indicating which of the 6 criteria the participant failed to meet and, therefore, which criteria she should focus on for the next set. Agreement between the participant and investigator following the first set of jump-landings was assessed using Cohen’s unweighted kappa with an a priori alpha level ≤ 0.05 . Levels of agreement were classified as almost perfect (k 0.81-1.00), substantial (k 0.61-0.80), moderate (k 0.41-0.60), fair (k 0.21-0.40), slight (k 0.0-0.20) and poor ($k < 0$). **Results:** Self-analysis demonstrated moderate agreement with expert provided feedback for criterion 1: landing symmetrically ($k = 0.43$, $P = 0.024$) and fair agreement for criterion 2: landing with a neutral knee ($k = 0.39$, $P = 0.040$). Self-analysis yielded poor agreement with expert-provided feedback for all other criteria ($k < 0.2$, $P > 0.05$). **Conclusion:** This investigation demonstrates that individuals do not accurately perceive their own biomechanical errors during jump-landing. These findings highlight the need for expert observers to provide feedback during jump-landing to improve biomechanics. Future research should investigate the optimal mode of feedback to produce lasting changes and reduce non-contact ACL injury risk.

Feedback Learned During A Jump-Landing Task Is Transferrable To A Cutting Task

Young LJ, Ericksen HM, Thomas AC, Gribble PA, Pietrosimone BG: University of Toledo, Toledo, OH, and University of North Carolina, Chapel Hill, NC

Context: Lower extremity joint injuries are common in sports. Feedback interventions administered during a jump-landing task may improve lower extremity kinetics and kinematics. Yet, it remains unknown whether these alterations can be transferred to a different task, such as an anticipated cutting maneuver. **Objective:** Determine the effect of a 4-week jump-landing feedback intervention on hip and knee flexion and knee abduction angles and peak vertical ground reaction force (vGRF) during jump-landing and anticipated cutting maneuvers. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Forty-one females with no history of lower extremity injury were randomized into two groups: feedback ($n = 26$; 20.0 ± 1.5 yrs; 1.63 ± 0.08 m; 58.34 ± 7.68 kg) and control ($n = 15$; 19.5 ± 1.7 yrs; 1.64 ± 0.06 m; 60.08 ± 8.41 kg). Randomization was weighted in favor of feedback. **Intervention(s):** Jump-landing feedback consisted of 3 sessions per week for 4-weeks during which feedback participants performed six sets of six jumps. After each set of jumps, participants completed self-analysis feedback and received expert provided feedback, consisting of visual and verbal cues on proper landing technique. Control participants attended two separate testing sessions 4 weeks apart. **Main Outcome Measure(s):** A 3-dimensional motion capture system with integrated force plates was used to collect biomechanics at baseline and 4-week time points during two tasks: 1) jump-landings from a 30 cm box set 50% of the subject’s height away from the target force plates and 2) anticipated cutting maneuvers with a 60° change of direction over a target force plate a

speed between 3.0-4.0m/s. Peak vGRF was averaged across trials and used for analysis. Hip and knee flexion and knee abduction angles were obtained at peak vGRF and averaged over 3 trials. Change scores were calculated (post-intervention minus baseline) and independent samples t-tests were used to evaluate differences between groups. **Results:** Feedback significantly increased hip flexion angle (feedback: $9.5 \pm 8.5^\circ$, control: $-1.8 \pm 10.8^\circ$, $t_{39} = 3.74$, $P = 0.001$), knee flexion angle (feedback: $-10.2 \pm 12.8^\circ$, control: $3.4 \pm 17.6^\circ$, $t_{39} = -2.86$, $P = 0.007$), and vGRF (feedback: $-0.47 \pm 0.4\text{N/kg}$, control: $-0.09 \pm 0.5\text{N/kg}$, $t_{39} = -2.63$, $P = 0.012$) during jump-landing. No significant changes were observed for knee abduction angle ($P = 0.107$) during jump-landing. Knee flexion angle was significantly greater in the feedback ($-1.2 \pm 5.4^\circ$) than the control group ($-1.5 \pm 3.1^\circ$, $t_{39} = -2.28$, $P = 0.028$) during cutting. No significant changes between groups were seen in hip flexion ($P = 0.876$) and knee abduction angles ($P = 0.670$) or peak vGRF ($P = 0.393$) for the cutting task. **Conclusions:** Following the 4-week feedback intervention, the feedback group demonstrated changes in sagittal plane biomechanics during the jump-landing task. The feedback group also demonstrated an increase in knee flexion angle during the cutting task. This novel finding suggests that learned biomechanics may be transferrable from one task to another. Future studies should investigate implementation of feedback into a more clinical setting to ensure improvements in biomechanics are realized during athletic activity. Funded by the National Athletic Trainers' Associated Research and Education Foundation.

Free Communications, Thematic Poster Presentations: Lower Extremity Clinical Interventions

Saturday, June 28, 2014, 12:30PM-2:00PM, Room 203/204; Moderator: Hayley Root, MS, ATC
14310MOTÉ 14346SOTÉ

Comparison Of Three Rehabilitation Programs For Chronic Ankle Instability On Center Of Pressure Distribution And Self-Reported Function

Miner K, Donovan L, Sauer L, Saliba S, Hertel J: University of Virginia, Charlottesville, VA

Context: Individuals with chronic ankle instability (CAI) have been shown to have a more posterolateral orientation of their center of pressure (COP) during single limb balance compared to healthy controls. Short foot exercises (SFE) have been incorporated into rehabilitation programs to further improve postural control by causing a shift in COP to the medial aspect of the foot. **Objective:** To determine whether SFE have an effect on COP location and self-reported function in participants with CAI compared to a control group, a home balance program (HBP) and a traditional ankle rehabilitation program (TRP). **Design:** Randomized controlled clinical trial. **Setting:** Laboratory and participant's homes. **Patients or Other Participants:** Forty-nine adults with CAI (height = 173 ± 10 cm, mass = 72 ± 13 kg, age = 22 ± 4 years, 28 males, 21 females) participated. There were no significant differences in demographics between groups. **Intervention(s):** Participants completed baseline self-reported function questionnaires (Foot and Ankle Ability Measure (FAAM) ADL and Sport) and baseline balance measures using a force plate. For the balance trials, participants completed three ten second eyes-open trials and three ten second eyes-closed trials on their involved limb. Participants were randomized into four groups (Control n = 11, HBP n = 12, TRP n = 12, SFE n = 14). The TRP consisted of ankle strengthening, range of motion, and balance exercises. Participants in the SFE group completed the same exercises as the TRP group, but also incorporated a progressive SFE program. The HBP group was instructed to balance on their injured leg anytime they brushed their

teeth. Participants in the control group were asked to maintain their current daily activities. After 4-weeks, each participant repeated the data collection procedures. **Main Outcome Measure(s):** Self-reported function was measured using the FAAM-ADL and FAAM-Sport. COP data was recorded for 10 seconds at a frequency of 50 Hertz, creating 500 COP data points for each trial. The proportion of total COP data points in 4 quadrants (anteromedial, anterolateral, posteromedial, posterolateral) of the foot was analyzed. Each dependent variable was compared using a 4x2 group by time mixed model ANOVA and post-hoc t-tests if appropriate. The level of significance was set a priori at $P \leq 0.05$. **Results:** There was a statistically significant time by group interaction for the FAAM-ADL ($P = 0.006$) and FAAM-Sport ($P = 0.001$). The SFE group ($95.93 \pm 3.01\%$) had higher post-treatment FAAM-ADL scores when compared to the control ($91.43 \pm 5.66\%$; $P = 0.019$) and HBP ($91.66 \pm 5.31\%$; $P = 0.022$) groups. In addition, the SFE ($88.33 \pm 8.56\%$) had higher post-treatment FAAM-Sport scores when compared to the HBP ($78.14 \pm 10.49\%$; $P = 0.008$) and TRP ($79.75 \pm 12.66\%$; $P = 0.022$) groups. There were no significant group by time interactions or main effects for any of the COP quadrant measures. **Conclusions:** A supervised ankle rehabilitation program that was augmented with SFE caused greater improvements in self-reported function than both supervised and home exercise programs that did not incorporate SFE.

Chronic Stretching During Two Weeks Of Immobilization Decreases Loss Of Girth, Strength, And Dorsiflexion ROM

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Context: Chronic stretching is proposed to improve muscle performance. During immobilization, there is an extensive loss in muscle strength, muscle size, and joint ROM. Chronic static stretching during immobilization, may maintain muscle strength, muscle size, and dorsiflexion ROM. **Objective:** To investigate the effects of chronic static stretching on plantarflexor strength, calf girth, and dorsiflexion ROM after two weeks of immobilization. Our hypothesis is that two weeks of static stretching during immobilization of the plantarflexor muscles will decrease in the loss of strength, girth and ROM. **Design:** Randomized controlled clinical trial. **Setting:** Athletic training room. **Patients or Other Participants:** Thirty-two female college aged (19.81 ± 2.48 yrs) students volunteered for the study (height = 164.15 ± 5.62 cm, mass = 64.76 ± 11.93 kg). Participants were excluded if they had a history of lower leg injuries or if they had lower extremity surgery in the past year. **Intervention(s):** Participants were randomly placed into one of three groups; control group (CG), experimental group (EG), and experimental stretching group (ESG). The EG and ESG wore the Walker (Aircast FP Walker, DJO Inc, Vista, CA) for two weeks on the left leg. During this time, the ESG participated in a stretching program, which consisted of two 10-minute stretching procedures each day for the 14 days. The intraclass correlation coefficient for the pre-post left leg calf girth, calf strength, and dorsiflexion ROM were .992, .803, and .812 respectively. **Main Outcome**

Measure(s): Each group participated in a familiarization period, a pre-test, and, two weeks later, a post-test. Measurements taken were ROM (goniometer), calf strength (Cybex II Isokinetic Dynamometer), and Girth (Gulick spring-loaded handle attachment). Three ANCOVA's were used to determine differences in girth, strength, and dorsiflexion ROM between groups with an α level of <0.05 . **Results:** Significant linear relationships between pre and post-test were found with girth ($F_{1,31} = 1158.3$, $P < 0.0001$), dorsiflexion ROM ($F_{1,31} = 89.02$, $P < 0.0001$), and strength ($F_{1,31} = 42.10$, $P < 0.0001$). Significant differences were found between groups for post-test measures of girth ($F_{2,31} = 6.50$, $P = 0.0048$), dorsiflexion ROM ($F_{2,31} = 29.06$, $P < 0.0001$), and strength ($F_{2,31} = 6.74$, $P = 0.0041$). Post hoc analysis showed that CG ultimately maintained girth, dorsiflexion ROM, and strength. Post hoc testing also showed that the EG lost more girth than the ESG, the EG decreased dorsiflexion ROM and the ESG increased in dorsiflexion ROM, and the EG decreased strength and the ESG increased in strength. **Conclusions:** Chronic static stretching during two weeks of immobilization can decrease the loss of calf girth, calf strength, and dorsiflexion in the ankle.

Effects Of A Simple Home-Based Balance Program On Patients With Chronic Ankle Instability

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Context: Home balance training programs have been shown to be effective in improving self-reported function and improving balance measures in patients with chronic ankle instability (CAI). One simple home program that is often prescribed to patients with CAI has them balance on their injured limb anytime they brush their teeth. However, there is little evidence to suggest whether this program reaches optimal training levels to improve balance and self-reported function. **Objective:** To investigate the effects of a simple home balance training program (HBP) on postural control and self-reported function in patients with CAI. **Design:** Randomized controlled trial. **Setting:** Research laboratory and participants' homes. **Patients or Other Participants:** Twenty-three young adults with CAI (height = 173 ± 10 cm, mass = 71 ± 11 kg, age = 21 ± 4 years, 11 males, 12 females) participated. There were no differences in demographics between groups. **Intervention(s):** Participants completed baseline self-reported function questionnaires (Foot and Ankle Ability Measure (FAAM) ADL and Sport). Postural control was measured using single limb balance tests on a force plate. For the balance trials, participants completed three 10 second eyes-open trials and three 10 second eyes-closed trials on their involved limb. Participants were randomized into two groups (HBP $n=12$, control $n=11$). The HBP group was instructed to balance on their injured leg anytime they brushed their teeth. Participants in the control group were asked to maintain their current daily activities. After 4-weeks, each participant repeated previous data collection procedures. **Main Outcome Measure(s):** Self-reported function was measured using the FAAM-ADL and FAAM-Sport.

Postural control was measured by using time-to-boundary (TTB) absolute minima, TTB mean minima, and TTB standard deviation in the medial-lateral and anterior-posterior directions in both eyes-opened and eyes-closed balance conditions. Each dependent variable was compared using a 2x2 group by time mixed model ANOVA and post-hoc t-tests if appropriate. The level of significance was set a priori at $P \leq 0.05$. **Results:** There was a significant time main effect indicating both the control (FAAM-ADL Pre: 89.4 ± 5.8 , Post: 91.43 ± 5.7 $P = 0.03$; FAAM-Sport Pre: 73.74 ± 7.7 , Post: 82.96 ± 7.6 $P = 0.006$) and treatment groups (FAAM-ADL Pre: 87.28 ± 6.4 , Post: 91.66 ± 5.3 $P = 0.019$; FAAM-Sport Pre: 66.14 ± 10.5 , Post: 78.14 ± 10.5 $P = 0.001$) had improvements in self-reported function scores. There was a statistically significant time by group interaction for the eyes open TTB mean minima medial-lateral (Control: Pre = 3.80 ± 1.06 s; Post = 4.44 ± 0.94 s; Treatment: Pre = 3.90 ± 1.12 s; Post = 3.73 ± 0.92 s, $P = 0.045$) and the standard deviation of the TTB minima medial-lateral (Control: Pre = 3.13 ± 1.33 s; Post = 3.90 ± 0.90 s; Treatment: Pre = 2.97 ± 0.94 s; Post = 2.74 ± 1.10 s; $P = 0.028$). However, neither measure demonstrated significant improvements in the home exercise group. There were no statistically significant time by group interactions or main effects for any eyes closed TTB measures. **Conclusions:** Compared to the control group, the 4-week home exercise training program consisting of balancing on one leg while brushing one's teeth did not cause significant improvements in postural control measures or self-reported function in CAI patients.

A Four-Week Real-Time Feedback Intervention Demonstrates Changes In Sagittal Plane Knee And Hip Biomechanics

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Context: Feedback has traditionally been utilized to alter jump-landing biomechanics to decrease knee injury risk in females. Real-time feedback (RTF) is a novel method that allows participants to view body segments as they complete a task, thus augmenting traditional feedback (TF) typically provided after the completion of the movement. A one-time RTF intervention can successfully, immediately alter jump-landing biomechanics. It remains unknown if increased exposure to the RTF intervention would optimize biomechanical changes from feedback.

Objective: Determine the effect of a four-week RTF intervention on jump-landing knee and hip biomechanics compared to TF and control groups.

Design: Randomized controlled trial.

Setting: Research laboratory.

Patients or Other Participants: Healthy females were randomized into 3 groups: RTF ($n = 14$; 20.29 ± 1.54 yrs; 1.61 ± 0.06 m; 58.95 ± 8.72 kg), TF ($n = 13$; 19.46 ± 1.45 yrs; 1.66 ± 0.08 m; 56.61 ± 7.28 kg), and control ($n = 15$; 19.8 ± 1.78 yrs; 1.64 ± 0.05 m; 60.08 ± 8.41 kg).

Intervention(s): Feedback groups completed twelve sessions over 4-weeks during which participants performed six sets of six jumps off a 30cm box. Both intervention groups were provided verbal and visual feedback of correct landing technique following each set of jumps. The RTF group also received real-time visualization of their frontal plane knee angle and instructions to align this knee angle with a vertical reference line during landing. **Main Outcome Measure(s):** A three-dimensional motion capture system with integrated force plates collected

frontal and sagittal plane knee and hip biomechanics pre-intervention and immediately after the 4-week intervention. At each test, participants performed three jump-landings off a 30cm box, set 50% of the participant's height from the force plate, and immediately upon landing, rebounded for maximum height. Peak kinetics and kinematics during the first 25% of stance were determined using standard inverse dynamics and averaged across trials. Data were analyzed using 2x3 repeated measures ANOVAs and Fisher's LSD multiple comparisons.

Results: There were no significant differences between groups for any of the outcome variables at baseline ($P > 0.05$). Following the intervention the RTF (pre: $-73.37 \pm 10.09^\circ$; post: -85.58 ± 9.60 , $P = 0.39$) and TF (pre: $-73.83 \pm 12.44^\circ$; post: $-96.07 \pm 15.17^\circ$, $P < 0.001$) groups increased knee flexion angles compared to controls (pre: $-74.52 \pm 10.81^\circ$; post: $-75.85 \pm 11.56^\circ$). The TF group was also significantly different from the RTF group for knee flexion angle ($P = .032$). The TF group (pre: $51.73 \pm 14.19^\circ$; post: $65.00 \pm 13.61^\circ$) increased hip flexion angles compared to the control group (pre: $47.84 \pm 12.79^\circ$; post: $49.39 \pm 13.8^\circ$, $P = 0.4004$). The RTF group decreased internal knee extension moment (pre: 1.46 ± 0.23 Nm/kgm; post: 1.17 ± 0.37 Nm/kgm) compared to the control group (pre: 1.42 ± 0.23 Nm/kgm; post: 1.40 ± 0.18 Nm/kgm, $P = 0.029$). There were no significant differences between groups for frontal plane hip or knee biomechanics ($P > 0.05$). **Conclusions:** Following the 4-week intervention, RTF and TF groups were able to use the feedback to make changes in sagittal plane knee and hip biomechanics. These changes in biomechanics could reduce risk of future knee injury, especially in females. Future research should investigate the retention of learned feedback and look to increase the clinical applicability of RTF. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Effect Of Patterned Electrical Neuromuscular Stimulation On Quadriceps Function In Individuals With Arthrogenic Muscle Inhibition

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Context: Quadriceps inhibition commonly occurs following knee joint injuries. Clinicians often use disinhibitory modalities such as ice or transcutaneous electrical nerve stimulation applied to the joint to assist with rehabilitation. Neuromuscular Electrical Stimulation (NMES) has been used to improve quadriceps strength in knee rehabilitation, but is often uncomfortable and results in muscular fatigue. Patterned Electrical Neuromuscular Stimulation (PENS) is a novel treatment used to increase functional muscle contractions by providing precisely timed electrical stimuli based on EMG activity of healthy individuals during functional movements. It is not known whether PENS has an immediate effect on this reflexive inhibition. **Objective:** To examine the effect of a 15-minute PENS treatment on quadriceps strength and muscle activation in patients with a history of knee pathology. **Design:** Double-blinded randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** 18 subjects (7 females, 11 males; 24.2 ± 3.4 yrs, 175.26 ± 11.82 cm, 78.69 ± 13.55 kg) with a history of knee injury/pain (10 ACL reconstructions, 6 chronic anterior knee pain, and 2 meniscal repairs). Participants demonstrated quadriceps inhibition with a central activation ratio (CAR) of $\leq 90\%$. **Intervention(s):** Subjects were randomly allocated into either a 15-minute PENS treatment or 15-minute-sham treatment group. The PENS group received an asymmetrical, low-frequency (50Hz), short phase duration (70µsec) biphasic square wave stimulation at an amplitude great enough to elicit a visible motor contraction. The Sham group received

minimal stimulus (1mA), which was not great enough to elicit a sensory or motor effect. **Main Outcome Measure(s):** Quadriceps force was measured by knee extension maximal volitional isometric contraction (MVIC) in a seated position and was normalized to body mass (Nm/kg). During maximal isometric contraction, an electrical stimulation was delivered using the superimposed burst technique (SIB) to produce a transient torque increase. Quadriceps CAR was calculated as $(MVIC/[MVIC+SIB100])$. A 2x2 (group x time) ANCOVA was used to determine differences in MVIC and CAR between groups. The MVIC was selected as a covariate due to differences at baseline. Cohen's d effect sizes were also calculated for mean change between groups for MVIC and CAR. **Results:** There were no differences between pre-post-intervention for MVIC (PENS: 0.09 ± 0.32 Nm/kg and Sham 0.15 ± 0.18 Nm/kg, $P = 0.713$), or CAR (PENS: -1.22 ± 6.06 and Sham: 1.48 ± 3.7 , $P = 0.270$). No between-subject effect was seen in the MVIC ($P = 0.295$) or CAR ($P = 0.138$). Effect size (95% Confidence Interval) for the change scores between PENS and Sham was calculated for MVIC $-0.18 (-1.10, 0.75)$ and CAR $-0.54 (-1.48, 0.40)$. **Conclusions:** Participants did not have an increase in knee extensor torque or quadriceps activation immediately following a single PENS treatment. Typically NMES treatments result in fatigue, however PENS did not cause this common limitation. Traditionally, electrical stimulation is applied in conjunction with a rehabilitation program and not as a single intervention. Future consideration should focus on the effect of multiple sessions of PENS in conjunction with a rehabilitation program.

Effect Of Patterned Electrical Neuromuscular Stimulation On Quadriceps Motoneuron Pool Excitability

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Context: Electrical stimulation (ES) is a common intervention used to address muscle weakness following knee injuries. Various forms of ES have been studied to examine their effect on arthrogenic muscle inhibition immediately following application as measured by motoneuron pool excitability (MNPE) of the vastus medialis. Transcutaneous Electrical Nerve Stimulation applied to the knee has been found to improve the MNPE in a pathological patient population, while traditional Neuromuscular Electrical Stimulation has been found to have no influence. Patterned Electrical Neuromuscular Stimulation (PENS) is a novel form of ES that provides a precisely timed stimulation to improve functional muscular contractions derived from healthy electromyography patterns. There is currently no knowledge on how PENS may influence MNPE in individuals with previous knee injuries. **Objective:** To examine the effect of a 15-minute PENS treatment on quadriceps muscle inhibition in patients with a history of knee pathology as measured by MNPE. **Design:** Double-blinded randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** 10 subjects (5 females, 5 males; 23.8 ± 3.08 yrs, 174.75 ± 14.05 cm, 75.89 ± 12.63 kg) with a history of a knee injury and quadriceps inhibition determined by a central activation ratio of less than 90%. **Intervention(s):** Independent variables were treatment group (PENS and Sham) and time (pre-intervention and post-intervention). Subjects were randomly allocated to a 15-minute PENS treatment or 15-minute sham session. The PENS group received an asymmetrical biphasic square wave stimulation with a low-frequency (50Hz) and a short phase duration (70µsec) with a amplitude great

enough to elicit a quadriceps motor contraction. The sham group received a 1mA treatment, a stimulus that was not great enough to elicit a sensory effect. **Main Outcome Measure(s):** Maximal H-reflex (Hmax) and motor wave (Mmax) from the vastus medialis were recorded in a supine position to calculate an Hmax:Mmax ratio to estimate MNPE. Individual 2x2 (Group X Time) ANOVAs with repeated measures were performed for statistical analysis. Effect sizes with 95% confident intervals were also calculated for mean change between groups for the Hmax:Mmax ratio. **Results:** There was no significant time effect for Hmax:Mmax pre-intervention to post-intervention in either group: PENS (Pre: 0.30 ± 0.10 , Post: 0.43 ± 0.27 , $P = 0.446$) or in the Sham group (Pre: 0.36 ± 0.16 , Post: 0.35 ± 0.16 , $P = 0.846$). There were no significant changes in Hmax:Mmax ratio between groups ($P = 0.379$) or a significant group x time interaction ($P = 0.315$). The mean change differences in Hmax:Mmax ratio between groups did produce a large effect size $1.39 (-0.01, 2.79)$ in favor the PENS treatment group. **Conclusions:** A single 15-minute treatment of PENS produced a large magnitude of change in MNPE of the vastus medialis, but not a statistically significant difference when compared to the sham group. Further research is needed to assess the influence of using PENS throughout a longer term rehabilitation program in knee-injured patients.

The Immediate Effects Of Transcutaneous Electrical Nerve Stimulation (TENS) On Quadriceps Activation In Subjects With Experimental Knee Pain (EKP)

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Context: Knee pain decreases quadriceps activation, and alters movement patterns. Reducing pain through intervention may help reestablish motor function. **Objective:** To examine the effects of TENS on quadriceps output in subjects with EKP. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** 15 TENS group (10M & 5F, 23.5 ± 2.8 yrs, 70.5 ± 12.5 kg, 178.1 ± 7.4 cm), and 15 sham group (10M & 5F, 22.5 ± 2.0 yrs, 72.1 ± 13.7 kg, 177.5 ± 9.3 cm). **Intervention(s):** Each subject underwent three different conditions (pain, neutral, and control) and measurements were recorded across 4 time points (pre, condition, treatment, and post-treatment). 5% and 0.9% sodium chloride were infused into the infrapatellar fat pad on the dominant limb for 50 min (total 7.2mL) to induce knee pain and no pain (neutral) conditions respectively. No infusion was administered to the control condition. The TENS group received a 20-min treatment. A sham treatment was administered to the sham group. The sham group was told that TENS was set to subsensory level and the indicator light was on during treatment. **Main Outcome Measure(s):** Knee extension maximum voluntary isometric contraction (MVIC) normalized to body mass, central activation ratio (CAR), and a 10-cm visual analog scale (VAS). **Results:** A group \times condition \times time interaction was detected for both the MVIC ($F_{6,168} = 2.92$, $P < 0.01$) and CAR ($F_{6,168} = 3.03$, $P < 0.008$) measurements. Post hoc analysis revealed that EKP acutely reduced knee extension MVIC by 29% (pre = 3.20 ± 0.66 , condition = 2.28 ± 0.98) in the TENS group, and by 26% (pre = 3.34 ± 0.80 , condition = 2.47

± 0.77) in the sham group ($P < 0.05$). However, while the MVIC remained depressed in the sham group by 26% following treatment (treatment = 2.48 ± 0.69 , post-treatment = 2.49 ± 0.61), there was no difference in the MVIC following treatment in the TENS group ($P < 0.05$). Similarly, a 10% decrease in CAR was detected in both sham (pre = 0.99 ± 0.01 , condition = 0.89 ± 0.07) and TENS (pre = 0.98 ± 0.01 , condition = 0.88 ± 0.12) groups prior to treatment. This 10% deficit remained in the sham group (treatment = 0.89 ± 0.06 , post-treatment = 0.90 ± 0.06) following treatment, while there was no difference in the CAR following treatment in the TENS group ($P < 0.05$). Knee pain peaked at 4/10 VAS in the pain condition and remained consistent across time in the sham group ($F_{2,28} = 49.90$, $P < 0.0001$), while knee pain gradually decreased to 1.5/10 VAS following TENS treatment ($F_{2,28} = 23.11$, $P < 0.0001$). **Conclusions:** Our findings suggest that EKP acutely reduced knee extension MVIC and CAR relative to the pre measurements (before infusion). TENS treatment reduced the deficits in the MVIC and CAR, suggesting enhanced force production and decreased inhibition. Future research is needed to link pain-associated motor deficiencies to changes in movement biomechanics, and further to investigate the effectiveness of TENS on altered movement strategies.

Free Communications, Poster Presentations: Undergraduate Poster Award Finalists

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14384UOEM

The Effects Of A Long Spine Board Vs. Vacuum Mattress On Patient Comfort And Cervical Spine Stability: A Systematic Review

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Context: The literature recommends the use of a long spine board (LB) when stabilizing an acute cervical spine-injured athlete. However, the efficacy of LB regarding patient comfort and cervical spine stability is unclear when compared to other full-body stabilizing devices. **Objective:** To systematically review the literature and evaluate the effectiveness of vacuum mattresses (VM) compared to LBs for patient comfort and cervical spine stability. **Data Sources:** Articles were identified from the following electronic databases: Cumulative Index to Nursing and Allied Health (CINAHL), Science Direct, Medline, and Pubmed from January 1985 through October 2013. Search terms consisted of: “cervical spinal stability” AND “spine board”, “ROM” AND “spine board,” “patient comfort” AND “spine board,” and “prehospital” AND “spine board” resulting in 223 studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed (full reports or abstracts), randomized controlled trials, or controlled or comparative trials without randomization, (2) written in English, (3) available abstract, and (4) included key outcomes measuring patient comfort (pain) and cervical spine movement (ROM). **Data Extraction:** Three reviewers independently assessed and graded each study on the Physiotherapy Evidence Database (PEDro) scale. Data of interest were methodological assessment and descriptive data (eg., means, frequency, and 95% CI when available) of the main outcome measures (pain and cervical ROM). **Data Synthesis:** Nine studies met the inclusion criteria; 8 full reports, 1 abstract. The PEDro scores for the 8 full reports ranged from 4-7.6 points (maximum score = 10 points; average = 5.9 ± 1.2). Data, where available, was collected

on healthy subjects (age = 29.6 ± 3.46 years (range 16-53), height = 172.37 ± 3.69 cm, weight = 72.82 ± 2.76 kg). Males accounted for 72% (n = 101) of subjects; women accounted for 28% (n = 39). All studies examined patient comfort; three focused on cervical spine ROM. All studies (9/9) found subjects experienced less pain using the VM compared to the LB, while 100% (3/3) noted a significant decrease in cervical spine ROM using a VM (with or without a cervical collar). In one study, subjects were 3.08 times more likely to complain of symptoms of some kind when immobilized on a LB compared to a VM after adjusting for effect of order of exposure ($p < 0.001$); a separate study found that movement at the head and shoulders was less for the VM (0.8 ± 1.4 cm) compared to the LB (5 ± 1.7 cm) when used without a cervical collar ($p < .001$). **Conclusions:** Vacuum mattresses when compared to LB demonstrated improved patient comfort (ie., less pain, irritation, and sores over bony prominences) and the ability to maintain spinal immobilization. When confronted with a cervical spine-injured athlete, athletic trainers and emergency medical providers have options available when preparing for transportation. Regardless of the situation, annual training and an understanding of the benefits and drawbacks of each immobilization device is imperative.

14356UOIN

Landing Kinematics Differ Between Adolescents With High And Low Values Of Asymmetrical Unilateral Hip Rotation

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Context: Femoral anteversion has been associated with greater passive hip internal rotation relative to external rotation and is commonly described as an asymmetrical unilateral hip rotation (AUHR). This structural deviation is theorized to contribute to dynamic alignments known to increase the risk of ACL injury. However, the relationship between AUHR and dynamic joint angles are unknown, particularly in the adolescent athlete. **Objective:** To compare hip and knee kinematics during a double-leg jump landing (JL) task in adolescent athletes with above (AUHRHIGH) and below (AUHRLow) average AUHR. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** Ninety-one female adolescent athletes (14.0 ± 2.9 yrs, 160.0 ± 13.4 cm, 53.6 ± 13.8 kg) volunteered as part of a larger, multi-center risk factor screening project. **Intervention(s):** Hip internal (HIR) and hip external (HER) rotation range of motion were measured with a digital inclinometer during three trials on the dominant limb. Three-dimensional hip and knee joint kinematics were assessed on the dominant limb using an electromagnetic motion analysis system while subjects performed three trials of a jump-landing task. The JL task required participants to jump from a 30-cm high box set 50% of their height away from a force plate platform and rebound for maximum vertical height upon landing. **Main Outcome Measure(s):** AUHR was calculated as the average HIR minus HER range of motion. Participants were dichotomized into an AUHRHIGH (n = 46, $19.3 \pm 9.3^\circ$) or AUHRLow (n = 45, $-1.8 \pm 9.1^\circ$) group

based on the average AUHR in the overall sample (8.9°). Frontal and transverse plane hip and knee joint angles at initial contact (GRF > 10N), peak joint angles during the deceleration phase (initial contact to peak knee flexion), and joint excursions were used for data analysis. Joint excursions were calculated by subtracting the initial contact joint angle from the peak angle during the deceleration phase of the JL task. Separate one-way ANOVAs compared AUHRHIGH and AUHRLOW groups on hip and knee kinematics. **Results:** At initial contact, the AUHRHIGH group landed with greater knee valgus ($5.2 \pm 5.6^\circ$ vs. $2.1 \pm 6.1^\circ$, $P = 0.016$) and external rotation ($6.0 \pm 7.4^\circ$ vs. $1.4 \pm 8.9^\circ$, $P = 0.010$) compared to the AUHRLOW group. During the deceleration phase of the JL task, greater peak knee valgus ($13.5 \pm 9.7^\circ$ vs. $9.3 \pm 9.1^\circ$, $P = 0.035$) and external rotation ($15.1 \pm 10.5^\circ$ vs. $8.4 \pm 8.5^\circ$, $P = 0.001$) were observed in the AUHRHIGH group. The AUHRHIGH group also went through greater knee valgus ($13.1 \pm 8.7^\circ$ vs. $7.4 \pm 5.7^\circ$, $P < 0.001$) and external rotation excursion ($12.2 \pm 6.7^\circ$ vs. $7.6 \pm 6.1^\circ$, $P = 0.001$), but less hip adduction excursion ($2.9 \pm 8.8^\circ$ vs. $8.3 \pm 6.4^\circ$, $P = 0.001$) compared to the AUHRLOW group during the deceleration phase of the JL task. **Conclusions:** Adolescent athletes with above average AUHR displayed greater transverse and frontal plane motion at the knee and less frontal plane motion at the hip. These findings suggest that adolescent athletes who are anatomically positioned with a more inwardly rotated femur display altered lower extremity mechanics, which could increase their risk of ACL injury.

Effectiveness Of Four-Decontamination Techniques On Bacterial Growth On CPR Manikins After Use In A CPR Course

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Context: The American Red Cross is a staunch advocate in preventing transmission of infectious diseases during cardiopulmonary resuscitation (CPR) training, and that equipment should be decontaminated carefully and consistently. Because CPR is taught worldwide, identifying low cost, efficient, and effective means of decontamination is imperative. **Objective:** Determine the degree of contamination on CPR manikins after routine use, and evaluate the efficacy of four disinfecting methods to reduce bacterial growth. **Design:** Descriptive laboratory. **Setting:** CPR class; microbiology laboratory. **Patients or Other Participants:** Forty-eight Actar 911™ CPR Manikins (Armstrong Medical Industries, Lincolnshire, IL). **Intervention(s):** Study consisted of two phases. Phase-1, disinfected manikins underwent a 50-minute educational intervention (CPR course), and were collected post-intervention, labeled, and aseptically swabbed and planted on sheep blood agar (SBA) plates. Separate swabs were taken around the mouth, and chest plate between the nipples. Plates were incubated at 37°C for 24-hours, and manikins were returned to the storage cabinet (simulating realistic storage) for 24-hours to begin Phase-2. After 24-hours, manikins were again swabbed, planted (SBA), and incubated for 24-hours. Manikins were randomized into four treatment groups and disinfected with either: (1) 1:10 bleach-to-water solution, (2) 70% isopropyl alcohol, (3) Clorox Disinfecting Wipes®, or (4) UVC-light; all following manufacturer's recommendations when applicable. Disinfected manikins were

swabbed, planted (SBA), and incubated for 24-hours. Plates were evaluated for colony counts and appearance. **Main Outcome Measure(s):** Dependent variable was bacterial colony growth (count); independent variable was treatment group. Colony growths too numerous to count were defaulted to a minimal threshold level of 300 following standard laboratory protocols. Data was analyzed with descriptive statistics and a repeated measures ANOVA (group X time [initial, post-24, post-disinfected swab]) set a priori at 0.05. **Results:** A repeated measures ANOVA revealed no significant main effect for interaction or group on mouth or chest plate swabs. Results revealed a significant main effect for time for chest plate ($F_{2,88} = 12.1$, $p < 0.001$) and mouth ($F_{1,14,50.2} = 7.2$, $p = 0.02$) bacterial colony counts. Chest plate decreased bacterial growth from post-24 (77.8 ± 12.6) to post-disinfected (12.2 ± 6.1). Mouth groups decreased bacterial growth from initial swabbing ($4.2 \pm .80$), to post-24 ($3.0 \pm .96$), to post-disinfected ($.5 \pm .16$). In chest plate post-disinfected swabs, 0% of UVC-light, 10.4% of Clorox Wipes®, 18.8% of 1:10 bleach-to-water solution, and 22.9% of 70% isopropyl alcohol showed no bacterial growth. Majority of organisms were normal flora; however, significant opportunistic bacteria found on pre-disinfected plates were eliminated with cleaning. **Conclusions:** If un-sanitized, CPR manikins are possible vectors for bacterial growth. Clorox Disinfecting Wipes®, 1:10 bleach-to-water solution, and 70% isopropyl alcohol proved to be low cost, efficient, and effective means of decontamination; UVC-light's effectiveness requires further research. Athletic trainers and educators can use these results to appropriately select disinfecting agents to reduce the risk of opportunistic bacterial growth on CPR manikins.

Pre-Activity Sports Massage Does Not Affect Vertical Jump Or Sprint Performance

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Context: Athletes in certain sports frequently request pre-activity massage to enhance performance. Previous research on the performance effect of massage has yielded mixed results. Some research suggests that activation of the parasympathetic nervous system would decrease performance. However, it's unclear if the net physiological and psychological effects of massage improve or decrease athletic performance (AP). **Objective:** To evaluate the effect of pre-activity massage on sprint performance, vertical jump (VJ) height and the psychological state of the athlete. **Design:** Crossover trial. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen Division III collegiate athletes (sports represented: football, volleyball, track, soccer). This included 9 males (age 21.00 ± 1.11 years, height 1.85 ± 0.05 m, weight 96.57 ± 16.66 kg, collegiate athletic experience 2.67 ± 1.12 years) and 6 females (age 19.83 ± 1.47 years, height 1.73 ± 0.03 m, weight 68.79 ± 6.72 kg, collegiate athletic experience 2.67 ± 1.37 years). **Intervention(s):** Participants were tested twice, separated by 1-2 weeks. In each session, participants were first familiarized with the testing protocol, then completed a baseline measure of the adult short-version Profile of Mood States (POMS2). Then participants performed a standard 15-min dynamic warm-up, followed by either an 8-min rest period or an 8-min vigorous Swedish massage on both lower extremities simultaneously performed by 2 athletic training students. Order of the intervention condition (massage vs. rest) was randomized between sessions. Following the intervention, participants completed a second POMS2, then rapidly moved to performance tests. First, 3 maximal VJs were recorded using a Vertec VJ trainer (Vertec Corporation, Roseville, MI, USA), followed by a 20m sprint recorded by handheld stopwatches by 2 investigators.

Main Outcome Measure(s): Sprint time and maximal VJ height were the performance measures, while the psychological effect of the intervention was evaluated using POMS2 mood categories pertinent to AP. Separate paired t-tests investigated the effect of intervention (massage, rest) on sprint time and maximal VJ height. Four POMS2 mood category scores [Total Mood Disturbance (TMD), Fatigue-Inertia, Tension-Anxiety, and Vigor-Activity] were compared pre- and post-intervention using paired t-tests ($\alpha = 0.05$). **Results:** There were no significant differences between rest and massage conditions for VJ or sprint performance (VJrest = 23.57 ± 5.14 in, VJmassage = 23.03 ± 5.51 in; $t = 1.331$, $df = 14$, $P = 0.205$; Sprintrest = 3.19 ± 0.26 s, Sprintmassage = 3.21 ± 0.27 s, $t = 0.874$, $df = 14$, $P = 0.397$). Individuals receiving massage significantly improved psychological state as measured by TMD and Fatigue-Inertia (TMDpre = 40.40 ± 9.30 , TMDpost = 36.60 ± 4.36 , $t = 2.143$, $df = 14$, $P = 0.050$; Fatigue-Inertiapre = 39.93 ± 7.29 , Fatigue-Inertiapost = 35.73 ± 3.92 , $t = 2.721$, $df = 14$, $P = 0.017$) but showed no difference on the Tension-Anxiety and Vigor-Activity scales (all $P > 0.50$). During the rest condition there were no significant changes in psychological states (all $P > 0.05$) except for TMD (TMDpre = 40.20 ± 5.13 , TMDpost = 38.00 ± 5.45 , $t = 2.18$, $df = 14$, $P = 0.046$). **Conclusions:** Pre-activity massage did not negatively affect explosive AP. It's possible that the positive psychological effect on mood state mitigated any physiologic disadvantage of massage. Based on the current findings of a neutral impact of massage on performance, clinicians should consider whether the use of pre-activity massage is an effective use of time.

Maturation Stage And Sex Differences In Lower Extremity Flexibility

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Context: Lower extremity injury risk appears to increase during adolescence, but it is unknown why this increase occurs. Muscle tightness is a proposed risk factor for lower extremity injury and a possible mechanism for movement-based risk factors for injury, such as medial knee displacement. Understanding how muscle flexibility changes between sexes and maturation stages may guide injury prevention and rehabilitation efforts. **Objective:** To evaluate changes in lower extremity muscle flexibility between sexes and maturation stages. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** 113 participants between the ages of 8-18 years (58 males: age = 13 ± 3 years, mass = 54.5 ± 20.0 kg, height = 161.5 ± 18.7 cm; 55 females: age = 12 ± 3 years, mass = 46.71 ± 15.5 kg, height = 153.0 ± 16.7 cm) recruited from high school sports teams and a youth soccer league volunteered to participate. **Intervention(s):** Participants completed a single test session. All participants completed a Pubertal Maturation Observational Scale (PMOS) in order to classify maturational stage (Post-pubescent (POST): PMOS > 5 ; Pubescent (PUB): PMOS: 2-5; Pre-pubescent (PRE): PMOS < 2). Participants then completed 2 trials of each flexibility assessment on their dominant limb: gastrocnemius, soleus, hip adductors, hip internal rotators, hip external rotators, and hamstrings. The dominant limb was the preferred limb to kick a ball for maximal distance. A digital inclinometer (Chattanooga Digital Inclinometer, Chattanooga Medical Supply, Chattanooga, Tennessee) was used for each flexibility assessment. **Main Outcome Measure(s):** The average value of two trials was used for all analyses. Separate univariate analysis of variance tests were used to compare maturation stages (PRE, PUB, POST) and sexes ($\alpha < 0.05$). **Results:** Of

the 113 participants, 31 were classified as PRE (16 males: 10 ± 1 years, mass: 33.2 ± 6.1 kg, height: 140.3 ± 5.7 cm; 15 females: 9 ± 1 years, mass: 29.6 ± 6.7 kg, height: 134.9 ± 9.2 cm), 26 were PUB (13 males: 13 ± 3 years, mass: 33.3 ± 12.7 kg, height: 155.7 ± 18.5 cm; 13 females: 10 ± 2 years; mass: 41.9 ± 14.2 kg, height: 148.6 ± 15.6 cm), and 56 were POST (29 males: 16 ± 1 years, mass: 71 ± 11.1 kg, height: 75.9 ± 7.8 cm; 27 females: 15 ± 2 years; mass: 58.5 ± 7.5 kg, height: 165.3 ± 8.3 cm). Regardless of sex, there were significant differences between maturation stages for flexibility measures of the soleus (POST: $16.3^\circ \pm 1.3^\circ > \text{PRE: } 27.1^\circ \pm 1.7^\circ$, PUB: $24.6^\circ \pm 1.8^\circ$, $P < 0.001$), hip adductors (PRE: $72.8^\circ \pm 1.8^\circ > \text{PUB: } 66.0^\circ \pm 2.0^\circ$, PRE: $72.8^\circ \pm 1.8^\circ > \text{POST: } 62.3^\circ \pm 1.8^\circ$, $P < 0.001$), and hamstrings (PRE: $70.4^\circ \pm 2.1^\circ > \text{POST: } 61.4^\circ \pm 1.6^\circ$, PUB: $65.1^\circ \pm 2.3^\circ$, $P = 0.004$). Regardless of maturation stage, females demonstrated greater flexibility than males for hip adductors (Males: $64.0^\circ \pm 1.4^\circ$, Females: $70.2^\circ \pm 1.5^\circ$, $P = 0.003$), hip internal rotators (Males: $39.1^\circ \pm 1.0^\circ$, Females: $44.7^\circ \pm 1.1^\circ$, $P < 0.001$), and hamstrings (Males: $62.3^\circ \pm 1.6^\circ$, Females: $68.0^\circ \pm 1.7^\circ$, $P = 0.04$). **Conclusions:** The observed changes in flexibility should be utilized as a guide for athletic trainers to correct muscle imbalances that occur across maturation. Stretching of the soleus, hip adductors and hamstring may be beneficial as children mature. Changes in flexibility and joint laxity should be further evaluated for their influence on injury risk in adolescents.

Free Communications, Poster Presentations: Master's Poster Award Finalists

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14397MONE

Test-Retest Reliability And Learning Effects Of The Stability Evaluation Test

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Context: Postural control plays an essential role in athletics, musculoskeletal rehabilitation, and concussion evaluation. The Stability Evaluation Test (SET) aims to objectively analyze an athlete's balance and postural control through measurement of sway velocity (SV) on the NeuroCom's VSR portable force platform (Natus, Clackamas, OR). **Objective:** To assess the test-retest reliability and potential for learning effects of the SET protocol. **Design:** Cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** Fifty healthy adults (males = 20, females = 30, age = 25.3 ± 3.6 years, height = 166.6 ± 12.8 cm, mass = 68.8 ± 13.9 kg). **Intervention(s):** The independent variable was trial. All participants completed four trials of the SET. Each trial consisted of six 20-second balance tests with eyes closed, under the following conditions: double-leg firm (DFi), single-leg firm (SFi), tandem firm (TFi), double-leg foam (DFo), single-leg foam (SFo), and tandem foam (TFo). Each trial was separated by a 5-minute seated rest period. **Main Outcome Measure(s):** The dependent variable was SV (deg/sec), with lower values indicating better balance. SV was recorded for each of the six conditions and as a composite score for each of the four trials. Test-retest reliability was analyzed across the four trials with Intraclass Correlation Coefficients (2, 1). Learning effects were analyzed with a repeated measures analysis of variance, followed by Tukey post-hoc comparisons for any significant main effects ($p < .05$). **Results:** The reliability of the SV values were good to excellent: DFi (ICC = 0.88; 95% CI: 0.81, 0.92), SFi (ICC = 0.75; 95% CI: 0.61, 0.85), TFi (ICC = 0.84; 95% CI: 0.75, 0.90), DFo (ICC = 0.83; 95% CI: 0.74, 0.90), SFo (ICC = 0.82; 95% CI: 0.72, 0.89), TFo

(ICC = 0.81; 95% CI: 0.69, 0.88), and composite score (ICC = 0.93; 95% CI: 0.88, 0.95). Significant learning effects ($p < .001$) were noted on the SFi, DFo, SFo, and TFo conditions. Post-hoc analyses for the SFi condition revealed significantly lower SV for trials two (1.86 ± 0.52 deg/sec), three (1.93 ± 0.81 deg/sec), and four (1.81 ± 0.61 deg/sec) compared to trial one (2.26 ± 0.69 deg/sec). For DFo, trials two (2.28 ± 0.63 deg/sec) and three (2.21 ± 0.51 deg/sec) were significantly lower than trial one ($2.81 \pm .87$ deg/sec), and trial four (2.12 ± 0.47 deg/sec) was significantly lower than trials one and two. For SFo, trials two ($3.75 \pm .93$ deg/sec) and three (3.73 ± 1.10 deg/sec) were significantly lower than trial one (4.33 ± 1.11 deg/sec) and trial four ($3.50 \pm .82$ deg/sec) was significantly lower than trials one and two. Lastly for the TFo, trials three (3.82 ± 1.71 deg/sec) and four (3.86 ± 1.60 deg/sec) were significantly lower than trials one (4.62 ± 1.52 deg/sec) and two (4.37 ± 1.50 deg/sec). **Conclusions:** Our results suggest good to excellent reliability of the SET for the assessment of postural control for musculoskeletal or concussive injuries. Due to the learning effects noted, primarily between trials one and two of each condition, we recommend allowing patients one practice trial (ie, all 6 conditions) prior to recording the data for evaluative purposes to reduce the potential of learning effects confounding the SV score. Future studies should evaluate injured patients to determine meaningful change scores for various injuries such as concussions or ankle sprains.

14263MOIN

Cooling Rates In Exercise Induced Hyperthermic Football Players And Runners Using Cold Water Immersion

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Context: Optimal cooling rates in hyperthermic athletes have been established primarily using average-sized subjects. Large American football players such as linemen have a small body-surface-area to mass ratio (BSA/mass) compared to smaller athletes, which hinders heat dissipation by conduction and convection. **Objective:** To determine if differences exist in cooling rate using cold-water immersion between hyperthermic football linemen (FB) and cross-country (CC) runners. **Design:** Cohort study. **Setting:** Controlled University laboratory. **Patients or Other Participants:** Nine FB linemen (age = 21.7 ± 2.1 y, ht = 188 ± 4.5 cm, mass = 128.1 ± 12.7 kg, % body fat = $28.4 \pm 7.1\%$, BSA = $2.5 \pm .13$ m², BSA/mass = 201.0 ± 11.7 cm²·kg⁻¹) and 7 CC runners (age = 20.0 ± 2.5 y, ht = 176.0 ± 3.7 cm, mass = 68.7 ± 8.3 kg, % body fat = $10.2 \pm 1.9\%$, BSA = 1.8 ± 0.16 m², BSA/mass = 268.3 ± 23.1 cm²·kg⁻¹) volunteered. **Intervention:** Subjects ingested an intestinal sensor (CoreTemp, HQI) the night prior to data collection and Core temperature (T_c) was recorded before the trial to insure the sensor was in the intestines and providing an accurate temperature reading. Subjects exercised in a climatic chamber (39°C, 35% RH) until they reached a T_c of 39.5°C or physical exhaustion, which was determined by their inability to continue to exercise. Immediately following the exercise the subjects were immersed up to their clavicles in a 10°C circulated bath until T_c declined to 37.5°C, at which time they were removed from the cold tub. Body composition was measured

using a BodPod. A 2x2 ANOVA and independent t-tests were used, with $P < .05$. **Main Outcome Measure(s):** Physical characteristics, maximal Tc, time (min) to reach 37.5°C, and cooling rate. **Results:** All physical characteristics (height, mass, % body fat, BSA, and BSA/mass) were different between the FB and CC groups. There were no differences in environmental measures or maximal Tc reached (FB = $39.12 \pm .39^\circ\text{C}$ and CC = $39.38 \pm .19^\circ\text{C}$, $P = .12$). Significant differences were found in immersion times required to reach 37.5°C (FB = 11.2 ± 4 min, CC = $7.7 \pm .06$ min, $P < .002$), and therefore cooling rate (CC = $.26^\circ\text{C}\cdot\text{min}^{-1}$, FB = $.16 \pm .05^\circ\text{C}\cdot\text{min}^{-1}$, $P < .05$). Significant correlations were found between body mass and cooling rate ($r = -.76$, $P < .001$), and between percent body fat and cooling rate ($r = -.66$, $P < .01$). **Conclusion:** As expected, the larger football players took considerably longer to cool (11 min) than the runners (7.7 min) which is supported by the correlation ($r = -.76$) between body mass and cooling rate. Using cold-water immersion the cooling rate ($.26^\circ\text{C}\cdot\text{min}^{-1}$) found in the smaller runners is considered acceptable ($\leq 0.20^\circ\text{C}\cdot\text{min}^{-1}$), however in the football players ($0.16^\circ\text{C}\cdot\text{min}^{-1}$) it was not. Cooling times for individuals suffering from exertional heat stroke should be based on the athletes' body size.

Self Myofascial Release Has No Effect On Iliotibial Band Flexibility

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Context: Tightness of the iliotibial band (ITB) is common amongst active populations, especially runners and cyclists. Due to the length and thickness of the ITB, static stretching may not provide a sufficient force to stretch the tissue. Therefore soft tissue mobilization such as self myofascial release has been proposed to enhance ITB extensibility. **Objective:** The purpose of this study is to determine if self myofascial release via foam rolling affects ITB extensibility. **Design:** Randomized controlled trial. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Forty-four participants volunteered for this study. All subjects presented with limited ITB extensibility which was defined as less than 26° of hip adduction. Subjects were randomly assigned to either the foam rolling (FR) group or the control (CON) group. (FR: $n = 21$, 19.0 ± 1.09 yrs, 168.93 ± 8.27 cm, 65.92 ± 10.41 kg and CON: $n = 23$, 19.13 ± 1.01 yrs, 170.85 ± 8.54 cm, 65.76 ± 10.29 kg). **Intervention(s):** Subjects received 6 treatments with 48 hours of rest in between each treatment. Self myofascial release treatment via a foam roller consisted of rolling on the anterior, central, and posterior slip of the ITB for 6 minutes total. This treatment was followed by two hip abduction strengthening exercises which were each performed for 2 sets of 20 repetitions. The control group received a sham microcurrent electrical stimulation treatment for 8 minutes. Electrodes were placed on the lateral aspect of the thigh, but intensity was not increased. **Main Outcome Measure(s):** Hip adduction range of motion($^\circ$) via an inclinometer (Lafayette Instrument Company, Lafayette, IN) was recorded using a modified Ober's test. Testing

occurred at baseline, following 3 treatments (mid), and following 6 treatments (post). A repeated measures ANOVA was completed with one between subject's factor (group at 2 levels: FR and CON) and one within subject's factor (time at 3 levels: baseline, mid, post). A priori alpha level was set at $p < .05$. **Results:** No significant time by group interaction was identified for hip adduction range of motion ($F_{2,84} = .72$, $p = .49$, $\eta_p^2 = .02$, power = .17). For both groups the mean range of motion varied little over the study period (FR baseline to post mean difference: $0.2 \pm 1.0^\circ$, 95% CI: -2.8 to 2.4° and CON baseline to post mean difference: $2.0 \pm 1.0^\circ$, 95% CI: -4.5 to 0.5°). **Conclusions:** Six foam rolling treatments over a two week time period does not sufficiently impact the ITB in a manner that creates increased extensibility. One potential reason for the lack of a significant improvement may have been the inability to control the amount of pressure that subjects used during the treatment. Standardized instructions were given to all participants but we could only assume that the instructions were followed.

14257MOHE

Content Analysis Of Eating Disorder Policies And Procedures Of Collegiate Institutions

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Context: In 2008, the National Athletic Trainers' Association (NATA) Position Statement on preventing, detecting and managing eating disorders (ED) recommended that collegiate health care teams should create and implement ED policies to assist at-risk athletes. **Objective:** The purpose of this study was to evaluate compliance with the NATA recommendations through the existence of and content included in ED policies of collegiate institutions. **Design:** This study was a quantitative content analysis. **Setting:** Field study of written collegiate athletic department documents. **Patients or Other Participants:** Stratified random sampling of 220 NCAA and NAIA collegiate institutions was completed, with 50 institutions participating. **Intervention(s):** Participants were asked to submit their written ED policy. Fifty-one units of analysis within five categories (early detection/recognition, intervention/management, treatment, consequences, roles and responsibilities) of recommendations were determined based on the NATA Position Statement. Institutions (n = 220) were asked to submit their written eating disorder policy. A second reviewer was utilized for validation of the analysis. **Main Outcome Measure(s):** The researcher evaluated policy content based on the NATA position statement recommendations. Each unit of analysis was coded according to inclusion, mention of or full description of the units of analysis. Frequencies were used to evaluate the outcome. **Results:** Of the 50 participating institutions, 28% (n = 14) had established written eating disorder policies while 72% (n = 36) indicated that they did not have a written eating disorder policy. Of the policies provided, only eight policies

(57%) included establishment of a university ED team (medicine, nutrition, mental health, athletic training, and administration) to assist in treatment and management of a suspected ED. Ten policies (71%) did not define screening methods for early detection and recognition. Under the intervention and management category, 100% (n=14) of the policies included intervention of an athlete with a suspected ED as well appropriate referrals to health care providers. Thirteen policies (93%) discussed medical treatment and mental health treatments, whereas 10 of the policies (71%) mentioned nutrition treatment. When evaluating consequences to participation, 57% of the policies (n=8) mentioned athlete suspension for noncompliance with the care plan and only 28% (n = 4) of institutions mentioned implementing a contract for the athlete outlining repercussions if an athlete refused the necessary treatment. **Conclusions:** Based on the results of this study, we conclude that there are a large number of institutions failing to implement the recommended ED prevention and management policies as demonstrated by both a lack of written policy and lack of key components within the existing written policies. Additionally, few of the written policies actually include all items recommended by the NATA, particularly the crucial piece of establishing an ED team, demonstrating a lack of attention to detail when it comes to preventing and managing eating disorders in collegiate athletes.

14289MONE

Electromyographic Biofeedback Immediately Increases Quadriceps Corticospinal Excitability

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Context: Quadriceps corticospinal excitability (CSE) pathways, originating in the motor cortex of the brain, are altered following knee injury and may contribute to chronic neuromuscular dysfunction. There is no accepted modality that specifically targets impaired CSE. Electromyographic biofeedback (EMG-BF) has previously been theorized to enhance the quality of muscle contraction, yet the ability of EMG-BF to alter CSE is unknown. **Objective:** Determine the immediate effects of EMG-BF during a maximal voluntary isometric contraction (MVIC) on vastus lateralis (VL) CSE and peak torque, compared to a MVIC without EMG-BF (Control), in healthy individuals. **Design:** Crossover study with one week between test conditions. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen healthy participants (6M/9F, 21.47 ± 3.78 yrs, 171.45 ± 10.55 cm, 70.80 ± 14.77kg) volunteered. **Intervention(s):** Participants were secured in an isokinetic dynamometer with knees flexed to 90°. Practice knee extension MVIC trials were performed at the beginning of each session; 1) to familiarize participants with MVICs, and 2) to collect peak VL root mean square EMG that would be used for setting targets during the EMG-BF condition. Participants were randomly assigned to condition order, during which five intervention MVICs were performed with or without EMG-BF. CSE measurements were collected with Transcranial Magnetic Stimulation (TMS) during five knee extension contractions (5% of MVIC) at baseline and again during intervention MVICs within each session. For the EMG-BF intervention, a target line was depicted on the handheld EMG-BF unit at 5% above the peak VL root mean square EMG collected during the practice MVICs. During the EMG-BF session

participants were encouraged to maximally contract their VL and attempt to exceed the target line with EMG output. On a separate day during the Control condition, participants were instructed to perform the same number of MVICs without any EMG-BF. **Main Outcome Measure(s):** VL CSE was evaluated by eliciting motor evoked potentials (MEP) with a TMS intensity corresponding to individual participants' active motor threshold at baseline (5% of MVIC) and during an intervention MVIC. Percent change scores were used to calculate the change in peak-to-peak MEP amplitudes that occurred during EMG-BF and Control MVICs compared to the baseline MEPs. Peak knee extension torque was recorded during MVICs prior to TMS for each condition. Dependent t-tests were utilized to determine differences in MEP change scores and torque between conditions. Alpha was set at $P < 0.05$. **Results:** EMG-BF produced significantly increased MEP change scores (EMG-BF: $1814.58 \pm 516.60\%$, Control: $1509.06 \pm 317.56\%$, $t_{14} = 2.926$, $P = 0.011$) and significantly greater torque (EMG-BF: 226.99 ± 100.68 Nm, Control: 215.40 ± 93.36 Nm, $t_{14} = 2.186$, $P = 0.046$) than the control condition. **Conclusions:** A single EMG-BF intervention produced immediate increases in VL CSE and knee extension torque production compared to knee extension MVICs without EMG-BF. EMG-BF may be a viable clinical method for targeting CSE in patients with neuromuscular dysfunction. Future studies should determine if EMG-BF improves therapeutic outcomes.

Contributing Factors To Star Excursion Balance Test Performance In Individuals With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have displayed dynamic postural deficits on the Star Excursion Balance Test (SEBT). However, contributing factors to SEBT performance in individuals with CAI have not yet been examined. **Objective:** To determine if strength, dorsiflexion range of motion (DROM), or static postural control can predict SEBT performance in individuals with CAI. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty individuals with CAI (13 males, 27 females, 23.25 ± 4.79 years, 168.85 ± 9.20 cm, 72.04 ± 14.36 kg) participated in the study. Participants were included if they reported ≥ 1 ankle sprain, ≥ 2 episodes of "giving way" in the past three months, scored < 24 on the Cumberland Ankle Instability Tool and answered "yes" to ≥ 5 questions on the Ankle Instability Instrument. **Intervention(s):** During a single test session, participants completed strength, DROM, and balance assessments in a counterbalanced order. Dorsiflexion, inversion, and eversion isometric strength were assessed using a handheld dynamometer. DROM was assessed using the weight-bearing lunge test. Static postural control was assessed by measuring single-limb stance on a force plate with eyes-closed and analyzed as time-to-boundary (TTB) mean minima in the medial/lateral (ML) and anterior/posterior (AP) directions. Dynamic postural control was assessed using the anterior (ANT), posteromedial (PM), and posterolateral (PL) reach directions of the SEBT. All reach distances were normalized to leg length. Participants performed three trials for each assessment, and the average was used for data analysis. **Main Outcome Measure(s):** Predictor variables included isometric dorsiflexion, inversion, and eversion strength, DROM, TTB-AP, and TTB-ML. Three

separate backward multiple linear regression models were developed with each SEBT reach direction serving as a criterion variable. Separate Pearson product moment correlations were performed to identify relationships between predictor variables and each SEBT reach direction. Predictor variables most associated with each reach direction were initially entered into the regression models ($p < 0.30$). Alpha level was set at $p \leq 0.05$ for the regression models. **Results:** Eversion strength (90.74 ± 41.98 N) and TTB-ML (0.84 ± 0.28 s) significantly predicted SEBT-PM reach ($90.38 \pm 8.81\%$, $R^2 = 0.31$, $p < 0.01$) and SEBT-PL reach ($80.69 \pm 11.24\%$, $R^2 = 0.16$, $p = 0.04$). DROM (7.79 ± 3.48 cm) was a predictor of SEBT-ANT reach distance ($81.19 \pm 5.52\%$), however the overall regression model was not statistically significant ($R^2 = 0.08$, $p = 0.07$). **Conclusions:** Eversion strength and TTB-ML explained 31% of the variance associated with SEBT-PM reach distance and 16% of the variance associated with SEBT-PL reach distance. Although DROM did not significantly predict SEBT-ANT reach it explained 8% of the associated variance in this reach direction. These findings suggest that anterior and posterior reaches require different physical demands to perform the task. Therefore, rehabilitation strategies that emphasize eversion strength, DROM, and static balance exercises may help restore these aspects of dynamic postural control in individuals with CAI.

The Immediate Effect of Fatigue on Balance as Measured by the Balance Error Scoring System: A Systematic Review

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Context: The Balance Error Scoring System (BESS) is an instrument utilized to evaluate postural stability and has demonstrated its effectiveness as a reliable test for mild traumatic brain injuries (MTBI's). It is commonly used as a baseline and sideline measure. However, the test is often administered under varying conditions and error scores may not be indicators of injury, but of an external factor such as fatigue.

Objective: To determine the effect of fatigue on balance as measured by the BESS. **Data Sources:** Pubmed (1966-2013), SPORTDiscus (1975-2013), CINAHL (1980-2013), and Medline (1965-2013) online databases were searched using the following terms: balance, balance error scoring system, concussion, exertion, fatigue. The search was limited to human subjects and articles published in the English language. All sources were cross-referenced to identify additional relevant studies.

Study Selection: Studies were selected for inclusion based on the following criteria: (1) Fatigue test was administered and (2) BESS was administered for measuring balance. **Data Extraction:**

Two investigators completed this systematic review of four articles. The quality of study methods was evaluated using the Physiotherapy Evidence Database (PEDro). Data regarding pre- and post-test BESS scores for male and female subjects and the time frame between fatigue protocol and post-test were extracted. **Data Synthesis:** Based on the range of PEDro scores (5-6), studies were not considered to be high quality. However, given the design of each study and outcome measures used, the PEDro score was not an accurate

reflection of quality. We calculated percent difference to assess the change in error scores from pre- to post-test. Results ranged from 16% to 105% increase in error scores. Effect sizes were calculated by subtracting the pre-test means from the post-test means and dividing by the standard deviation of the pre-test. Effect sizes were moderate to high, ranging from 0.49 to 2.75. Significant differences were found between pre- and post-test BESS scores even after a brief rest period of three minutes. Overall, female participants demonstrated lower BESS scores at baseline and had smaller increases after fatigue. **Conclusions:** When tested immediately post exercise, it was shown that balance is negatively impacted by fatigue. Clinicians using BESS as an assessment to evaluate balance following a concussive blow should not administer the test immediately following fatiguing exercise, as it may result in inaccurate scores. We suggest that clinicians allow for athletes to recover longer than three minutes from intense exercise bouts prior to administering the BESS. More research should be conducted quantifying the time it takes to fully return to baseline BESS scores following fatiguing exercise, providing an appropriate timeframe to report accurate BESS scores. Word Count: 429

Free Communications, Poster Presentations: Doctoral Poster Award Finalists

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14095DOBI

14129DONE

Jogging Biomechanics After Exercise In Individuals With ACL Reconstructed Knees

Kuenze C, Hertel J, Weltman A, Diduch DR, Saliba S, Hart JM: University of Virginia, Charlottesville, VA; University of Miami, Coral Gables, FL

Context: Return to recreational activity is a common goal following ACL reconstruction (ACLR). Decreased peak knee flexion angle and external knee flexion moment during walking and jogging have been indicated as significant contributors to cartilage degeneration over time following knee joint injury. The effects of exercise on gait biomechanics following ACLR remain unclear and may have significant implications for long term knee joint health. **Objective:** To compare frontal and sagittal plane kinematics and kinetics between participants with a history of ACLR and healthy controls before and after exercise. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-three recreationally active healthy individuals (12M/11F: age = 21.9 ± 3.6 yrs, height = 168.5 ± 8.7 cm, mass = 69.6 ± 13.8 kg) and 20 recreationally active individuals with a history unilateral, primary ACLR at least 6 months prior to testing (11M/9F: age = 22.7 ± 5.2 yrs, height = 172.2 ± 7.2 cm, mass = 72.7 ± 13.7 kg, time since surgery = 33.9 ± 23.4 mo). **Intervention(s):** 30 minutes of continuous exercise comprised of repeated bouts of 5 minutes of uphill walking and 1 minute of jump squats and lateral hopping. **Main Outcome Measure(s):** Participants jogged on force plate imbedded treadmill at a pace of 9.66 km/h before and after exercise. Three-dimensional gait analysis using a 12 camera motion analysis system was performed. Kinematic and kinetic variable group means were reduced to 101 data points representing 0-100% of the gait cycle. Sagittal and frontal plane kinematics ($^{\circ}$) and kinetics (Nm/kgm) were measured in the involved limb for the ACLR group and compared to healthy participants across the gait cycle using 90% confidence

intervals (CI). Additionally, pre-exercise to post-exercise changes during the stance phase of gait (0-40% of the gait cycle) were calculated and plotted with 90% CI for both groups. Significant between group differences for all outcome measures were established as a consecutive 3% of the gait cycle in which 90% CI did not overlap. **Results:** Pre-exercise, ACLR participants had higher magnitude external hip flexion moments (10-12% and 22-24% of the gait cycle) and lower magnitude external knee flexion moments (9-11% and 14-16% of the gait cycle) during the stance phase. Following exercise, ACLR participants experienced higher magnitude declines in hip flexion angle (3-6% and 35-40% of the gait cycle), as well as smaller magnitude declines in knee flexion angle (9-28% of the gait cycle), ankle dorsiflexion angle (1-31% of the gait cycle), and trunk flexion angle (0-40% of the gait cycle) when compared to healthy controls. ACLR participants also experienced declines in external hip flexion moment (8-10% of the gait cycle) and increases in external knee flexion moment (8-10% of the gait cycle). **Conclusions:** Exercise related adaptations in lower extremity biomechanics were different in participants with a history ACLR when compared to healthy control participants despite an average of 33.9 months since surgery. ACLR participants exhibited gait patterns consistent with quadriceps avoidance accompanied by increased hip extensor contributions which may have implications for fatigue related injury risk.

Identifying The Specific Neural Motor Pathways Associated With Altered Postural Control Variability In Individuals With Chronic Ankle Instability

Terada M, Bowker S, Thomas AC, Hiller CE, Pietrosimone BG, Rice MS, Gribble PA: University of Toledo, Toledo, OH; University of Sydney, Sydney, New South Wales, Australia; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Altered postural control variability has consistently been found in patients with chronic ankle instability (CAI). Limited evidence suggests inhibition of multiple central nervous system (CNS) motor pathways may lead to postural control dysfunctions in CAI patients. Identifying the specific neural pathways associated with clinical impairments in CAI patients will provide a foundation for establishing effective therapeutic interventions for CAI. **Objective:** Investigate the influence of CAI on CNS excitability and postural control variability, and evaluate correlations between CNS excitability and postural control variables in CAI participants. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen participants with self-reported CAI (11M, 8F; 22.74 ± 4.41 yrs; 171.55 ± 9.31 cm; 77.73 ± 15.45 kg), and 15 healthy control participants (6M, 9F; 21.33 ± 3.81 yrs; 170.51 ± 9.12 cm; 68.12 ± 12.39 kg) volunteered. **Intervention(s):** Participants performed single-leg eyes closed static balance trials. Ankle kinematics in the sagittal and frontal plane and center of pressure trajectories in the anteroposterior (AP) and mediolateral (ML) directions were recorded during three, 20-second trials using a passive retroreflective marker motion capture system interfaced with a force platform. Spinal reflex excitability of the soleus muscle was assessed by eliciting Hoffman reflex (H-reflex) and muscle responses, while intracortical excitability was measured with transcranial magnetic stimulation using paired pulse paradigms for

short interval intracortical inhibition (SICI) and intracortical facilitation (ICF). **Main Outcome Measure(s):** Time-to-boundary (TTB) mean of minima (seconds) was used to assess postural control variability. The temporal structure of ankle kinematic variability was analyzed with approximate entropy (ApEn). The H:M ratio was calculated from the peak-to-peak amplitudes for the maximal H-reflexes and muscle responses. Paired pulse peak-to-peak motor evoked potential amplitudes were assessed for SICI and ICF. Independent t-tests were used to assess group-differences in each dependent variable. Pearson product moment correlations were used to assess the relationship between postural control and neural excitability measures. Significance was set a priori at $P < 0.05$. **Results:** The CAI group demonstrated significantly lower H:M ratio ($CAI = 0.38 \pm 0.19$, $Control = 0.52 \pm 0.18$, $t_{32} = -2.15$, $P = 0.04$) and TTB-ML values ($CAI = 1.30 \pm 0.51$ seconds, $Control = 1.78 \pm 0.65$ seconds, $t_{32} = -2.46$, $P = 0.02$), as well as greater ApEn values in frontal-plane kinematics ($CAI = 1.07 \pm 0.08$, $Control = 0.98 \pm 0.14$, $t_{32} = 2.47$, $P = 0.03$) compared to the control group. No significant group differences were observed for SICI ($P = 0.61$) and ICF ($P = 0.91$). There were significant, positive, moderate correlations between H:M ratio and TTB-ML ($r = 0.41$, $P = 0.04$) as well as between SICI and frontal-plane kinematic variability ($r = 0.45$, $P = 0.04$) in CAI participants. **Conclusions:** Levels of spinal reflex excitability and postural control variability were decreased and correlated with each other in CAI participants. Lower intracortical inhibition was associated with irregular patterns of ankle kinematics, and a greater inhibition was associated with periodic patterns in CAI participants, indicating the optimal state of kinematic variability may be achieved by proper levels of intracortical inhibition. This may lead to therapeutic interventions that target spinal and intracortical inhibition to improve clinical outcomes for CAI.

Ankle Injury Alters The Links Between Joint Laxity, Peripheral Sensation, And Cortical Activation

Needle AR, Swanik CB, Baumeister J, Higginson JS, Farquhar WB, Greaney JL, Kaminski TW: Appalachian State University, Boone, NC; University of Delaware, Newark, DE; University of Paderborn, Paderborn, Germany; Pennsylvania State University, University Park, PA

Context: The etiology of ankle instability remains misunderstood as functional deficits inconsistently correlate with mechanical or proprioceptive changes. Studies suggest altered muscle spindle afferent (MSA) and cortical activity exist among this patient subset, possibly disrupting the nervous system's perception of the joint. It remains unclear how the relationship between joint laxity, MSA and cortical activation are affected by injury. **Objective:** To investigate the relationship between joint laxity and sensation as quantified through micro-neurography and electroencephalography (EEG) among subsets of healthy and functionally unstable ankles, and copers. **Design:** Correlational. **Setting:** University laboratory. **Patients or Other Participants:** 42 participants were recruited with 27 providing usable data for analysis (12M/15F; 21.4 ± 3.0 yrs; 169.9 ± 12.2 cm; 63.8 ± 12.4 kg). Subjects were stratified into healthy control (CON, $n = 11$), functionally unstable (UNS, $n = 10$) and coper (COP, $n = 6$) groups using the Cumberland Ankle Instability Tool and history of injury. **Intervention(s):** Participants reported for a single test session during which they were fitted with an EEG cap following international standards. Subject laid supine as a modified ankle arthrometer was affixed to the ankle and a microelectrode was inserted into the common peroneal nerve at the level of the fibular head. The electrode was adjusted until recordings from MSA's were confirmed by an increased response to muscle stretch and silence during cutaneous stimulation and muscle shortening.

Anterior translations from -30 to 125N were performed on the test leg. **Main Outcome Measure(s):** Peak values of ankle laxity (mm), MSA activity (%max), and upper alpha (α -2) event-related desynchronization (ERD, %) at the contralateral somatosensory cortex were extracted for the first (early) and second (late) 1000ms of loading. Overall and within-group correlations between ankle laxity, MSA, and ERD were assessed using Pearson correlations. Between-group correlational differences were assessed using Fisher's r-to-z transformation ($\alpha = 0.05$). **Results:** Early and late laxity were 3.4 ± 1.4 mm and 4.0 ± 1.8 mm, respectively. Correlation main effects were observed for early laxity between late MSA ($r = 0.581$, $p = 0.039$), and both early ($r = 0.548$, $p = 0.002$) & late ($r = 0.468$, $p = 0.011$) ERD. Within-group correlations were observed in CON between late laxity and both early ($r = 0.652$, $p = 0.016$) & late ($r = 0.729$, $p = 0.004$) ERD. The UNS group displayed a significant correlation between early laxity and early MSA ($r = 0.652$, $p = 0.04$) that was significantly different from CON ($r = -0.490$, $p = 0.018$). **Conclusions:** Our results indicate that more compliant joints have greater sensation at the peripheral and central levels. This link was strongest when considering short-range stiffness, but CON appeared to have a consistent association across late-range stiffness as well. UNS differed from CON in the link between early laxity and MSA activity, suggesting alterations in the fusimotor system contribute to this pathology. These data suggest that sensory activity is tuned to an individual's laxity, and efforts to maintain this link may be critical to joint stability.

Positive And Negative Influences Impacting The Professional Commitment Of Collegiate Athletic Trainers

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Context: Professional commitment is a construct that centers on an individual's commitment to their profession and the organization that employs them. In the health care profession it is essential that providers impart quality care at all times. In athletic training, however, the demanding work environment can pose challenges in providing care. The collegiate clinical settings possess unique professional challenges to the athletic trainers (ATs). The numerous obligations may challenge the collegiate AT's motivation and commitment for a prolonged period of time throughout their career and can also make it difficult for the athletic training professional to stay excited. Lack of motivation and excitement may lead to an inability to offer quality care. There is limited research focusing on professional commitment in the context of athletic training. **Objective:** To evaluate factors that positively or negatively impact that commitment for ATs employed in the collegiate setting. **Design:** Structured, online asynchronous interviews. **Setting:** Full-time ATs working in the collegiate setting (Division I, II, or III) with at least 1 year of experience beyond a graduate assistantship. **Patients or Other Participants:** Thirty-three BOC certified ATs employed in the collegiate setting (Division I = 11, Division II = 9, Division III = 13) volunteered with an average of 10 ± 8 years of clinical experience. Data saturation guided the total number of participants. **Data Collection and Analysis:** Participants responded to a series of questions by journaling their thoughts and experiences via QuestionPro™. Multiple analyst triangulation and peer review were included as steps to establish data credibility. The

data was analyzed borrowing from the principles of general inductive approach. **Results:** Results were separated into two categories: 1) Positive and 2) Negative Influences impacting professional commitment. The emergent themes defining positive influences of professional commitment were professional responsibility, and co-worker support. Professional responsibility encompassed dedication to the profession, ardor to job responsibilities, dedication to student athletes, and commitment to education. Co-worker support speaks to the participants' ability to maintain professional commitment when they felt their co-workers were also committed to the profession. Negative influences of professional commitment included life stage, work overload, organization, and resources and facilities. Life stage reflects the influence age and family can play on career planning. The remaining 3 themes reflect the impact job demands, work scheduling, and limited personnel can have on maintaining commitment. **Conclusions:** Collegiate ATs demonstrate professional commitment, which is driven by their dedication to student athletes and athletic training students as well as their desire to advance the profession. There are however many factors that undermine their professional commitment. Understanding what may positively and negatively impact an AT's professional commitment is essential in developing retention strategies and highlighting an organization's influential role in helping ATs maintain their commitment.

Knee Stiffness Regulation Changes When Startled At Different Times

An YW, Swanik CB, Walls BL: University of Delaware, Newark, DE

Context: Altered neuromuscular control (NMC) is contributes to the high incidence of non-contact joint injury mechanisms. Recent studies have shown that unexpected, startling events alter preparatory (feed-forward) and reactive (feedback) systems needed for maintaining knee stability. These unanticipated events may lead to alterations in an athlete's ability to stiffen a joint normally. However, it remains unclear how the timing of startling episodes may interrupt joint stiffness regulation strategies necessary for functional stability. **Objective:** To examine how two different startle stimulus epochs influence knee joint stiffness regulation strategies. **Design:** Case-control study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Thirty-seven males (21.2 ± 1.9 yrs, 79.5 ± 12.5 kg, 178.6 ± 7.4 cm) and 29 females (20.9 ± 1.8 yrs, 62.5 ± 9.7 kg, 160.1 ± 32.0 cm) with no history of knee injury volunteered for this study. Subjects participated in either Short Startle Delay (SSD, 18 males and 18 females) or Long Startle Delay (LSD, 19 males and 11 females). **Intervention(s):** joint stiffness was examined by a custom-built device while electromyographic data from the quadriceps and hamstrings were collected. Subjects were instructed to relax and immediately provide maximum resistance to a perturbation from 30-degree to 70-degree flexion. Perturbations were randomly applied in 2 different conditions: control and acoustic startle (100dB, 50ms duration, 1000Hz). Only one startle was randomly triggered to each subject to avoid habituation. The time of startle was 100ms for the SSD group and 1000ms for the LSD group. **Main Outcome Measure(s):** Short-range ($0-4^\circ$) and the total-range ($0-40^\circ$) normalized knee joint stiffness ($\text{Nm}/^\circ/\text{kg}$) was compared across groups (2-levels) and conditions (2-levels) by using

2-way repeated-measures ANOVAs. Muscle activity (timing and amplitude) of the quadriceps and hamstrings was compared across groups (2-levels), conditions (2-levels), and muscles (4-levels) by using 3-way repeated-measures ANOVAs. **Results:** A significant main effect for the condition ($F_{1, 87} = 6.68$, $p = .011$) revealed the acoustic startle condition (0.047 ± 0.02 Nm/ $^{\circ}$ /kg) produced higher short-range stiffness values than the control condition (0.042 ± 0.01 Nm/ $^{\circ}$ /kg). A significant 2-way interaction effect was only observed for total-range stiffness ($F_{1, 87} = 6.046$, $p = .016$). Pairwise comparisons revealed total-range stiffness is greater in LSD group (0.043 ± 0.02 Nm/ $^{\circ}$ /kg) than SSD group (0.028 ± 0.021 , $p = 0.001$) under the acoustic startle condition. The significant main effect for group revealed LSD subjects had higher peak EMG activity ($p < 0.001$), 150ms before ($p = 0.003$) and 250ms after-perturbation ($p = 0.028$) in both the quadriceps and hamstrings. **Conclusions:** Our findings reveal startling events that occur 100ms before a knee perturbation result in lower total-range stiffness, and less muscle activation, whereas unanticipated events that occur 1 second before a knee perturbation cause higher short-range stiffness but normal reactive muscle contractions. This suggests that the timing of startling events may interrupt NMC and stiffness regulation strategies and that startling events preceding a knee load by 100 ms may be more adverse to knee stability than those occurring 1 second before a perturbation.

Free Communications, Poster Presentations: Concussion

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14302MOSP

Baseline Symptom Factors Differ Between Male And Female Interscholastic Athletes

Dunn K, Shepherd LI, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Recent data suggest that females may be at a higher risk for sustaining concussive injuries, especially in soccer and basketball. Furthermore, some studies have identified that females may present differently with respect to symptoms and neurocognitive function following concussion. For clinicians, understanding sex differences in baseline concussion assessment measures is important for interpretation of post-injury scores.

Objective: To investigate whether the factor structure of the graded symptom scale and individual symptom items differs between male and female adolescent athletes at baseline. **Design:** Cross-sectional. **Setting:** High school athletic training facilities. **Patients or Other Participants:** A convenience sample of 11,864 adolescent athletes (3912 females, 7952 males, age = 15.6 ± 1.2 years) participating in interscholastic contact sports.

Intervention(s): All subjects completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), as part of a concussion baseline assessment protocol. The independent variable was sex. **Main Outcome Measure(s):** Dependent variables included the 22-items of the graded symptom scale within ImPACT. Separate principal axis factor analyses with oblimin rotation and Kaiser normalization were conducted for each sex. Items were retained if loading factors were > 0.32 . Separately, Mann-Whitney U tests were used to evaluate sex differences for each of the individual symptom items.

Results: For males, a four-factor solution, consisting of 16 symptoms (Kaiser-Meyer-Olkin Measure = .93) was found: cognitive (28.2% of the variance) included: difficulty remembering, difficulty concentrating, balance problems, feeling slowed down, visual problems, foggy; emotional (4.3%) included: feeling emotional, sadness, nervousness; somatic (3.5%) included: nausea, vomiting, dizziness, headache; and sleep (2.0%) included: sleeping less, trouble

falling asleep, fatigue. A four-factor structure, consisting of 21 items, was identified for females (Kaiser-Meyer-Olkin Measure = .93): cognitive (29.5%) included: difficulty concentrating, difficulty remembering, foggy, sensitivity to noise, feeling slowed down, visual problems, sensitivity to light, drowsiness; somatic (3.9%) included: vomiting, dizziness, nausea, numbness-tingling, headache, balance problems, sleep (3.2%) included: sleeping less, trouble falling asleep, fatigue; emotional (2.2%) included: feeling emotional, sadness, nervousness, irritability. For the individual symptom items, females reported significantly higher symptom scores ($p < .001$) for headache, $.57 \pm 1.1$ vs $.43 \pm .96$, irritability ($.41 \pm 1.0$ vs $.28 \pm .83$), nervousness ($.43 \pm 1.0$ vs $.33 \pm .87$), feeling emotional ($.48 \pm 1.1$ vs $.19 \pm .69$), sadness ($.36 \pm .93$ vs $.26 \pm .77$) and sleeping less ($.72 \pm 1.3$ vs $.61 \pm 1.2$). **Conclusions:** Sex differences were noted in both the baseline factor structure and severity reports of some individual symptom items. While the general factor categories were similar, there were differences in the loading of some symptoms including: sensitivity to noise and light, balance problems, numbness and irritability. Clinicians should expect higher baseline symptom scores in female athletes and take this into account during the post-injury assessment of symptoms and over the course of recovery. Future studies should continue to evaluate the psychometric properties of the symptom scale to develop an evidence-based symptom evaluation for concussion assessment.

14214FOSP

Baseline Concussion Symptomology In A Collegiate Rodeo Population

Boham M, Cripps AE, O'Connell-Brock K: New Mexico State University, Las Cruces, NM

Context: Rodeo is an extreme sport with many injuries. Rodeo competitions are divided into two categories: rough stock (bull riding, bareback riding, and saddle bronc riding) and timed events (tie-down roping, steer wrestling, team roping, barrel racing, break away roping, and goat tying). Bull riding is one of the most dangerous sports in the world, with many injuries occurring to the head and neck. Concussion injury incident rates in rodeo are reported at 3.4/1000 contact exposures which is nearly ten times the rate for American football at 0.37/1000 exposures. Rodeo is an understudied population and as such there is little research examining the specific injury and symptoms of concussion in rodeo athletes. **Objective:** To determine the presence of concussion related symptoms in a "healthy" collegiate rodeo population during routine baseline testing.

Design: Cross-sectional study. **Setting:** University research laboratory. **Patients or Other Participants:** 191 collegiate rodeo participants (67 females, age 19.97 ± 1.35 years, height 166.21 ± 6.23 cm, mass 61.49 ± 10.11 kg; 124 males, age 20.84 ± 2.39 years, height 178.08 ± 6.36 cm, mass 77.54 ± 12.55 kg). **Intervention(s):** All participants completed the computerized ImPACT concussion assessment prior to the start of rodeo competitions in conjunction with pre-participation examinations. From this assessment, the independent variables (gender [male, female]; and event [rough stock, timed events]) were used for analysis. **Main Outcome Measure(s):** Total symptom score was identified as the dependent variable. Descriptive statistics were calculated. Two one-way ANOVAs were used to calculate differences between: 1) total symptom scores and gender; and 2) total symptom scores and rodeo event. Alpha level was set a priori at 0.05. **Results:** Females reported a significantly greater number of concussion symptoms ($t_{190} =$

4.221, $p = 0.041$, 95% confidence interval [CI], 0.110-5.382). 64.4% (123/191) of participants reported concussion symptoms during the baseline testing; 41.5% (51/123) of females and 58.5% (72/123) of males reported at least one concussion symptom. Participants had an average of 11.24 ± 9.14 symptoms for females and 10 ± 9.16 for males respectively. There were no statistical differences between rodeo events ($t_{190} = 0.014$, $p = 0.907$, 95% CI, -2.740-3.085).

Conclusions: Over half of the participants reported concussion symptoms during baseline testing even though a healthy population was tested. Rodeo participants, particularly the females, reported a significant number of concussion symptoms regardless of event. Due to the high incidence of symptom reported during baseline concussion assessments; it is imperative for health care providers to collect and analyze baseline data. Further investigation is needed to determine if previous concussion history has a significant impact on the number of concussion symptoms reported during baseline testing and if the presence of symptoms at baseline testing influences the incidence of concussion or the time to return to competition after concussion.

Post-Injury Confirmatory Factor Analysis Of The Graded Symptom Scale And Change In Factor Scores Over 21 Days In Concussed Adolescent Athletes Bay RC, Valovich McLeod TC: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

Context: In a recently published manuscript (2012), the authors presented a 4-factor solution for the 22-item Post-Concussion Symptom Scale (PCSS), based on 1438 high school and college participants who had suffered a sport-related concussion within the past 7 days. Their solution, using an exploratory approach, discarded nausea, balance problems, sleeping more than usual, irritability and vision problems based on low primary factor loadings or high cross-factor loadings. In this report, the proposed 4-factor solution was tested and cross-validated using a confirmatory approach on a novel dataset with data collected from concussed high school athletes. **Objective:** To test the proposed factor solution for the PCSS on a novel set of athletes who had suffered a sport-related concussion within 7 days, using a confirmatory approach, and to estimate the monotonic relationship of derived factor scores with number of days post-concussion. **Design:** Prospective cohort. **Setting:** High school athletic training facilities. **Patients or Other Participants:** Adolescent athletes ($n = 201$, 149 males, 52 females, age = 16.0 ± 1.2) participating in interscholastic contact sports, who suffered a sport-related concussion diagnosed by an athletic trainer and completed the PCSS between 1-and-7 days post-concussion. **Intervention(s):** Subjects used for the confirmatory phase of the study completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) test within 7 days post-concussion. They repeated the PCSS at least once during the subsequent 21 days. Independent variables included the 22 individual symptom items, as well as the number of days post-concussion. **Main Outcome Measure(s):**

Dependent variables included factor scores derived from an asymptotically distribution-free confirmatory factor analysis. Spearman correlation coefficients (r_s), were used to estimate the monotonic relationships between factor scores and number of days post-concussion, up to 21 days. **Results:** The proposed 4-factor solution was supported using a confirmatory approach. The 4 factors (cognitive-fatigue-migraine, affective, somatic and sleep) were moderately inter-correlated ($r = .27$ to $.57$, all $p < .001$). Both the $\chi^2/DF = 2.97$ and root mean square error of approximation (RMSEA) = $.099$ (95% CI: $.087$, $.112$) indicated a moderately acceptable fit of the proposed model to a novel dataset. The Comparative and Incremental Fit indices (both $= .94$) were acceptable. Scale scores derived from the factor analysis showed a decreasing monotonic relationship with number of days post-concussion, over 21 days (437 PCSS administrations): Cognitive-Fatigue-Migraine, ($r_s = -.50$) Affective ($r_s = -.31$), Somatic ($r_s = -.27$) and Sleep ($r_s = -.22$) scales (all $p < .001$). **Conclusions:** The exploratory 4-factor solution for the PCSS is supported using a confirmatory approach, and cross-validated on a novel dataset. The significant, negative correlations of symptom report and days post-concussion for all factors support the validity and usefulness of the PCSS for tracking recovery from concussion. However, moderate inter-factor correlations suggest that clinicians should not focus only on the total symptom severity score, but assess prominent symptoms to better tailor treatment following concussion. Funded by a grant from the National Operating Committee on Standards for Athletic Equipment (NOCSAE).

Identifying And Differentiating Ehrlichiosis From Post-Concussive Symptoms In A High School Football Athlete

Rafeldt D, Butterfield TA: University of Kentucky, Lexington, KY

Background: A sixteen year old African-American male football player in a rural setting presented acutely with chief complaints of headache, nausea, hyperthermia, gastrointestinal distress and general malaise following a non-contact practice in mild weather conditions. He was unable to provide any information on a potential physical mechanism of injury, but described experiencing symptoms for approximately two hours prior to communication with athletic training staff. Three weeks prior to presentation, the patient was diagnosed with a concussion following a direct collision during competition. He was brought through an appropriate return to play progression and was asymptomatic for the previous ten days. A physical examination revealed mild systemic muscular weakness. His neurocognitive assessment revealed no deficits compared with his previously established baseline data. A cranial nerve assessment revealed no deficits. No epidermal abnormalities were observed. Oral temperature assessment yielded 99.2 degrees Fahrenheit. Blood pressure was recorded as 124/86 with radial pulse 76 bpm and normal capillary refill. He had no previous general medical conditions, and no known allergies. The patient was instructed to continue hydration and exercise cognitive rest. **Differential Diagnosis:** Concussion, influenza, dehydration, hyperthermia, hypoglycemia, bacterial meningitis, mononucleosis, Lyme disease, anaplasmosis, gastroenteritis. **Treatment:** The patient was treated acutely by administering a commercial electrolyte beverage with an added electrolyte tablet, as well as rest in a cool environment. After twenty four hours with no alleviation in symptoms and consultation with the athletic trainer, the patient was taken to an emergency care unit. Lumbar puncture results were ruled as negative for meningitis. Extensive blood testing showed

atypical lymphocytes, neutropenia, increased levels of serum transaminases, and the presence of the bacteria ehrlichia chaffeensis. The patient was diagnosed with Ehrlichiosis and was immediately administered intravenous antibiotics. He was kept for observation over five days in the hospital, at which point symptoms resolved and blood test values returned to normal levels. He was prescribed oral Doxycycline to continue to take for a ten day duration, at which point an outpatient follow-up visit occurred, resulting in medical clearance to begin a return to participation progression. **Uniqueness:** Ehrlichia chaffeensis is a bacteria carried by the Lone Star tick, and a diagnosis of Ehrlichiosis indicates a chronic, systemic infection following a tick bite. Although the diagnosis of Ehrlichiosis is very rare in collegiate athletics, the overall incidence of tick-borne illnesses is increasing worldwide, due to its association with climate change. As climate temperatures have increased over the past decade, so too has the insect population, and the incidence of tick bites. Ehrlichiosis and other insect-borne infections require immediate care in order to obtain optimal patient outcomes, and can be life-threatening if left untreated. However, these infections may present as musculoskeletal pathology, and should be ruled out during a thorough physical examination, particularly in athletes participating in outdoor sports. A review of the literature revealed that during the years of 1966-2005, there was one published incident of a disease outbreak due to tick bite during competitive sports in the United States. Because less than fifty percent of people bitten by a tick ever see the insect, care should be taken to limit the sharing of equipment, and inspections should be done to assure unwashed equipment is insect free. **Conclusions:** Establishing a correct differential diagnosis requires extensive evaluation of the thermoregulatory, musculoskeletal, neurovascular, and epidermal systems. A meticulous and systematic patient history should be taken in order to rule

out serious pathology, and provide adequate resources and referrals. In addition, careful inspection of equipment worn outside should be performed to limit potential insect-induced illnesses.

Return-To-Play (RTP) Probabilities Following Concussion In Football Are Not Strongly Affected By National Collegiate Athletic Association (NCAA) Division

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Context: Physiological effects on concussion resolution have been studied; however, direct contrast of the probability of return-to-play (RTP) timelines amongst National Collegiate Athletic Association (NCAA) Divisional levels has not been explored. **Objective:** Compare RTP probabilities stratified by National Collegiate Athletic Association (NCAA) Division following new concussions sustained while playing football. **Design:** Observational, epidemiological. **Setting:** Secondary analysis of the NCAA Injury Surveillance System. **Patients or Other Participants:** Collegiate football athletes with first-time (new) concussions sustained during school-sanctioned athletic participation. **Intervention(s):** New concussions were stratified by NCAA Division in which the individual was participating when injured: Division 1 (D1), Division 2 (D2), or Division 3 (D3). A new concussion was defined as an acute concussion with no prior history of that same injury. **Main Outcome Measure(s):** Kaplan-Meier (KM) estimators[censored data] were stratified by Division and used to statistically compare the probability of time until RTP after new concussion for each division. Cases for which the athlete did not RTP (medical disqualification or season ended before the athlete was released) were considered censored. For the estimators, each concussion was analyzed based the number of days until RTP. Alpha levels were set at $p < .05$. **Results:** In total, 1189 [52 censored] concussions were analyzed (D1 = 605 [27 censored]; D2 = 125 [4 censored]; D3 = 459 [21 censored]). The overall estimator indicated as significant difference amongst the 3 Divisions (median RTP [IQR] = 7 days [4, 10 days], $p = .03$), therefore, separate comparisons were made. Individually, the median [IQR] days until

RTP for each Division were: D1 = 6 days [4, 9 days], D2 = 6 days [4, 9 days], and D3 = 7 days [4, 11]. There was not a significant difference between RTP probabilities for D1 v D2 ($p = .18$) or D1 v D3 ($p = .07$). There was a significant difference for D2 v D3 ($p = .01$). Selected RTP probabilities are based on the overall estimator median and IQRs; these are presented as RTP [exact 95% CIs]. For a 3-day return, D1 = 24.5% [20.7, 28.8], D2 = 23.6% [16.2, 33.3], and D3 = 21.9% [17.7, 26.8]. For a 7-day return, D1 = 77.6% [71.5, 83.3], D2 = 81.1% [65.5, 91.3], and D3 = 67.9% [60.1, 74.4]. For a 10-day return, D1 = 95.1% [87.3, 98.8], D2 = 94.3% [73.5, 99.8], and D3 = 93.4% [85.0, 97.5]. **Conclusions:** Although statistically significant, RTP probabilities were not meaningfully different amongst the NCAA Divisions. Further, it is evident that RTP timelines following concussion are aligned with standards of practice. Although psychosocial factors associated with upper Division play may affect RTP timelines, this was not overtly apparent for concussions sustained in football. A consideration for RTP that is unique to football is participation schedule: many teams refrain from participation for 1 to 2 days following a competition, therefore not allowing participation (based on concussion) these days will have little impact on the team. However, knowledge of probability of RTP for 3 days out from a concussion and longer allows for more informed prognosis, thereby allowing better planning for coaches, ATs, and athletes.

Resultant Linear Acceleration And Rotational Head Velocity In Junior And Senior Taekwondo Athletes: A Pilot Study

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Context: Head injuries in taekwondo are reported to have an incidence four times greater than in American football. To understand the biomechanics of head injury in this sport an analysis of the impacts in a controlled laboratory setting may provide a framework for improving safety of the athletes. **Objective:** To compare head impacts by junior and senior taekwondo athletes following a turning kick. **Design:** Between groups. **Setting:** The athletes kicked the head of a Hybrid III Crash Test Dummy in a biomechanics laboratory. **Patients or Other Participants:** Two junior (13.0 ± 1.4 years, 62 ± 2.8 kg, 141.6 ± 41.0 cm) and five senior male (27.0 ± 8.8 years, 80.6 ± 11.9 kg, 184.0 ± 10.1 cm) taekwondo athletes were recruited. All participants read and signed informed consents/assents prior to participation. **Intervention(s):** The turning kick was performed five times on a Hybrid III head-neck complex by each athlete. The Hybrid III was instrumented with a tri-axial accelerometer (PCB Piezotronics-356A66) and an angular rate sensor (DTS ARS-12K) mounted inside the Hybrid III head. The Hybrid III was fixed to a height-adjustable frame and fitted with a protective taekwondo helmet. Dummy head height was positioned to each athlete's standing height. Acceleration data were captured using a customized processing program (LABVIEW Signal Express 2013, National Instruments, USA) and processed in accordance with SAE J211-1. **Main Outcome**

Measure(s): The dependent variables were head maximum resultant linear acceleration (RLA) and maximum resultant head rotational velocity (RRV). A Mann-Whitney U test was used to compare the RLA and RV of the turning kick between junior and senior taekwondo athletes. The level of significance was set to an effect size of 0.20. **Results:** There were significant differences in RLA (juniors: 68.6 ± 21.4 G vs. seniors: 74.1 ± 46.9 G, $r = 0.45$, 95% CI: 0.27–0.66) and in RV (juniors: 19.5 ± 3.2 rad/s vs. seniors: 22.6 ± 5.8 rad/s, $r = 0.33$, 95% CI: 0.18–0.55) but the latter is not clear. **Conclusions:** It is worrisome that junior athletes may be subject to similar impacts produced by adult competitors. This study provides a glimpse into the possible impacts of rotational velocities experienced during full-contact competition. These data may provide a stepping-stone towards developing more age-specific designs for protective headgear.

The Hook Punch, Resultant Linear Acceleration And Rotational Head Velocity In Junior and Senior Boxers: A Pilot Study

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Context: Head injuries in boxing are a typical characteristic of the sport. To our knowledge, no study to date provides analyses on head impact biomechanics of young boxers. **Objective:** To investigate head impact mechanics of punches in junior and senior boxers. **Design:** Between groups. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Three elite junior (14.6 ± 0.6 years, 159.6 ± 20.3 cm, 57.0 ± 15.4 kg,) and three senior male (21.6 ± 5.5 years, 176.6 ± 7.4 cm, 67.0 ± 10.4 kg) amateur male boxers were recruited. All participants read and signed informed consents/assents prior to participation. **Intervention(s):** The independent variable was competition age group (i.e., junior or senior). The hook punch was performed five times on a Hybrid III Crash Test Dummy head-neck complex by each boxer. The Hybrid III was instrumented with a tri-axial accelerometer (PCB Piezotronics-356A66) and an angular rate sensor (DTS ARS 12k) mounted inside the head. The Hybrid III was fixed to a height-adjustable frame and fitted with a protective boxing helmet. Dummy head height was positioned to each boxer's standing height. Acceleration data were captured using a customized program (LABVIEW Signal Express 2013, National Instruments, USA) and processed in accordance with SAE J211-1. **Main Outcome Measure(s):** The dependent variables were head maximum resultant linear acceleration (RLA) and maximum resultant head rotational velocity (RV). A Mann-Whitney

U test was used to compare the RLA and RV of the hook punch. The level of significance was set to an effect size of 0.2. **Results:** There were no significant differences in both the RLA between junior boxers when compared to their senior counterparts (57.8 ± 25.7 g vs. 61.6 ± 16.0 g, $p=0.286$, $r=0.1$). Similarly there also was no significant difference, however there is a medium effect size in RV (juniors: 23.5 ± 9.8 rad/s vs. seniors: 28.9 ± 3.3 rad/s, $p=0.052$, $r=0.28$). **Conclusions:** This is the first known laboratory study comparing head impacts among junior and senior amateur boxers. The results indicate that young boxers impart larger impacts than their older counterparts in this cohort. It is alarming that the junior boxers recorded impacts similar to those of their Olympic counterparts.

The Validity Of Single-Item Patient-Rated Outcome Measures In Concussed Adolescent Football Athletes

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Context: Concern about time to administer, complete, and score multi-item patient-rated outcome measures (PROMs) has been expressed as an impediment to their use. Single-item PROMs (SI-PROMs) may provide a more feasible health status assessment when time is limited. However, no studies have reported on the validity of SI-PROMs in specific patient populations, such as concussed football athletes. **Objective:** To determine the concurrent and longitudinal validity of global ratings of change (GROC), daily activities (GRODA), and athletic activities (GROAA) SI-PROMs in concussed adolescent football athletes. **Design:** Longitudinal. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of 94 interscholastic male adolescents (age = 15.7 ± 1.1 ; grade = 10.1 ± 1.1) who suffered a concussion due to football participation. **Intervention(s):** Participants were administered the GROC (13 point Likert scale; 1 = a very great deal worse; 13 = a very great deal better), GRODA (7-point Likert; 0 = no difficulty, 6 = cannot perform daily activities), GROAA (7-point Likert; 0 = no difficulty, 6 = cannot perform athletic activities), Pediatric Quality of Life Inventory (PedsQL), Multidimensional Fatigue Scale (MFS) and Headache Impact Test (HIT-6) at days 3 (D3), 10 (D10), and 30 (D30) post-concussion. **Main Outcome Measure(s):** Dependent variables included the scores on the GROC, GRODA, and GROAA. Descriptive statistics [means, standard deviation (SD)] are reported for all variables. Correlations (Pearson's r) were conducted between the SI-PROMs and the PedsQL total score, MFS general (MFS-GF), sleep (MFS-SF), and cognitive (MFS-CF) fatigue subscales, and the HIT-6 total score at each post-injury time

point. Longitudinal validity was determined through repeated measures analysis of variance, with pairwise differences assessed using Bonferroni-correction ($P < .05$). **Results:** Moderate correlations were found between the SI-PROMs and the PedsQL total score at D3 ($r > .30$, range = .30-.56), D10 ($r > .47$, range = .47-.59), and D30 ($r > .51$, range = .51-.72). Fair to moderate correlations were found for the SI-PROMs and the MFS at D3 (MFS-GF: $r > .25$, range = .25-.56; MFS-SF: $r > .24$, range = .24-.47; MFS-CF: $r > .26$, range = .26-.45), D10 (MFS-GF: $r > .36$, range = .36-.52; MFS-SF: $r > .32$, range = .32-.50; MFS-CF: $r > .30$, range = .30-.58), and D30 (MFS-GF: $r > .40$, range = .40-.49; MFS-SF: $r > .41$, range = .41-.47; MFS-CF: $r > .36$, range = .36-.64). Fair to moderate correlations were found between the SI-PROMs and the HIT-6 at D3 ($r > .18$, range = .18-.56), D10 ($r > .38$, range = .38-.61), and D30 ($r > .37$, range = .37-.49). GROC scores improved between D3 (7.1 ± 1.4), 10 ($8.4 \pm .98$) and D30 ($8.6 \pm .90$), $P < .001$. GRODA scores improved between D3 (1.4 ± 1.3), D10 ($.76 \pm 1.0$), and D30 ($.17 \pm .56$), $P < .001$. GROAA scores improved between D3 (3.5 ± 2.2), D10 (2.4 ± 2.5), and D30 ($.34 \pm 1.2$), $P < .001$. **Conclusions:** The GROC, GROD, and GROAA are moderately related to common multi-item PROMs used in concussed athletes, suggesting that the content of those SI-PROMs is relevant to football athletes suffering from concussions. Because only moderate correlations were noted, SI-PROMs should be used with multi-item PROMs. Additionally, the improvement of GROC, GROD, and GROAA scores over a post-injury time period of 30 days suggests that these SI-PROMs respond as expected to patient recovery. Funded by the National Operating Committee on Standards for Athletic Equipment.

Characteristics Of Patients Presenting To A Concussion Clinic Program following Emergency Department Referral

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Context: The number of young athletes presenting to the emergency department (ED) with head injury has skyrocketed. Many of these patients are referred to a concussion clinic or to their Athletic Trainer for follow-up care. **Objective:** To compare characteristics and early outcomes at first concussion clinic visit between patients referred from the ED (with or without Emergency Medical Services (EMS) transport) vs. those with no-ED referral. **Design:** Retrospective cohort. **Setting:** Concussion clinic. **Patients and Other Participants:** Pediatric patients (age 10-18 years), with a goal of returning to sport, presenting to a hospital system's dedicated concussion clinic from August 2009-July 2011, within 10 days of their concussion ($n = 245$; age = 14.2 ± 2.1 years; 78% male). **Intervention(s):** Patients completed a systematic concussion assessment including a clinical interview, symptom assessment (Graded Symptom Checklist – GSC), neurocognitive (Immediate Postconcussion Assessment and Cognitive Test – ImPACT) and balance testing (Balance Error Scoring System – BESS), and physician evaluation. ED Referral vs. no-ED referral to the clinic and EMS transport vs. no-EMS transport served as the comparators. **Main Outcome Measure(s):** Demographic factors (age, gender, sport contact level, race, family history of headache/migraine, previous history of head trauma); injury factors (mechanism, loss of consciousness (LOC), amnesia); first clinic visit and time of injury (TOI) symptoms endorsed and total symptom severity (GSC); first clinic visit ImPACT composite domain scores, BESS total scores and management

recommendations were examined for univariate associations with ED referral and/or EMS transport using independent Student's t-tests for continuous variables and Chi-Square tests for categorical variables (a priori $\alpha < .05$). **Results:** Of the 245 patients, 59% reported a previous history of head trauma and 55% were ED referrals. Twenty percent of ED referrals were transported by EMS. ED referrals were more likely to be in the younger age group (OR = 2.1; 95% CI: 1.3, 3.5; $P = .004$) and more likely to report TOI numbness (OR = 3.5; 95% CI: 1.6, 7.7; $P < .001$), greater TOI symptom severity (OR = 2.0; 95% CI: 1.0, 4.0; $P = .043$), LOC (OR = 2.1; 95% CI: 1.1, 3.9; $P = .018$), and amnesia (OR = 2.3; 95% CI: 1.3, 3.9; $P = .004$). There were no other associations with ED referral for demographics, injury factors, symptom severity, cognitive outcomes, or balance outcomes at TOI or first clinic visit. ($P > .05$) Those transported by EMS to the ED were more likely to have a non-sport related mechanism, report LOC, TOI numbness, confusion, neck pain, first visit balance problems, dizziness, photophobia, memory problems and neck pain ($P < .05$). **Conclusions:** Overall, patients referred from the ED were more symptomatic at TOI but at initial follow-up looked clinically similar to those without ED referral. However, those transported by EMS to the ED were more symptomatic upon first clinic evaluation and may represent a group with more severe injury. Further study is required to determine if outcome differences exist beyond the first follow-up visit.

Normative Values For The SCAT3 In High School Athletes

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Context: Sport-Related Concussion (SRC) is increasingly recognized as a major public health concern in the United States. In March 2013, the newest version of the Sport Concussion Assessment Tool (SCAT3) was published as a tool to help provide a more complete clinical assessment of concussed athletes. Normative values of the SCAT3 have not been reported in high school athletes. **Objective:** To determine normative SCAT3 values in a cohort of high school athletes. **Design:** Prospective cohort study. **Setting:** 7 high schools in Wisconsin. **Patients or Other Participants:** A convenience sample of 758 high school (Female = 187, Male = 571) athletes (age = 15.9 + 1.1 yrs.). **Intervention(s):** During summer 2013, the SCAT3 test battery was administered at participating schools. Subjects also completed a short survey to provide information regarding their sex, sport participation status (19 sports), and previous history of SRC in the past 12 months. **Main Outcome Measure(s):** Mean scores (95% CI) were calculated for Total Number of Symptoms (TS, 0-22), Symptom Severity (SS, 0-132), total Standardized Assessment of Concussion (SAC, 0-30), each SAC component [Orientation (OR, 0-5), Immediate Memory (IM, 0-15), Concentration (CO, 0-5), Delayed Recall (DR, 0-5)] and Balance Error Scoring System total errors (BESS, 0-20, floor and foam pad combined). Wilcoxon rank sum tests ($p < 0.05$) were used to determine if there were significant differences in scores based on sex and previous history of SRC for each SAC component. **Results:** Mean scores (95% CI) were: TS 1.32 (1.31, 1.33); SS 2.15 (1.80, 2.48); total SAC 26.12 (25.90, 26.26); OR 4.69 (4.64, 4.72); IM 14.25 (14.15, 14.31); CO 3.25 (3.15, 3.33); DR 3.93 (3.85, 3.99); BESS total errors 13.46 (13.05, 13.79). There were no differences

in scores based on sex for IM ($p = 0.583$), CO ($p = 0.384$), DR ($p = 0.221$), and BESS ($p = 0.661$). Males reported a higher mean TS ($p = 0.001$) and SS ($p = 0.001$), however scored lower on total SAC ($p = 0.026$), and OR ($p = 0.021$). There were no differences in scores based on previous history of SRC in the past 12 months for total SAC ($p = 0.452$), OR ($p = 0.708$), IM ($p = 0.512$), CO ($p = 0.670$), DR ($p = 0.638$), and BESS ($p = 0.219$). Athletes with a history of previous SRC reported a higher mean TS ($p = 0.001$) and SS ($p = 0.001$). **Conclusions:** SCAT3 normative values indicate athletes with a previous history of SRC within the past twelve months reported a higher TS and SS; no differences were found for SAC, OR, IM, CO, DR, or BESS. Regardless of previous history of SRC, males reported a higher TS and SS, however they scored lower on the total SAC. No differences were found based on gender for IM, CO, DR, and BESS.

Comparison Of Sport Concussion Assessment Tool 2 Scores To Computerized And Paper And Pencil Neurocognitive Assessments Following Sport Concussion

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Context: The Sport Concussion Assessment Tool 2 (SCAT2) is a convenient test that has been recommended for sport-related concussion assessment. Neurocognitive tests are not commonly administered until symptoms have subsided, while the SCAT2 can be administered at any time without equipment. No comparisons have been made between the SCAT2 and other commonly used neurocognitive tests. **Objective:** To compare scores on the SCAT2 to scores from computerized and paper and pencil neurocognitive assessments in healthy and concussed athletes. **Design:** Case-control. **Setting:** Sports medicine clinic. **Patients or Other Participants:** Six concussed athletes (5 males, 1 female; age: 20.5 ± 1.05 years) and 6 age- and gender-matched healthy controls were recruited from NCAA Division I athletic teams. Concussion was confirmed by physician diagnosis. **Intervention(s):** The SCAT2, the Concussion Resolution Index (CRI), and 3 paper and pencil tests including the Hopkins Verbal Learning Test-Revised (HVLTR), Trail Making Tests (TMT), and the Ruff 2 and 7 Selective Attention Test (RUFF) were administered. Concussed subjects were tested 48 to 72 hours after injury (average = 58 ± 11.8 hours). **Main Outcome Measure(s):** Scores of each test were calculated using standard guidelines outlined by each test manual. Outcomes were as follows for each: SCAT 2 – total score, symptoms, symptom severity, the standardized assessment of concussion (SAC) total score and subdomains, and the modified Balance Error Scoring System; CRI – simple and complex reaction time and processing speed; HVLTR – total recall, delayed recall, percent retained, and recognition

index; TMT – time to complete each test and number of errors; RUFF – controlled selection speed and accuracy, automatic detection speed and accuracy, total speed, and total accuracy. We compared all outcomes between groups using Mann-Whitney U tests and calculated correlations between SCAT2 outcomes and the outcomes from CRI, HVLTR, TMT, and RUFF using Spearman's Rho. Alpha was set to $P \leq 0.05$.

Results: Significant differences were found between groups on SCAT2 total scores [Concussed: 82 (70-94); Healthy 96.5 (95-100); $P = 0.004$], symptoms [Concussed: 10.5 (0-22); Healthy: 22 (22-22); $P = 0.022$], symptom severity [(Concussed: 18 (0-53); Healthy: 0 (0-0); $P = 0.022$], SAC total [(Concussed: 25.5 (25-28); Healthy: 29 (27-30); $P = 0.014$], SAC concentration [(Concussed: 3 (2-4); Healthy: 5 (5-5); $P = 0.004$], and CRI simple reaction time [(Concussed: 0.46 (0.4-0.81); Healthy: 0.33 (0.31-0.47); $P = 0.036$]. SCAT2 total symptoms ($\rho = 0.641$; $P = 0.025$) and SCAT2 without symptoms ($\rho = -0.689$; $P = 0.013$) were significantly correlated with CRI simple reaction time. SAC delayed recall was significantly correlated with CRI processing speed ($\rho = -0.702$; $P = 0.011$).

Conclusions: The SCAT2 was able to discriminate concussed athletes from healthy at 48 to 72 hours post-injury. This was supported with between-group differences in simple reaction on the CRI and correlations between SCAT2 outcomes and CRI simple reaction time and processing speed. While it appears that symptoms played a significant role in the SCAT2's ability to recognize concussion, its multi-faceted approach makes it a good tool to use in managing sport-related concussion.

Does Item Order/Placement Play A Role In Immediate Memory Assessment?

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Context: It is common for memory to be assessed when evaluating a concussion. Two assessment tools used to assess memory that are included in the Sports Concussion Assessment Tool-3 (SCAT 3) are the Standardized Assessment of Concussion (SAC) and Maddock's Score. Though memory assessment is common with concussions, little attention has been paid to the factor structure of these tools. **Objective:** To evaluate the role of item placement/order for the immediate memory section of the SAC using factor analysis. **Design:** Cross-sectional design. **Setting:** Laboratory. **Patients or Other Participants:** Two-hundred seventy-three participants with no history of concussion in the previous 6 months (aged 21.2 ± 1.8 years; $n=121$ men, $n=152$ women) volunteered for this study. **Intervention:** Participants completed a health history questionnaire. The participants were administered new 10 word lists which were developed to be similar to the word lists found on the SAC. The word lists were designed to be more difficult by increasing word length, examining relationships among items, and determining rhyming patterns. The administration of the immediate memory section was changed by increasing the immediate memory to 10 words repeated 1 time. **Main Outcome Measure(s):** The immediate memory items were analyzed using Principle Axis Factoring (PAF) with a varimax rotation. The factors were confirmed using Parallel Analysis (PA). **Results:** Three factors were extracted from the Principle Axis Factoring analysis which was confirmed through Parallel Analysis. The mean eigenvalues approach of parallel analysis was used to determine the number of factors, yielding three factors (PAF eigenvalues > PA eigenvalues: Factor 1: $1.796 > 1.313$, Factor 2: $1.327 > 1.214$, Factor 3: $1.129 > 1.140$). The first factor included items (rotated-factor weights): 9 (.574), 10 (.441), and 8 (.301).

The second factor included items: 1 (.667), 2 (.337), 4 (.132), 3 (.036), 6 (.015) and 5 (-.052). The third factor included item 7 (.507). These factors were also confirmed when including two additional word lists of 10. **Conclusions:** Considering the results from the Principle Axis Factoring, it appears that item placement and order does play a role when developing memory lists. It seems that participants choose between two groups of words; either group 1 (beginning of the word list) or group 2 (end of the word list). Items 1 through 6 can all be found on one factor which makes sense if the participants started by remembering words at the beginning of the word list. This coincides with the idea that people tend to remember between 5 and 6 words at a time. Items 8 through 10 were also on the same factor, which makes sense if participants started to remember words towards the end of the word list first. Because Item 7 is between the normal memory ranges it makes sense that it has its own factor.

Concurrent Validity Of The Balance Error Scoring System Performed With Skates

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Context: Clinical balance tests, such as the Balance Error Scoring System (BESS), are an important component to a multi-faceted concussion evaluation. The BESS is widely used by clinicians to acutely evaluate potential brain injury and inform return-to-play decisions. Due to its ability to save time during competition, clinicians often prefer to administer the BESS while hockey players wear his or her skates, especially if testing will rule out concussion and permit the athlete to return to competition. Despite this common practice, baseline testing is usually conducted barefoot. There is no evidence to concurrently validate that the traditional BESS (barefoot) can be compared to the BESS with skates on. **Objective:** To determine the concurrent validity of the BESS with skates on compared to the traditional BESS. We hypothesized that participants would have significantly worse ($P < 0.05$) BESS scores with skates on compared to the traditional barefoot test. **Design:** Prospective cohort. **Setting:** Clinical research center. **Patients or Other Participants:** Seventy-four adolescent (age = 15.1 ± 1.4 years; mass = 75.4 ± 9.5 kg; height = 173.0 ± 21.2 cm) male hockey players. **Intervention(s):** The BESS was completed as part of a clinical preseason baseline protocol. Participants completed two fully counterbalanced trials of the BESS. Half of our participants completed the traditional BESS followed by the BESS with skates, while the remaining participants completed the BESS with skates followed by the traditional BESS. With the exception of skates, both BESS administrations were identical and included the following stance/surface combinations: double leg, single leg (non-dominant leg), and tandem (non-dominant leg behind) stances completed on firm and foam surfaces. To prevent likely damage to the foam and to replicate testing in hockey venues,

participants wore skate guards over the skate blades. **Main Outcome Measure(s):** The BESS firm-surface total, foam-surface total, and overall total scores were the main outcome measures. Differences between the traditional BESS and BESS with skates were analyzed using paired-samples t-tests (with Bonferroni corrections). **Results:** Participants performed significantly worse on the BESS while wearing skates for firm-surface total (mean difference = 10.2 more errors; 95% CI: 9.0-11.3; $P < 0.001$), foam-surface total (mean difference = 5.0 more errors; 95% CI: 3.7-6.2; $P < 0.001$), and overall total (mean difference = 15.0 more errors; 95% CI: 13.0-17.0; $P < 0.001$) compared to barefoot conditions. **Conclusions:** Our results demonstrated greater difficulty (evidenced by significantly higher errors) when the BESS was administered to participants with skates on compared to traditional BESS outcomes. Therefore, comparing post-injury BESS measures with skates to pre-injury BESS measures without skates is not a clinically valid approach, and likely to cause overly conservative decisions during competition. If clinicians prefer evaluating players with skates on during competition, we suggest that the BESS should also be administered with skates during baseline testing.

Free Communications, Poster Presentations: Heat Illness

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14250MOEX

The Effects Of Intravenous Cold Saline On Hyperthermic Football Players

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Context: Exertional heat stroke (EHS) is a deadly condition that can affect individuals exercising in the heat and at risk are American football players. EHS must be treated immediately with rapid cooling or central nervous system dysfunction, multi-organ failure, and death will occur. Although there are many methods for rapid cooling, few studies have examined the use of intravenous cold saline (CS) on hyperthermic individuals and none have examined the football population. **Objective:** To evaluate the cooling effects of intravenous cold normal (0.9%) saline on hyperthermic football players. An additional goal was to assess the influence of %body fat on total change in core temperature (T_c) after CS intervention. **Design:** Randomized crossover design. **Setting:** Controlled research laboratory. **Patients or Other Participants:** Eight male subjects (height: 183.92 ± 4.7 cm, mass: 117.38 ± 6.0 kg, %body fat: 30.05 ± 6.2) that were current or previous American football players. **Intervention(s):** Subjects were placed in a BodPod for body composition analysis. All participants were then brought to a T_c of 39.5°C with dynamic exercise in an environmentally controlled chamber. Once hyperthermia was reached they were brought to a controlled treatment area where they were treated with either 2L of CS (4°C) or room temperature (22°C) intravenous saline (RS) over a 30 minute period. We measured T_c with rectal temperature probes every minute during the treatment period. Participants were randomly given either the CS or RS on the first trial, and received the remaining treatment at their second trial one week later. **Main Outcome Measure(s):** Total change in T_c (ΔT_c : ending T_c - starting T_c), the rate of

cooling per minute (total change in $T_c/30$ minutes), and % body fat compared to ΔT_c . Independent t-tests were used to assess ΔT_c and cooling rates between trials. A Pearson correlation was used to determine a relationship between %body and ΔT_c for both trials. **Results:** There was a significant difference ($P = 0.032$) in the ΔT_c between the CS ($-1.81 \pm 0.43^\circ\text{C}$) and RS ($-1.38 \pm 0.45^\circ\text{C}$) trials. No statistical difference ($P = 0.107$) was determined for rate of cooling per minute between CS ($-0.059 \pm 0.001^\circ\text{C}\cdot\text{min}$) and RS ($-0.049 \pm 0.001^\circ\text{C}\cdot\text{min}$). Pearson correlation revealed a non-significant, but moderate positive correlation for %body fat compared to ΔT_c in the CS ($r = 0.434$, $P = 0.39$) and RS ($r = 0.51$, $P = 0.301$) trials. **Conclusions:** Although ΔT_c was significantly greater in the CS intervention, it was unable to reproduce an acceptable cooling rate ($< -0.078^\circ\text{C}\cdot\text{min}$). Due to the correlation found between %body fat and ΔT_c there is support for the notion that body type influences this rapid cooling method and others reported. Future research is needed to further examine CS and to determine the affect body composition has on all cooling rates.

14105DOEX

The Influence Of Intermittent Hand Cooling On Core Body Temperature During Exercise In The Heat Wearing An American Football Uniform

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Context: The American football uniform increases net heat storage and limits the evaporation required for thermoregulation. Maintaining hydration status and cooling during exercise have been shown to mitigate rises in core body temperature. Heat extraction via peripheral hand cooling coupled with fluid replacement may aid in reduced thermal strain. **Objective:** To determine the effect of intermittent hand cooling with and without fluid replacement on rectal temperature (TRE). **Design:** Randomized crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** Thirteen males (age: 24 ± 3 yrs, height: 179 ± 5 cm, body mass: 82.64 ± 9.77 kg). **Intervention:** Participants performed three separate 90- minute treadmill exercise bouts while wearing an American football uniform in a hot environment (39°C , 40% RH). Participants were randomly allocated to hand cooling (HC), HC with fluid replacement (HCF), and no cooling (CON). Participants performed hand cooling using a negative pressure device (~ 140 mmHg) on 1 hand every 12th minute of exercise for 3 minutes in duration. **Main Outcome Measure(s):** Mean TRE and heart rate (HR) were measured before exercise (PRE), during exercise every 12 minutes, and after exercise (POST). Body mass (BM), was collected PRE and POST. A repeated measures ANOVA for condition x time with post-hoc Bonferroni tests set at ($\alpha \leq 0.05$) were utilized to test between group differences. Mean differences, 95% confidence intervals, and effect sizes (MD, 95%CI, ES) were used to

compare between conditions. Change in TREC for every additional 1% body mass loss (BML) was also calculated. **Results:** % BML differed across conditions, (Mean \pm SD) HCF = $1.60 \pm 0.53\%$, HC = $3.08 \pm 0.59\%$ CON = $3.29\% \pm 0.68\%$ confirming that HCF partially replaced sweat losses compared to HC and CON ($p = 0.001$, $p = 0.001$) respectively. A significant main effect for time was observed for TRE in all conditions ($p \leq 0.05$). Starting at minute 57 and through POST, HCF TRE was significantly lower than CON ($p \leq 0.05$). TRE for HC was not statistically different than HCF or CON at any time point ($p \geq 0.05$). Δ TRE for HCF, HC, and CON was $1.43 \pm 0.35^\circ\text{C}$, $1.70 \pm 0.48^\circ\text{C}$, and $2.06 \pm 0.40^\circ\text{C}$ respectively. Δ TRE per 1%BML for [HCF-HC] and [HCF-CON] was $-0.26 \pm 0.64^\circ\text{C}$ and $-0.37 \pm 0.32^\circ\text{C}$ respectively. Moderate to strong effects for HR [HCF-CON] at min 57, 72, and 87 were MD = -8bpm, (95% CI = -22 to 6), ES = 0.74; MD = -13bpm (95% CI = -27 to 2), ES = 1.10; MD = -10, (95% CI = -26 to 5), ES = 0.87 respectively. MD in HR for [HCF-HC] at min 57, 72, and 87 were MD = -8bpm, (95% CI = -22 to 6), ES = 0.60; MD = -9bpm, (95% CI = -24 to 5), ES = 0.71; MD = -6bpm, (95% CI = -22 to 10), ES = 0.36. **Conclusions:** HCF significantly reduced TRE starting at minute 60 while wearing an American football uniform. Furthermore, reductions in HR were observed in the HCF condition from minute 57 to 87. Increased blood volume in the HCF condition may have resulted in more effective heat transfer from the hand and reduced cardiovascular drift.

Regional Heat Safety Thresholds For Athletes Across The Contiguous United States

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Context: Wet Bulb Globe Temperature (WBGT) is a common measure of heat exposure used widely in athletics, the military, and occupational safety. Current guidelines that utilize WBGT, such as those recommended by the American College of Sports Medicine (ACSM), use fixed safety thresholds which neglect regional variations in acclimatization to heat. It is well established that exposure-response relationships to heat varies geographically, with lower minimum mortality and morbidity thresholds in regions with cooler climates. **Objective:** To determine regional safety thresholds for heat exposure. **Design:** Observational study. **Setting:** Weather stations across the United States. **Patients or Other Participants:** None. **Intervention(s):** A 15-year WBGT climatology (1991-2005) was computed for 217 locations across the contiguous United States using weather station observations and a physically-based WBGT model. **Main Outcome Measure(s):** We examined multiple percentiles of warm season (May-Sept) daily maximum WBGT in the context of ACSM (2007) guidelines and use the 90th percentile value as a guide in establishing regional thresholds for oppressive heat. **Results:** Our data indicate that in portions of the southern United States, WBGT values may exceed the ACSM recommendations for ceasing athletic activity ($> 32.3^\circ\text{C}$ WBGT) at < 80 th percentile while some areas in the Pacific Northwest, Upper Midwest, and New England regions may not meet this threshold until > 95 th percentile. The percentage of stations that exceed the 32.3°C safety threshold steadily increases with greater percentiles. For instance, there is a jump from 9% to 32% of stations exceeding the ACSM threshold between the 70th to 85th percentiles and a change from 32% to 95% of stations between the 85th and 99th percentiles. **Conclusions:** The

geographically diverse values for extreme WBGTs suggest that lower thresholds may be needed in areas that infrequently experience oppressive heat. We recommend the development of regional guidelines using the local 90th percentile warm season WBGT as a threshold for oppressive heat to account for local acclimatization. Using this definition, the creation of four heat categories for when practice activities should cease would be developed, including those with 90th WBGT percentiles $\geq 32.3^\circ\text{C}$ as category 1, $30\text{-}32^\circ\text{C}$ as category 2, $28\text{-}30^\circ\text{C}$ as category 3, $< 28^\circ\text{C}$ as category 4. Geographically, Category 1 regions extend across the Southeastern quadrant of the U.S. and southern Arizona and New Mexico; Category 2 regions extend across the portions of the West, Midwest, Ohio Valley, and Northeast; Category 3 in the upper Midwest and the New England, with Category 4 primarily along the Pacific Coast. Athletic trainers would then be able to utilize regional WBGT thresholds to assist in the development of safety thresholds that would be used in the development of specific heat safety policies for practice and competitions.

Free Communications, Poster Presentations: Interventions and Therapies

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14298MOPR

The Practical Effects Of Glenohumeral Repositioning Tape In Division I Baseball Players

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Context: The application of tape is common in athletic training, but is rarely used on the glenohumeral joint (GHJ) since many sports require substantial GHJ range of motion (ROM). However, certain injuries or instability may necessitate external stabilization. Taping techniques at the GHJ provides stability but alters biomechanics and function. **Objective:** To determine if joint repositioning sense (JRS), active and passive internal and external rotation ROM (IRROM & ERROM), and throwing velocity and accuracy of baseball players was affected by the application of glenohumeral repositioning tape (GHRT). It was hypothesized that GHRT would increase IRROM and decrease ERROM, decrease JRS, and would not alter throwing velocity and accuracy. **Design:** Quasi-experimental crossover design. **Setting:** Athletic training facility and indoor batting cages. **Patients or Other Participants:** Fifteen NCAA Division I baseball players (age: 20.3 ± 0.9 years, height: 184.6 ± 4.6 cm, mass: 86.2 ± 7.1 kg), without history of surgery or current injury in the throwing shoulder. **Intervention(s):** Each subject completed three protocols: no tape (NO), GHRT, and “sham” tape (SHAM). GHRT consisted of coverroll application from the anterior GHJ to the inferior angle of the scapula, followed by Leukotape application to draw the GHJ posteriorly. SHAM involved coverroll application in the same configuration as GHRT, without tension or repositioning. The NO condition was performed first, then each subject performed SHAM and GHRT protocols in random order. Subjects were blind to tape condition, confirmed by post-testing questionnaires.

Testing order in each condition was ROM, JRS, then throwing tests. **Main Outcome Measure(s):** ROM and JRS were measured using a Pro 3600 Digital Inclinometer (accuracy $\pm 0.5^\circ$). JRS was assessed in 3 positions. Subjects were blindfolded and passively positioned for 10 seconds, rested for 10 seconds, then actively attempted to reposition the GHJ. The degrees of error in ER or IR ROM was measured. Velocity was measured using a Bushnell Speedster III radar gun (accuracy ± 1 mph). Accuracy (cm) was measured using a target made of particleboard and a chalk imprint left from the baseball at contact. Repeated measures ANOVAs with pairwise Bonferroni contrasts were performed on each variable ($\alpha \leq 0.05$). **Results:** A significant decrease in passive IRROM was observed ($F(2,28) = 3.53$, $p = 0.043$). Pairwise Bonferroni contrasts revealed the GHRT ($68.1 \pm 8.4^\circ$) approached significance when compared to NO ($72.9 \pm 9.8^\circ$) ($p = 0.053$). Velocity was also decreased ($F(2,28) = 6.16$, $p = 0.006$). Throwing velocity decreased between GRT (29.0 ± 3.4 m/s) and NO (30.4 ± 2.8 m/s) ($p = 0.045$), and approached significance with SHAM (30.4 ± 2.2 m/s) ($p = 0.051$). All other comparisons were non-significant. **Conclusions:** Athletic trainers should use caution if using the GHRT application in healthy individuals due to decreased passive IRROM and throwing velocity during the full body overhead throw. GHRT may negatively impact performance as a result of these alterations. However, these results may not be representative of the effects of GHRT on unstable shoulders, which warrants additional research.

14315MOTE

The Effectiveness Of Kinesio® Tape In Decreasing Pain And Edema Associated With Delayed Onset Muscle Soreness

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Context: The manufacturers of Kinesio® Tape claim that its proper application will correct myofascial alignment, enhance lymphatic function, increase muscular strength, enhance proprioception, and decrease somatic pain. Few randomized controlled trials have been conducted to evaluate the veracity of these claims. **Objective:** To evaluate the capacity of Kinesio® Tape to enhance lymphatic function, reduce edema and decrease somatic pain associated with delayed onset muscle soreness (DOMS). **Design:** Randomized controlled trial. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** 29 healthy adults (15 women, 14 men; age = 21.5 ± 1.7 yrs; hgt = 169.6 ± 8.8 cm; mass = 69.9 ± 12.1 kg) were stratified by sex and then randomly assigned to 1 of 3 experimental groups: Kinesio® Tape (K-TAPE), sham Kinesio® Tape (SHAM), or no treatment (CONTROL). **Intervention(s):** DOMS was induced in the elbow flexors of the non-dominant arm using an eccentric exercise protocol administered with an isokinetic dynamometer. A mixed between/within Group (3) x Time (4) ANOVA approach was used with Scheffé post-hoc testing ($\alpha = 0.05$). **Main Outcome Measure(s):** Limb girth measured at 4 locations, elbow extension active range of motion (AROM), elbow flexor isometric peak torque, and self-reported functional level (Quick DASH) and pain level (100 mm VAS pain scale). These 8 measures were assessed at baseline and on 3 subsequent occasions at 24-hour intervals following the induction of DOMS. **Results:** Significant main effects for Time were found for 6 of 8 outcome measures: VAS pain level ($p < 0.001$), isometric peak torque ($p < 0.001$), girth 8 cm distal to the olecranon ($p < 0.001$), Quick DASH ($p = 0.006$), elbow

AROM ($p=0.014$), and girth 4 cm proximal to the olecranon ($p=0.029$). There were no significant Group differences for any of the outcome measures ($p>0.238$). The VAS pain scores peaked at 48 hours post-DOMS induction for all 3 groups (K-TAPE = 26.6 ± 20.8 ; SHAM = 22.4 ± 28.2 , CONTROL = 20.4 ± 16.2). We found one Group x Time interaction, upper arm girth measured 4 cm proximal to the olecranon process ($p=0.02$); however, Scheffé post-hoc analyses did not differentiate the K-TAPE treatment (mean girth = 25.4 ± 3.4 cm) from the SHAM (24.2 ± 2.1 cm) or CONTROL groups (25.9 ± 2.6 cm) ($p > 0.05$). **Conclusions:** The significant changes that we observed in levels of self-reported pain and function, limb girth, range of motion and isometric peak torque over a 72-hour period indicated that our protocol was highly effective in inducing DOMS in the elbow flexor musculature. The absence of significant differences among the true Kinesio® tape, sham Kinesio® tape, and control groups suggests that Kinesio® tape did not facilitate improved lymphatic function, reduce edema or decrease pain following the introduction of DOMS to the elbow flexors.

Does Kinesio® Tape Effect The Force Production Of The Rectus Femoris And Tibialis Anterior In Healthy, Non-Injured Individuals
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Context: The manufacturers of Kinesio® Tape claim that the tape increases the force production of muscles when applied with a specific procedure. Very few studies have tested this claim and little scientific evidence exists to provide statistical proof that the tape may be utilized in this manner. **Objective:** The main objective of the study was to determine if Kinesio® Tape effects concentric force production of the rectus femoris and tibialis anterior in a non-injured, healthy population. **Design:** Randomized Control Trial. **Setting:** Florida Gulf Coast University Athletic Training Laboratory. **Patients or Other Participants:** 31 males (25.33), 19 females (22.83) with no previous history of injury to the knee or ankle participated in the study. **Intervention(s):** The two independent variables were the application of Kinesio® Tape as well as the predetermined velocities of the isokinetic dynamometer (30 and 120 degrees, ankle; 60 and 240 degrees, knee). The System 4 Pro Biodex Isokinetic Dynamometer was utilized to measure force production in the right rectus femoris and the right tibialis anterior in each participant. Each muscle was tested on a separate day, with tape and without, and in random order. Participants completed 3 trial repetitions on the Biodex. After the trial period, the participants completed 5 maximal concentric effort repetitions for the two chosen dynamometer speeds. The protocol was implemented for both rectus femoris and tibialis anterior. **Main Outcome Measure(s):** The main dependent variables examined included peak torque and average peak torque. A paired T-test with a Bonferroni correction was used to examine if there was a statistically significant difference between the two conditions. **Results:**

Due to the Bonferroni correction the alpha level set for this study was $p<.001$. There was no statistically significant increase or decrease in peak torque or average peak torque when analyzing the 2-tailed values which ranged from .142-.726. However, a significant decrease was seen at time to peak torque with Kinesio® Tape when applied to the knee at 60 degrees (.003, $P < .05$). **Conclusions:** The current study displayed that Kinesio® Tape has no positive or negative effect on force production when applied to the rectus femoris and the tibialis anterior muscles of healthy, un-injured individuals. Even though there was one measure found to be one area of significance, it appears that a learning effect was still present as indicated by increased peak torques on the patients 2nd attempt regardless of intervention.

The Effects Of Two Arch Taping Techniques On Navicular Height And Plantar Pressures Throughout Exercise

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Context: Arch tapings have been used to support the arch by increasing navicular height. Few studies have looked at navicular height and plantar pressures following physical activity. Additionally, no present study has examined the Navicular Sling taping. **Objective:** To determine if taping techniques are effective in supporting the arch during exercise. **Design:** Crossover study design. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Twenty-five subjects (13 males and 12 females, 20.0 ± 1.0 years, 70.1 ± 10.2 kg, and 172.3 ± 6.6 cm) with a navicular drop of over 8 mm (mean 12.9 ± 3.3 mm) volunteered. **Intervention(s):** All subjects participated in 3 days of testing, one for each tape conditions: No Tape (NT), Navicular Sling (NS), and Low-Dye (LD). On each day of testing, navicular height and plantar pressures were measured. For navicular height, the subject was in a standing/relaxed position and the distance from the floor to the navicular tuberosity was measured using a Vernier height caliper (Mitutoyo 506-207 Mitutoyo, Japan). Plantar pressures were collected with the participant in a single-leg stance on the pressure mat (VersaTek System model HRV1, South Boston, MA). Data were recorded for 10 seconds. Then subjects ran for 15 minutes at a self-selected pace (mean $= 8.2 \pm 1.3$ km/hr). Navicular height and plantar pressures were measured at five intervals: pre-tape, post-tape, and following 5, 10, and 15 minutes of running. The order of tape condition was counterbalanced. **Main Outcome Measure(s):** The dependent variables were navicular height in millimeters (mm) and plantar pressures in kilopascal (kPa). Plantar pressures were divided into five masks (medial forefoot (MFF), lateral forefoot (LFF), midfoot, lateral rearfoot (LRF), and medial rearfoot (MRF)). Separate repeated measures ANOVAs were

used for each dependent variable. **Results:** Navicular height was significantly higher immediately after NS (mean difference: 2.4 ± 0.6 mm; $p = 0.01$), but after 5 minutes of running there was a significant decrease in navicular height. For LD and NT, no significant changes in navicular height were found pre-tape to post-tape ($p > 0.05$). A significant decrease in pressures was found in the MFF for NS (mean difference: 47.9 ± 13.5 kPa; $p = 0.02$). A significant decrease in pressures was identified in both the MFF (mean difference: 70.3 ± 10.0 kPa; $p = 0.01$) and LFF (mean difference: 51.3 ± 11.5 kPa; $p = 0.01$) for LD. In the midfoot, a significant increase in plantar pressures were identified in both the NS (mean difference: 49.6 ± 10.6 kPa; $p = 0.01$) and LD (mean difference: 70.3 ± 10.0 kPa; $p = 0.01$) conditions. All changes were identified immediately after application and were maintained during the 15 minutes of running. In the NT condition, there were no significant differences for any time period in any area of the foot ($p > 0.05$). **Conclusions:** The NS technique was more effective than the LD in supporting navicular height. Both the NS and LD were similar for plantar pressures and were sustained throughout the 15 minutes of exercise.

Prophylactic Ankle Tape Changes The Frequency Distribution Of Center Of Pressure During Static Balance In Subjects With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) demonstrate altered postural control. Recent research has shown that individuals with CAI utilize a more anterior center of pressure (COP) location during single-limbed static balance compared to control subjects, which may put them at risk for subsequent ankle sprains. Prophylactic ankle tape is a common preventative measure for recurrent ankle sprains despite an unknown mechanism. Changes in the spatial location of COP location following prophylactic ankle tape may provide insight into the preventive mechanism of this intervention. **Objective:** To determine if prophylactic ankle taping alters the spatial location of the frequency of COP data points during static balance in subjects with CAI. **Design:** Randomized crossover. **Setting:** Laboratory. **Patients or Other Participants:** 12 individuals with self-reported CAI (3 males, 9 females; age = 21.7 ± 3.2 years; height = 171.3 ± 11.2 cm; mass = 79.0 ± 25.4 kg; previous number of sprains = 4.2 ± 3.2 ; Foot and Ankle Ability Measure (FAAM) = $78.5 \pm 18.5\%$; FAAM-Sport = $72.9 \pm 11.6\%$) and 12 control subjects volunteered (3 males, 9 females; age = 21.6 ± 3.6 years; height = 170.3 ± 7.2 cm; mass = 66.7 ± 12.2 kg; previous number of sprains = 0.0 ± 0.0 ; FAAM = $100.0 \pm 0.0\%$; FAAM-Sport = $100.0 \pm 0.0\%$). **Intervention(s):** All subjects performed data collection in two conditions, tape and no-tape. The tape intervention was a traditional preventative procedure performed by the same researcher with 10 years of taping experience. The order of condition was randomized. **Main Outcome Measure(s):** All subjects performed three successful 10-second single limb balancing trials on a force plate with eyes open and closed, with and without the prophylactic ankle intervention.

COP data was collected at 50 Hz resulting in 500 data points in each trial. The location of each COP data point relative to the geometric center of the foot was determined and the frequency count in 4 quadrants (anteromedial, anterolateral, posteromedial, posterolateral) was analyzed for differences between groups and conditions. The independent variables were group (CAI, control) and condition (tape, no-tape). For each quadrant, separate 2x2 ANOVAs with repeated measures were computed for eyes open and eyes closed data. Alpha was set at a priori of $p \leq 0.05$. **Results:** There were no group by condition interactions or group main effects ($p > 0.05$) for any analyses. There were two condition main effects. In the eyes open trials, all subjects had a decrease in the frequency count in the posteromedial quadrant while taped (no-tape = 131.9 ± 107.2 ; tape = 77.1 ± 86.4 ; $p = 0.01$). In the eyes closed trials, all subjects had an increase in frequency count in the anterolateral quadrant while taped (no-tape = 135.5 ± 76.1 , tape = 161.8 ± 55.6 , $p = 0.05$). **Conclusions:** The application of a prophylactic ankle tape intervention did not alter the location of the frequency of COP data points differently between subjects with and without CAI. However, the tape intervention did result in a shift in the frequency of COP data points in all subjects. This shift may potentially indicate a sensorimotor response to the application of tape.

Jump Ground Reaction Forces And Loading Rates Associated With Brace Support In Ankle Complex Stability

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Context: The primary mechanism responsible for preventing ankle sprains is the ability of braces to restrict ankle inversion-eversion (I-E) motion. Because ankle braces restrict normal ankle motion, specifically plantar-dorsiflexion (PF-DF), they may have a detrimental effect on the lower extremity to attenuate vertical ground reaction forces (GRFv) when landing from a jump. Greater landing impact GRFv is linked to injury and joint pathologies. No comprehensive analysis of differences in ground reaction force magnitude and loading rate associated with various brace types has been reported.

Objective: To compare the effects of brace support on ankle-complex behavior and ground reaction forces and loading rates involved in jump landings. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Both ankles of 20 athletes (21.7 ± 1.2 years, 80.9 ± 17.5 kg, 174.8 ± 9.8 cm). **Intervention(s):** Participants performed three trials of a countermovement vertical jump with double-leg landings on a force plate across four ankle support conditions consisting of no brace and braced ankles (soft-shell [Zoom™]; lace-up [ASO™]; semi-rigid [Active Ankle T2™]). Maximal active PF-DF range-of-motion (ROM) and passive I-E load-displacements for each support condition were obtained using an ankle arthrometer with the subject wearing a low-top athletic shoe. **Main Outcome Measure(s):** Arthrometric measured maximal PF-DF ROM and I-E rotation at 4-Nm. The ratio between the ROM wearing each brace and the ROM without each brace was calculated and reported as a percentage. Maximal GRFv (normalized to bodyweight; N/kg), time to maximal GRFv (s), and loading rate to maximal GRFv (N/kg/s) were assessed at landing. Repeated

Measures ANOVA's compared arthrometric and mean GRFv measures. The a priori α level was set at .05. **Results:** The semi-rigid ($40.6 \pm 13.0^\circ$) and soft-shell ($38.3 \pm 10.8^\circ$) braces provided superior I-E support ($P < .001$) when compared with the lace-up ($51.1 \pm 16.2^\circ$) and NB ($81.72 \pm 16.7^\circ$) conditions. The ROM ratios showed the semi-rigid and soft-shell braces provided greater DF (95% and 96%) and PF (97% and 92%) as a percentage of the NB ROM. Whereas, wearing the lace-up brace resulted in significantly lower DF (93%; $P = .01$) and PF (86%; $P = .001$) ratios. No significant differences ($P > .05$) were found among the ankle support conditions for maximal GRFv (NB: 34.2 ± 7.3 N/kg; soft-shell: 34.15 ± 6.9 N/kg; lace-up: 34.07 ± 6.7 N/kg; semi-rigid: 33.39 ± 7.6 N/kg); time to maximal GRFv (NB: $0.078 \pm .01$ s; soft-shell: $0.079 \pm .02$ s; lace-up: $0.078 \pm .01$ s; semi-rigid: $0.078 \pm .02$ s); and loading rate to maximal GRFv (NB: 460.03 ± 202.8 N/kg/s; soft-shell: 455.12 ± 173.9 N/kg/s; lace-up: 456.35 ± 179.7 N/kg/s; semi-rigid: 468.95 ± 235.6 N/kg/s). **Conclusions:** Double-leg landing GRFv measures were not increased with brace application. The arthrometric and sagittal-plane kinetic data support the use of ankle bracing for injury prevention and treatment following ankle sprain. Objective information on the amount and nature of ankle brace support may assist athletic trainers when recommending braces to patients.

14364UOPR

Bracing Effects On Dynamic Stability In Individuals Who Have Never Utilized Prophylactic Ankle Bracing

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Context: Prophylactic ankle bracing is used to increase joint stability in hopes of decreasing injury rates. In some sports, coaches are requiring all athletes to wear ankle braces regardless of past injury history. **Objective:** To examine time to stabilization (TTS) with and without ankle bracing in subjects who have never worn ankle braces. **Design:** Case-control study. **Setting:** Movement Analysis Lab. **Patients or Other Participants:** Seventeen active individuals (9 Females, 8 Males; age = 18.9 ± 1.8 years; height = 173.9 ± 11.1 cm; weight = 75.0 ± 15.1 kg) that participate in sports that involve jumping and cutting motions, free of any previous ankle injuries, volunteered for this study. **Intervention(s):** Two jumping tasks from the forward and lateral directions were executed barefooted onto the force plate. For the forward jump, participants were asked to take two preparatory steps, jump to 50% of their maximum vertical jump, taking off from one leg and landing single-legged on the opposite leg at the center of the force plate. For the lateral jump, participants were asked to take two side shuffle steps, jump to 50% of their maximum vertical jump, taking off from one leg and landing single-legged on the opposite leg at the center of the force plate. All participants were instructed to stabilize as quickly as possible on a single leg and remain as motionless as possible for 5 seconds. In a randomized order, three jumps were collected and averaged for each jump direction and each brace condition for a total of 12 jumps. **Main Outcome Measure(s):** A within-subject paired t-test was conducted for the TTS of the forward and lateral jumps in a braced and non-braced condition. **Results:** The braced forward jumps resulted in a TTS of 1.29 ± 0.57 secs. The non-braced forward jumps resulted in a TTS of 1.33 ± 0.42 secs. The braced lateral jumps resulted in a TTS of 1.33 ± 0.52 secs. The

non-braced lateral jumps resulted in a TTS of 1.34 ± 0.53 secs. There were no differences in the TTS between the braced and non-braced conditions for the forward or lateral jumps ($P = 0.804$, $P = 0.935$, respectively). **Conclusions:** Teams that require their athletes to wear prophylactic ankle braces do so in hopes to increase stability and reduce the risk and rate of injury. Ankle braces aim to increase ankle joint stability, but these results show that individuals who wore prophylactic bracing for the first time did not improve or worsen their TTS. Therefore, without any ill effects of bracing individuals without an ankle injury history, coaches may decide to continue with the practice. However, only further research can determine the long term effects of prophylactic bracing in individuals who have never sustained an ankle sprain.

14090DOBI

Lower Extremity Kinematics With And Without Patellar Tendon Straps

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Context: Patellar tendinopathy is a common, degenerative condition and is often treated with patellar tendon straps. Currently, there is only anecdotal support and limited biomechanical evidence to advocate patellar tendon strap use. **Objective:** To determine if 2 commercially available patellar tendon straps alter hip and knee kinematics compared to a no-strap control condition during a drop-jump task. **Design:** Repeated measures. **Setting:** Biomechanics Research Laboratory. **Patients or Other Participants:** 39 recreationally active participants with no history of knee pain (21 females, 18 males, mean \pm standard deviation: age 20.6 ± 2.0 yr, height 171.34 ± 8.66 cm, mass 70.05 ± 12.32 kg). **Intervention(s):** Participants were fitted with 16 retro-reflective markers using the Vicon Plug-in-Gait Model. Marker trajectories were recorded via a 7-camera motion capture system (120 Hz) synchronized with two non-conductive force platforms (1200 Hz). In a single-test session participants completed five trials of 40 cm 2-legged drop-jumps during three different conditions (no-strap, Chopat strap™, Matt-Strap™) in a counter balanced order. **Main Outcome Measure(s):** Dependent variables of interest included hip and knee joint angles in three planes at initial contact (IC), at maximum vertical ground reaction force (VGRF), and corresponding angular displacements. 18 separate one-way repeated measures analyses of variance ($p \leq .05$) were utilized to compare the angles and angular displacements among strap conditions from the period of interest. Post-hoc testing used pairwise comparisons ($p \leq 0.05$) to identify specific differences among the three conditions. **Results:** At IC with the Matt-Strap™, participants landed with significantly less

hip internal rotation ($2.1 \pm 12.7^\circ$) compared to the no strap ($6.1 \pm 12.7^\circ$, $p = .007$) and Chopat strap™ ($4.5 \pm 11.8^\circ$, $p = .013$) conditions. At maximum VGRF in the strapped conditions compared to no strap, hip flexion was greater (Matt-Strap™ = $49.7 \pm 11.9^\circ$, $p = .025$, Chopat strap™ = $50.5 \pm 14.3^\circ$, $p = .023$, no strap = $47.6 \pm 12.0^\circ$) and knee adduction was decreased (Matt-Strap™ = $6.9 \pm 10.5^\circ$, $p = .001$, Chopat strap™ = $7.4 \pm 9.3^\circ$, $p = .011$, no strap = $9.0 \pm 9.3^\circ$). Hip internal rotation during the Matt-strap™ (Matt-Strap™ = $4.4 \pm 12.9^\circ$) condition was decreased compared to no strap ($7.1 \pm 11.9^\circ$, $p = .008$) and Chopat strap™ ($5.8 \pm 12.0^\circ$, $p = .029$) at maximum VGRF. For angular displacement values, the Matt-Strap™ condition displayed less knee adduction ($0.5 \pm 5.7^\circ$) compared to no-strap ($1.9 \pm 4.7^\circ$, $p = .02$). Participants also trended ($p = .054$) towards exhibiting greater hip flexion angular displacement from IC to maximum VGRF, specifically with the Chopat strap™ ($15.6 \pm 9.5^\circ$) compared to the no-strap condition ($12.9 \pm 6.7^\circ$, $p = .01$). **Conclusions:** During Matt-Strap™ and Chopat strap™ conditions, there were potentially beneficial alterations in hip and knee landing kinematics when landing from a drop-jump. Landing kinematics may play a role in developing or perpetuating patellar tendinopathy. Alterations in hip and knee kinematics secondary to strapping may serve as a mechanism to moderate patellar tendinopathy symptoms. Future research should identify the effects of patellar tendon straps on those with symptomatic patellar tendinopathy.

A Single Bout Of Massage Following Eccentric Exercise Produces An Anti-Inflammatory Cross-Over Effect In Skeletal Muscle

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Context: Our previous work in non-perturbed muscle indicated a systemic cross-over effect when massage applied to one limb promoted a load-independent cellular immune response in the contralateral non-massaged limb. Whether a systemic effect of massage also occurs when applied following eccentric exercise has not yet been investigated. **Objective:** Determine if a single bout of massage applied immediately after a damaging bout of eccentric exercise provokes an immunomodulatory response in the contralateral limb 6, 12, and 24 hours post massage. **Design:** Randomized controlled, time-point experimental design. **Setting:** Controlled basic science research laboratory. **Patients or Other Participants:** 44 male Long Evans rats (200-400g) randomly assigned to 1 of 8 groups: Control ($n = 6$), Surgical Sham ($n = 6$), Eccentric Exercise Control groups (EEX) (EEX 6hrs $n = 6$, EEX 12hrs $n = 5$, EEX 24hrs $n = 6$), and Exercise + Massage groups (EEX+Mass 6hrs $n = 5$, EEX+Mass 12hrs $n = 5$, EEX+Mass 24hrs $n = 5$). **Intervention(s):** Animals were surgically instrumented (with exception of control) with nerve cuff electrodes around the peroneal nerves. Wires were routed subcutaneously to a 12-pin connector at the base of the skull for external stimulation. One week after the surgery, EEX and EEX + Mass rats underwent eccentric exercise of the dorsiflexor muscles. The EEX + Mass group received a single 30 min bout of massage to the tibialis anterior (TA) of the right limb only post-exercise. Rats were euthanized according to assigned time point. **Main Outcome Measure(s):** TA muscle cross-sections were stained with H&E and immunoreacted for M1 and M2 macrophages (CD68, CD163). General

cellular infiltration was counted on H&E stained sections as extramyofibrillar nuclei and specific infiltration was counted as cells reacting positive for respective antibody and the nuclear stain DAPI per 0.15mm² field. **Results:** Cellular infiltration was not different between Control and Sham, rejecting surgical intervention as initiating inflammation (22 ± 8.21 , 19 ± 3.76 , $p = 0.69$). General cellular infiltration was increased in the EEX 6hr group and massaged limb of the EEX + Mass6hr vs. non-massaged limb (139.9 ± 19.43 vs. 54.06 ± 5.69 , $p = 0.01$; 134.50 ± 4.90 vs. 54.92 ± 7.95 , $p = 0.02$). M2s were increased at 6 hours in the EEX + non-massaged limb compared to the EEX + massaged limb group ($3.94 \pm .19$ vs. $3.31 \pm .17$, $p = 0.03$) and the EEX 6hr group ($3.94 \pm .19$ vs. $3.41 \pm .05$, $p = 0.04$). No significant differences were observed between EEX 6hrs and the massaged limb of EEX + Mass 6hr (M1: 3.58 ± 0.54 vs. 4.28 ± 0.47 , $p = .41$; M2: 3.40 ± 0.05 vs. 3.31 ± 0.17 , $p = 0.54$). **Conclusions:** Together these data suggest a cross-over effect of massage at 6hrs. Previous investigations have demonstrated earlier recovery of muscle mechanical properties and function, as well as resolution of the inflammatory response when massage was applied immediately following eccentric exercise compared to a muscle that did not receive massage. Here, we have shown that the immunomodulatory effects of massage influence anti-inflammatory M2 populations within six hours. Modulation of immune cell populations may alter the temporal course of the inflammatory response, ultimately influencing skeletal muscle repair and regeneration.

Comparison Of An Indirect Measure Of Blood Flow Changes With Soft Tissue Mobilization And Massage Therapy

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Context: Instrument Assisted Soft Tissue Mobilization (IASTM) and massage therapy are manual techniques that claim to be able to increase blood flow to treated areas. There are no studies on human subjects that have directly investigated the effects of IASTM on blood flow. **Objective:** To compare the effects of Graston Technique (GT) and Massage therapy on calf blood flow, using skin temperature measures (a valid, indirect measure of blood flow), on the lower leg. **Design:** Single-blinded prospective, longitudinal, controlled, repeated-measures design. **Setting:** Research Laboratory. **Patients or Other Participants:** 28 volunteers participated in the study (Age = 23 ± 3 ; Males = 14/28 (50%); Females = 14/28 (50%); Girth = 39.5 ± 4.31 ; Skinfold = 27.9 ± 5.6). **Intervention(s):** Each participant received 10-minute treatment (Massage and IASTM) in two separate sessions with the non-treatment leg used as a control. **Main Outcome Measure(s):** We measured baseline skin temperature on the calf prior to treatment, and again every 5min after treatment for a total of 60min. We evaluated differences between conditions (4) and time (13) with a repeated measures ANOVA. Significance was set at $p < 0.05$ a-priori. **Results:** We identified significant differences with Greenhouse-Geisser corrections between conditions ($F_{2,4} = 61.2 = 39.252$, $p < 0.001$, $ES = 0.602$) and time ($F_{2,1} = 54.4 = 192.8$, $p < 0.001$, $ES = 0.881$), but failed to achieve a significant main effect ($F_{2,1} = 53.5 = 2.944$, $p = 0.060$, $1-\beta = 0.558$). The massage condition ($32.05 \pm 0.16^\circ\text{C}$) yielded significantly higher skin temperatures as compared to the massage control ($30.53 \pm 0.14^\circ\text{C}$, $p < 0.001$), GT (31.11 ± 0.20 , $p < 0.001$), and GT control (30.32 ± 0.14 , $p < 0.001$)

conditions. Only the control conditions were not significantly different from one another ($p = 0.189$). We also identified significant differences in time, whereas the baseline ($25.83 \pm 0.30^\circ\text{C}$) acquired prior to treatment was significantly lower than all other temperature measurements ($p < 0.001$). Moreover, temperatures at 5min ($30.21 \pm 0.12^\circ\text{C}$), 10min ($31.00 \pm 0.30^\circ\text{C}$), and 15min ($31.65 \pm 0.12^\circ\text{C}$) showed significant increases ($p < 0.001$). After 15min, the skin temperatures continued to rise and each time point was statistically different from the baseline and up to the 25min peak temperature ($31.76 \pm 0.12^\circ\text{C}$), but these differences were not clinically significant differences ($< 0.80^\circ\text{C}$). **Conclusions:** This study demonstrated that massage and GT increase skin temperature. A rise in temperature theoretically indicates an increase in blood flow to the area. Blood flow increases theoretically stimulate the delivery of nutrients and oxygen to tissues in the body, increase tissue mobility, and increase muscle flexibility. Massage had a higher temperature increase when compared to GT, but both techniques increased temperature consistently for up to 25min post treatment. Further research is needed to conclude how deep this temperature and blood flow increase is occurring in the muscle tissue. If a clinician's therapeutic goal is to increase temperature and blood flow, both massage and GT would be good treatment choices with massage yielding significantly higher temperature and blood flow.

Inter-Clinician And Intra-Clinician Reliability Of Force Application During Joint Mobilizations: A Systematic Review

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Context: Joint mobilizations (JM) are commonly used to restore joint arthrokinematics and decrease pain following musculoskeletal injury. The force applied during JM treatment is determined by each clinician with no established guidelines for the range of force application. The reliability of clinician force application during JM needs to be investigated prior to studying the effects of this treatment parameter on patient outcomes. **Objective:** The purpose of this systematic review was to synthesize and critically appraise the published evidence describing the inter-clinician and intra-clinician reliability of force application during spinal and peripheral JM. **Data Sources:** PubMed and EBSCO host (CINAHL, MEDLINE, SportDiscus) databases were systematically searched from inception to March 1, 2013. Searches were limited to English and humans and used key words including joint, mobilization, mobilisation, manipulation, force, reliability, reproducibility, repeatability, accuracy, inter-rater, intra-rater, inter-therapist, and intra-therapist. A hand search of the references in the articles identified through the electronic search was also conducted. **Study Selection:** Studies were included if inter-clinician or intra-clinician reliability of force application was assessed during a graded JM treatment applied to the spine or a peripheral joint and included a measure of relative reliability. Exclusion criteria included studies which were in vitro, restricted the range of force application, or did not measure the reliability of force application. **Data Extraction:** All reviewers assessed studies for inclusion. Two reviewers utilized the Quality Appraisal of Reliability Studies

(QAREL) assessment tool to determine the methodological study quality. Studies were deemed high quality if they received a QAREL score >60%. All results were synthesized qualitatively with a modified level of evidence approach. **Data Synthesis:** The search resulted in 52 possible studies of which seven met the eligibility criteria. Five studies examined inter-clinician reliability and six studies examined intra-clinician reliability. There were a total of four high quality and three low quality studies. All studies provided estimates of relative reliability using intra-class correlation coefficients (ICC). ICC values ≥ 0.75 were deemed acceptable while values < 0.75 were considered unacceptable. Inter-clinician reliability ranged from ICC = -0.04 - 0.70. The combination of study results and study quality indicated there is moderate evidence that inter-clinician reliability is unacceptable. Intra-clinician reliability ranged from ICC = 0.75 - 0.99. The combination of study results and study quality indicated there is strong evidence that intra-clinician reliability is acceptable. **Conclusions:** Considerable variability in force application was exhibited between clinicians when applying graded JM treatments which resulted in unacceptable reliability. However, clinicians could successfully replicate their own forces during JM treatments which resulted in acceptable reliability. This systematic review indicates there is a need for innovative instructional methods to improve the reliability of force application between clinicians and determine the appropriate force application during JM in order to improve treatment efficacy and patient outcomes.

Comparing The Effectiveness Of A Foam-Rolling Technique To Stretching For Iliotibial Band Extensibility

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Context: The iliotibial band (ITB) is a thickened fascia, located on the outside of the thigh, which originates at the lateral hip and attaches at the lateral knee. ITB tightness is a common occurrence seen in clinical settings, and often leads to iliotibial band syndrome or other injury. Stretching and self-myofascial release using a foam-roller are two common interventions for treating individuals with tight ITBs. However the immediate effects of these interventions on ITB extensibility are unknown. **Objective:** To determine the immediate effects of self-myofascial release using a foam-roller versus ITB stretching on ITB extensibility. **Design:** Controlled laboratory study, with repeated measures. **Setting:** University athletic training facility. **Patients or Other Participants:** 24 participants (15 females, 8males; age 23.09 ± 9.91 yrs, height = 169.86 ± 18.12 cm, mass = 67.16 ± 35.14 kg) with no history of lower extremity pathology or disorders, no myofascial release of the ITB within the past six months, or previously diagnosed ITBS. **Intervention(s):** The independent variables were exercise group (stretching or foam-rolling) and time (pre- and post-exercise). Participants were randomly assigned to an exercise group. Regardless of the intervention, participants performed a five-minute warm-up walking on a treadmill at a pace they were comfortable with. Then an investigator blind to exercise group performed the Modified Ober's test to assess ITB flexibility, and used a handheld electronic inclinometer to measure the degree from horizontal. Following the initial measurements, another investigator explained the intervention (stretching or foam-rolling) to the participant. For stretching the participant was standing, the non-involved leg crossed in front of dominant

leg, arms extended overhead with hands clasped together, and side-bent away from stretched side; held for 30 seconds, rest for 30 seconds, and repeated three times. For foam-rolling the participant was side lying with the foam-roller positioned under the involved leg. Starting at the hip and rolling all the way down to the knee the participant moved on top of the foam-roller for 1 minute, with 30 seconds rest, and repeated 2 times. Immediately following, the blinded investigator re-measured the ITB extensibility. **Main Outcome Measure(s):** The dependent variable was the ITB extensibility, the independent variables were time and exercise group. A repeated measures ANOVA was used for analysis ($p < 0.05$). **Results:** There was no significant interaction between group and time ($F_{(1,21)} = .75, p = .39$). Regardless of performing the foam-rolling or stretching, all participants ITB extensibility increased (Pre: $27.1 \pm 5.6^\circ$ Post: $28.7 \pm 6.7^\circ$; $F_{(1,21)} = 4.7, p = .04$). **Conclusions:** It was predicted the foam-roller would produce greater acute ITB extensibility than the stretching, however ITB extensibility increased following both foam-rolling and stretching interventions. Though significant, the magnitude of change was small, thus the clinical meaningfulness of this change should be further investigated. These changes represent immediate effects, and future studies should investigate the effects from repeated, longer term interventions.

The Effects Of Static Stretching Versus Dynamic Stretching On Lower Extremity Joint Range Of Motion And Dynamic Balance

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Context: Research supports the beneficial effects of dynamic stretching on muscular performance, however less is known about the effects on balance. Static stretching has been shown to negatively affect muscular performance and balance. **Objective:** To examine the effects of static and dynamic stretching on dynamic balance and lower extremity joint ROM. **Design:** Repeated measures, cohort study. **Setting:** Research laboratory **Patients or Other Participants:** Healthy, recreationally active adults (8 Male, 7 female; 25 ± 4.2 yrs; 172.2 ± 4.8 cm; 66.2 ± 11.2 kg) who demonstrated tightness of the gastrocnemius/soleus (unable to perform a deep-squat having thighs parallel with the floor) and hamstring muscles (having $\geq 15^\circ$ knee extension deficit on 90-90 hamstring test). **Intervention(s):** Baseline hip, knee, and ankle ROM and dynamic balance were measured. After a 5-min treadmill warm-up, all participants performed three interventions on separate days. Dynamic stretching (DS) involved movements where the entire leg was dynamically moved through the full ROM. Static stretching (SS) involved holding a stretch for each muscle group to the point of discomfort. The control (CN) involved only the treadmill warm-up. ROM and balance measures were repeated after the interventions. The interventions were counterbalanced to minimize bias and learning effect. **Main Outcome Measure(s):** Baseline hip flexion and knee extension ROM were measured using a fluid inclinometer. Ankle dorsiflexion ROM was measured using the validated weight-bearing lunge test. The Star Excursion Balance Test (SEBT) assessed dynamic balance in three directions (A-anterior, PM-posterior-medial, PL-posterior-lateral). The independent variables were the interventions (DS, SS, CN),

and time (pre and post). Three separate ANOVA's ($p < .05$) analyzed the dependent variables: ROM (Hip flexion, knee extension, and ankle dorsiflexion) and dynamic balance (SEBT-A, SEBT-PM, SEBT-PL). **Results:** Knee extension significantly increased (Pre: $31.4 \pm 2.3^\circ$, Post: $23.9 \pm 2.5^\circ$; $F_{[1,14]} = 90.2$, $p < 0.001$), hip flexion significantly increased (Pre: 129.2 ± 3.1 , Post: 131.5 ± 2.7 ; $F_{[1,14]} = 7.2$, $p = 0.019$), and ankle dorsiflexion significantly increased (Pre: 8.0 ± 0.7 cm, Post: 8.8 ± 0.7 cm; $F_{[1,14]} = 78.2$, $p < 0.001$) regardless of condition. SEBT-A (Pre: 76.5 ± 1.7 cm, Post: 79.2 ± 2.1 cm; $F_{[1,14]} = 25.3$, $p < 0.001$), SEBT-PM (Pre: 111.9 ± 1.8 cm, Post: 114.9 ± 2.0 cm; $F_{[1,14]} = 18.9$, $p = 0.001$), and SEBT-PL (Pre: 105.5 ± 2.4 cm, Post: 109.4 ± 2.6 cm; $F_{[1,14]} = 50.9$, $p < 0.001$) all significantly increased regardless of condition. **Conclusions:** Static and dynamic stretching as well as the general warm-up all led to improved ROM and dynamic balance. Separate from the effects of the stretching, the warm-up caused a physiological response that influenced the neurophysiology (i.e. increased soft-tissue compliance, nerve conduction velocity, muscle tone) that led to improved dynamic balance. The finding that performing a short warm-up improves SEBT performance should be further evaluated in a future study of a larger sample.

The Effect Of Ankle Positioning During Hamstring Stretches For Improving Straight Leg Hip Flexion Motion

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Context: Hamstring stretching can help increase hip range of motion (ROM), thereby potentially increasing muscle performance and decreasing the risk of injury. However, past research has shown greater straight leg hip flexion ROM when the ankle is in a plantar flexed position compared to a dorsiflexed position. These findings have increased speculation that hamstring stretching with the ankle plantar flexed may allow for greater lengthening of the hamstring muscles. Unfortunately, the effect of maintaining the ankle in a dorsiflexed or plantar flexed position during a hamstring stretching protocol for the purpose of improving hip ROM has not been investigated. **Objective:** To compare the effects of stretching the hamstrings with the ankle in either a plantar flexed or dorsiflexed position for improving straight leg hip flexion ROM over a 4 week period. **Design:** Randomized, single-blinded, pre-test, post-test design. **Setting:** Athletic training facility. **Patients or Other Participants:** Each limb of 34 asymptomatic, physically active individuals (15 males, 19 females) (age = 21.5 ± 1.8 years; height = 169.7 ± 9.9 cm; mass = 71.0 ± 10.9 kg) was randomly assigned to one of three groups. Twenty-four limbs received hamstring stretches with the ankle in dorsiflexion, 24 limbs received hamstring stretches with the ankle in plantar flexion, and 20 limbs received no stretch (control). **Intervention(s):** We measured pre and post-test passive straight leg hip flexion ROM (ICC = 0.88, SEM = 6.6°) with the contralateral leg stabilized and the test ankle in a neutral position using the Pro Digital Inclinometer (SPI-Tronic, Garden Grove, CA). For the intervention groups, the test limb was passively stretched with the ankle held in end range DF or PF for

their respective group while the contralateral leg was stabilized. Each stretch was held for 30 seconds for a total of 3 applications. Two treatment sessions were completed per week for a total of 4 weeks. The control limbs received no stretching during the 4 week period. We conducted one-way analyses of covariance to determine significant changes in ROM between groups ($p < .05$). **Main Outcome Measure(s):** Post-test straight leg hip flexion ROM. **Results:** There was no significant change in ROM between the dorsiflexion group (pre-test = 92.5 ± 16.5 , post-test = 104.5 ± 17.7) and the plantar flexion group (pre-test = 88.4 ± 21.6 , post-test = 99.3 ± 21.2) ($p = 0.90$). However, both the plantar flexion ($p = 0.04$) and dorsiflexion ($p = 0.01$) groups had significant increases in ROM when compared to the control group (pre-test = 94.0 ± 27.9 , post-test = 95.7 ± 25.3). **Conclusions:** Our results show that hamstring stretching with the ankle in either a dorsiflexed or plantar flexed position increases straight leg hip flexion ROM when compared to a control group. Furthermore, there is no difference in ROM between the two intervention positions. Our findings indicate that ankle position does not play a role in the effectiveness of hamstring stretching.

Dynamic Stretch Versus Complex For EMG Activity And Vertical Jump Performance

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Context: Sport performance is the number one concern for all athletes currently competing. Current research shows conflicting results over the use of static stretching and dynamic stretching before competition. However, evidence suggests that dynamic stretching prepares the body for athletic movements more effectively than static stretching. A relatively new therapeutic modality, the Compex motor stimulation unit has a program that the manufacturers' claim to prepare the motor neuron of the muscle to fire and therefore prime the musculature for sport performance. **Objective:** The purpose of this study was to compare the effects of dynamic stretching versus the Compex modality on muscle activation and vertical jump performance. **Design:** A repeated measures design. **Setting:** Sports medicine research laboratory. **Patients or Other Participants:** Fourteen males (age: 20.4 ± 1.28 , height: 182.40 ± 4.75 cm, weight: 194.78 ± 12.66 lbs) and 14 females (age: 20.92 ± 1.14 , height: 168.50 ± 4.78 cm, weight: 138.21 ± 18.48 lbs) volunteered to participate in the study. **Intervention(s):** Participants were randomly assigned to either the Compex group or the dynamic stretch group. Electromyography (EMG) electrodes were placed on the Rectus Femoris (RF), Vastus Medialis (VM), and Vastus Lateralis (VL) musculature of all participants. Prior to intervention treatment, muscle activation was recorded during a maximum voluntary isometric contraction of each muscle to allow for normalization of the EMG data for group comparison. Each participant then performed 3 vertical jumps that were measured with a Vertec Jump Trainer to obtain baseline height and muscle activations. The participants then completed their group intervention treatment of either dynamic stretches or Compex. Dynamic stretches included high knees, butt kicks,

karaoke, squats, high kicks, and jogs. Each stretch was performed for 60 seconds. The Compex pads were placed over the RF, VM and VL muscles with the unit set to potentiation at intensity of 15 for a 3 minutes and 30 seconds treatment. Once intervention treatment was completed, the participants performed 3 post intervention vertical jumps to obtain jump height and muscle activation measures. **Main Outcome Measure(s):** Vertical jump height (inches) and RF, VM and VL muscle activation (%). **Results:** There was a significant increase in vertical jump height in both the males ($p = <0.0001$) and females ($p = <0.0001$) for the dynamic stretch but not for the Compex ($p = .076$ males and $p = .749$ females). No significant differences were identified between groups on all muscle activation measures ($p > 0.05$). When examining the vertical jump heights in the dynamic stretching group the average increase for males was 1.59 inches and for females 1.14 inches. **Conclusions:** The study findings indicate that a dynamic warm up was more effective than the Compex treatment as a warm-up intervention before performing vertical jumps for maximal height. However, further research is needed to explore the effect dynamic stretching and Compex treatment has on muscle activation.

Effects Of Light Brushing On Clinical Pain Intensity And Experimental Pain Sensitivity In Fibromyalgia Patients

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Context: The Graston Technique (GT) is an instrument-assisted soft tissue mobilization technique based on the concepts of manual therapy and cross friction massage, which have been proven to decrease pain intensity and disability in injured subjects. The “light brushing” stroke is proposed to desensitize the treatment area prior to more aggressive stages of the protocol. However, no studies have been conducted to assess the effectiveness of “light brushing” in subjects with chronic pain. **Objective:** To determine the effect that light brushing stroke has on the central and peripheral pain processing. **Design:** Experimental cross-sectional with pre and post test measures. **Setting:** Experimental Pain Research Laboratory at Indiana State University. **Patients or Other Participants:** This preliminary analysis includes 7 participants with Fibromyalgia Syndrome (mean age = 55; SD = 9.83 years, 1 male and 6 females). **Intervention(s):** Demographic information, medical history and validated self-report questionnaires were gathered at the beginning of the session. Fibromyalgia diagnosis was confirmed using American College of Rheumatology criteria. Subjects underwent a baseline experimental pain assessment, which consisted of the measurement of thermal pain threshold, thermal pain tolerance, heat temporal summation (five consecutive heat stimuli at 48°C), and cutaneous sensation. Participants then received a 45-second light brushing treatment over 3 Fibromyalgia tender points: right occiput at suboccipital muscle insertions (site A), right trapezius muscle at midpoint of the upper boarder (site B), and right supraspinatus muscle at origin above the medial border of the scapular spine (site C). Immediately following the treatment, the participants underwent a

post-test experimental pain assessment. **Main Outcome Measure(s):** Central pain processing was measured with thermal pain threshold, thermal pain tolerance, and heat temporal summation. Peripheral pain processing was assessed by measuring cutaneous sensation threshold with Von Frey monofilaments. Dependent t-tests were conducted to assess the treatment effect on each outcome measure. **Results:** Analysis indicated no differences between pre and post measurements of thermal pain threshold (pre 43.53 ± 4.29 ; post 43.50 ± 4.28 ; $p = 0.979$), tolerance (pre 47.78 ± 2.03 ; post 47.92 ± 1.35 ; $p = 0.807$), temporal summation (pre 40.14 ± 25.44 ; post 28.57 ± 25.81 ; $p = 0.226$), or cutaneous sensation site A (pre 3.71 ± 0.76 ; post 3.57 ± 0.79 ; $p = 0.356$), site B (pre 3.82 ± 0.75 ; post 3.91 ± 0.54 ; $p = 0.341$), site C (pre 4.00 ± 0.58 ; post 4.29 ± 0.49 ; $p = 0.172$). **Conclusions:** In this cohort, the light brushing GT demonstrated no effect on central or peripheral pain processing. However, further analysis is needed to assess the real efficacy of GT in a larger sample size. Using light brushing to increase pain threshold and pain tolerance in individuals with chronic pain may change allodynia or decrease hyperalgesia. Decreasing these debilitating factors could enable individuals to perform rehabilitative exercises which will help improve their syndrome.

Block-Periodized Training Improves Physiological And Tactically-Relevant Performance In Naval Special Warfare Operators

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Context: Naval Special Warfare (NSW) Operators are at risk for injury and may experience physical readiness decrement due to the operational demands and requirements of tactical training and deployment. Specific human performance training and prevention strategies are necessary to promote physical readiness and mitigate musculoskeletal injuries throughout the tactical life cycle. The Tactical Athlete Program (TAP) was refined based two years of laboratory and field testing to scientifically evaluate physical, physiological, and tactically-relevant characteristics in NSW Operators. **Objective:** To evaluate the effectiveness of a 12-week block-periodized training program to induce improvements in physical, physiological, and tactically-relevant performance in NSW Operators. **Design:** Controlled clinical trial. **Setting:** University-operated, Special Operations Forces human performance research laboratory. **Patients or Other Participants:** A total of 82 Operators participated (Experimental (N: 46)- Age: 29.4 ± 5.5 years, Height: 176.7 ± 6.4 cm, Mass: 86.7 ± 11.6 kg; Control (N: 36)- Age: 29.0 ± 6.0 years, Height: 177.1 ± 6.3 cm, Mass: 85.7 ± 12.5 kg). **Intervention(s):** Operators in the experimental group performed a 12-week block-periodized training program while Operators in the control group performed a 12 week daily undulating program. All training was performed concurrent with tactical training. **Main Outcome Measure(s):** Pre- and post-testing was performed to assess strength (isokinetic),

flexibility, body composition, aerobic capacity/lactate threshold, and tactically-relevant performance (medicine ball throw, broad jump, 5-10-5 and 300-yard shuttle runs, weighted pull-up, body weight bench press, 1RM deadlift). Two way repeated measures ANOVA tests were used to analyze the dependent variables ($p < 0.05$). **Results:** The experimental group demonstrated a significant loss in body fat (Pre: $16.6 \pm 7.1\%$, Post: $15.2 \pm 6.7\%$) and fat mass (Pre: 15.0 ± 8.1 kg, Post: 13.7 ± 7.6 kg) and increase in fat free mass (Pre: 73.0 ± 9.1 kg, Post: 73.6 ± 9.2 kg) while no changes were demonstrated in the control group ($p = 0.016-0.024$). Within group improvements in VO_2 peak were demonstrated for the experimental (Pre: 50.0 ± 6.6 ml/kg/min, Post: 52.0 ± 6.7 ml/kg/min, $p = 0.008$) and control (Pre: 50.9 ± 7.3 ml/kg/min, Post: 54.0 ± 6.9 ml/kg/min, $p = 0.003$) groups. The experimental group demonstrated a significant improvement in the pro agility test to the right (Pre: 5.1 ± 0.37 s, Post: 4.97 ± 0.36 s) and left (Pre: 5.09 ± 0.4 s, Post: 4.93 ± 0.32 s) directions and loaded pull up task (Pre: 13.4 ± 5.1 reps, Post: 17.5 ± 4.9 reps) while no changes were demonstrated in the control group ($p = 0.01-0.019$). Within group improvements for the experimental group were demonstrated for the medicine ball toss (Pre: 390.0 ± 40.0 cm, Post: 400.0 ± 40.0 cm, $p = 0.005$), broad jump (2.4 ± 0.23 m, 2.52 ± 0.38 m, $p < 0.001$), and deadlift (171.2 ± 25.5 kg, 179.8 ± 22.4 kg, $p = 0.036$). **Conclusions:** These data suggest implementation of a population-specific TAP based on scientific evaluation using a 12-week block-periodized design or daily undulating program design are both effective at inducing adaptations in physical readiness when performed concurrently with tactical training. However greater improvements were observed using block periodization. Further refinement is required to address improvements in injury mitigating characteristics.

The Effects Of Chocolate Milk On Time-To-Exhaustion In Endurance Athletes: A Systematic Review

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Context: Endurance athletes must consume adequate amounts of carbohydrates post-workout to restore glycogen stores in order to exercise at similar, if not, higher intensities during subsequent training sessions. Chocolate milk (CM) has been noted for its' taste, availability, low-cost, and convenience, making it a popular alternative to other hydration beverages (HB) and carbohydrate replacement drinks (CRD) for athletes. **Objective:** To systematically review the literature to evaluate the efficacy of chocolate milk as recovery aid compared to other hydration beverages in endurance athletes. **Data Sources:** Relevant articles were identified from the following electronic databases: PubMed, Science Direct, Medline from January 2000-November 2013 using the following terms: "chocolate milk and recovery" and "sports drinks and recovery" resulting in 25 studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed, randomized controlled trials or controlled trials without randomization on endurance athletes, aged 18-50 training on a regular basis (five days/week), (2) written in English, (3) available abstract, and (4) included study outcomes measuring the efficacy of CM as a recovery aid for endurance athletes (ie., time-to-exhaustion or recovery time). **Data Extraction:** Three reviewers independently assessed and graded each study on the Physiotherapy Evidence Database (PEDro) scale. Data of interest were subjects, intervention, means (SDs), confidence intervals (when available), and effect size (calculated from relevant data) of the main outcome measures. **Data Synthesis:** Five studies met the inclusion criteria, all full reports. PEDro scores ranged from 5 to 9 points (maximum score=10 points) with an average of 6.3 ± 1.4 across the three reviewers.

Mean subject age was 22.7 ± 3.4 (range 19-40), all trained on a regular basis. All studies examined time-to-exhaustion (min) post endurance activity. Three of the five studies found CM (mean = 26.77 ± 16.47 min) significantly increased the time-to-exhaustion compared to CRD (18.01 ± 10.60 min). Mean calculated effect size for the three significant studies of CM time-to-exhaustion demonstrated a small effect, $d = 0.40 \pm 0.20$ (range 0.17-0.56). In all five studies the mean time-to-exhaustion when consuming CM increased (20.60 ± 14.44) compared to those consuming CRD (15.59 ± 8.27). Two studies examined collegiate soccer players ($n = 39$, $M = 28$, $F = 11$) and found means time-to-exhaustion for males consuming CM increased (9.01 ± 0.98) compared to those consuming CRD ($8.32 \pm .96$). Females consuming CM increased time-to-exhaustion with CM was ($12.6 \pm .96$) compared to CRD ($13.3 \pm .05$). **Conclusions:** Results suggest that CM as a recovery aid for endurance athletes appears to improve time-to-exhaustion compared to other recovery products (ie., water, carbohydrate/protein drinks). This increased time-to-exhaustion, while small, may mean the addition of another quarter in football or 2-3 additional miles on a training run for a marathoner. With many athletic budgets facing funding issues; CM becomes an effective and cost efficient means for endurance athletes to increase their time-to-exhaustion and reduce recovery time following endurance training.

Effect Of Post-Race Nutritional Intervention On Delayed-Onset Muscle Soreness And Return To Activity In Ironman Triathletes

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Context: Ironman triathletes often experience delayed-onset muscle soreness (DOMS) after races. Post-exercise nutritional interventions have been shown to be an effective recovery strategy for DOMS, however little is known on how post-race nutritional intervention affects DOMS in triathletes. **Objective:** To examine the effect of a post-race nutritional intervention on DOMS and ability of triathletes to return to activity (RTA). **Design:** Randomized field study. **Setting:** 2013 Lake Placid Ironman triathlon. **Patients or Other Participants:** Thirty-six (males: $n=30$, females: $n=6$) triathletes participated (mean \pm SD; age = 38 ± 9 y, height = 178 ± 9 cm, weight = 76.9 ± 11.1 kg, body fat = $12.2 \pm 5.4\%$, finish time = 732 ± 108 min). **Intervention:** Subjects were randomly assigned to either an intervention (INT) or control (CON) group by finish time. The INT group received two recovery shakes (540 kcal, 90g carbohydrate, 40g protein, 16g fat) both 1-hour (1h) and 3-hours (3h) post-race. **Main Outcome Measure(s):** We used a 100mm-visual analogue scale (VAS) and 11-point global rating of change (GRC) scale to measure DOMS in standing position (VASs & GRCs respectively) and sitting-to-standing motion (VASa & GRCa respectively). GRC scores measured change in DOMS compared to previous time point. DOMS was evaluated at 11 time points (pre-race, 1h, 3h, 12h post-race, and everyday for up to 7 days (1-7d)

post-race) using paper-based and on-line surveys. RTA questionnaires were used to assess days to RTA, length, intensity, and composition of activity. Activity intensity was measured with a 15-point rated perceived exertion (RPE) scale. Subjects completed RTA questionnaires via online survey for 2 weeks post-race. Two-way ANOVA (group \times time) was used to compare outcomes between groups over time and independent t-tests were utilized for group comparisons. **Results:** VASs and VASa scores significantly increased from pre-race (INT: 3 ± 5 cm, 2 ± 4 cm; CON: 3 ± 4 cm, 3 ± 3 cm respectively) to 1-hour post-race, which represented peak VASs and VASa values (INT: 50 ± 19 cm, 52 ± 23 cm; CON: 46 ± 24 cm, 47 ± 26 cm, $p < 0.001$, respectively). Both VASs and VASa values remained significantly elevated from pre-race until 4 days post-race (INT: 10 ± 14 , 12 ± 16 ; CON: 6 ± 10 , 5 ± 11 , $p < 0.05$ respectively). Negative GRC values only occurred 1-hour post-race in both INT (-4 ± 1) and CON (-3 ± 1) and demonstrated improvement at all other time points. VAS and GRC showed no differences between groups any time point ($p > 0.05$). No significant differences occurred for days to RTA (INT: 4 ± 4 d; CON: 4 ± 2 d), activity intensity (INT: 10 ± 3 , CON 10 ± 4) or composition of activity between groups ($p > 0.05$). However, activity length was significantly longer for INT group (1.2 ± 0.5 h) than CON group (0.8 ± 0.4 h, $p < 0.01$). **Conclusions:** DOMS increased dramatically in response to the race and gradually subsided by 4 days post-race regardless of treatment group. Within the context of this study, the post-race nutritional intervention did not result in differences on DOMS compared to CON. Despite this, upon RTA, the intervention group performed longer exercise bouts.

Effects Of Motor Imagery On Altering Corticospinal Excitability: A Systematic Review

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Context: Corticospinal excitability alterations have been reported in the musculature surrounding various injured joints, leading to disability and possibly influencing the development of chronic joint breakdown. Motor imagery, or the mental rehearsal of movement without any overt muscle activation, is a technique used to increase corticospinal excitability. Before motor imagery can be further adopted into the clinical management of joint injury, a systematic investigation of the effects of motor imagery on corticospinal excitability must be conducted. **Objective:** Determine the magnitude of the effect of motor imagery on corticospinal excitability compared to a resting control condition in healthy participants. **Data Sources:** The Web of Science and PubMed databases were searched between the years of 1950 and November 15, 2013 with the keyword “imagery” paired with “transcranial magnetic stimulation (TMS)” or “motor evoked potential (MEP)”. **Study Selection:** The initial search query included 374 articles. Included studies investigated the effects of kinesthetic motor imagery (i.e. imagining what the movement feels like) on MEP amplitudes measured by single-pulsed TMS in the dominant limbs of healthy control subjects. Studies were excluded if means and standard deviations were not reported in tabular form. Pertinent studies were cross-referenced for relevant articles, leaving 10 studies that met our inclusion criteria. **Data Extraction:** Peak-to-peak MEP amplitudes, our main outcome measure, were used to estimate corticospinal excitability. We extracted MEP amplitude means and standard deviations at baseline and following motor imagery. **Data Synthesis:** Cohen’s effect sizes [$d = (\text{posttest mean} - \text{pretest mean}) / \text{pooled standard deviation}$] with 95% confidence intervals (CI) were calculated for each muscle and motor imagery task. Twelve effects

sizes were calculated from the 10 studies due to multiple muscles or motor imagery tasks utilized in two individual studies. Moderate to strong effect sizes (d -range = 0.47-3.05), indicative of an increase in MEP amplitude following motor imagery, were observed for the majority of the effect sizes calculated (75%, 9/12). One-third (4/12) of the effect sizes were strong (d -range = 1.12-3.05) with conclusive CIs that did not cross zero. One study found a weak negative effect size ($d = -0.05$, $CI = 0.56, 0.46$), but effects are inconclusive as CIs crossed zero. All included studies investigated upper extremity muscles: intrinsic index finger muscles (4 studies: d -range = 0.34-3.05), intrinsic thumb muscles (5 studies: d -range = -0.05-0.82), and extrinsic wrist muscles (2 studies: d -range = 0.59-1.12). Motor imagery in index finger muscles demonstrated the largest effect sizes (3/4 studies: d -range = 1.19-3.05). **Conclusions:** Motor imagery appears to be a viable rehabilitation technique aimed at increasing corticospinal excitability; however, the majority of research is conducted on hand and wrist musculature. Future research should be expanded to determine the effectiveness of motor imagery for increasing corticospinal excitability in the lower extremity, as well as determining if motor imagery is capable of altering corticospinal excitability following joint injury.

Free Communications, Poster Presentations: Dynamic Balance and Postural Control

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14120DOMU

The Effect Of Trial Duration On Instrumented Measures Of Single-Limb Stance Postural Control

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Context: Quiet single-limb stance is often used to assess static postural control in both the clinical and laboratory setting for an array of sports-related injuries. Currently, there are no recommendations for the trial duration of single-limb balance tests. However, trial duration may influence test results. **Objective:** To examine the effect of trial duration on instrumented measures of postural control in healthy adults. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Ten healthy adults (8 females, 2 males; age = 22.1 ± 1.5 years; 167.4 ± 9.3 cm; 67.4 ± 12.3 kg) participated. **Intervention(s):** Static postural control was assessed using quiet single-limb stance on a force plate. With eyes open, participants stood barefoot on one limb with the contralateral limb held at 45° of hip and 30° of knee flexion. Instructions were to look straight ahead with hands on hips and remain as motionless as possible. A practice trial was performed prior to the collection of three 10 second trials on each limb. The data collected during each trial was analyzed as the initial 2.5 seconds (2.5s), the initial 5 seconds (5s) and 10 seconds (10s). **Main Outcome Measure(s):** The independent variables included limb and trial duration. The dependent variables included postural control examined using time-to-boundary (TTB) variables measured in seconds (s). The mean of TTB minima (TTB-mean) and the standard deviation of TTB minima (TTB-SD) in the anterior-posterior (AP) and medial-lateral (ML) directions were calculated for each trial duration (10s, 5s and 2.5s) and limb. For each TTB variable, a 2x3 ANOVA examined differences between trial duration and limbs. Post hoc comparisons were performed when indicated using Fisher's LSD. Alpha level was set at $p \leq 0.05$ for all analyses. **Results:** No significant limb-by-trial duration interactions

or limb main effects were identified ($p > 0.05$). Main effects were identified for trial duration in all TTB variables ($p < 0.05$). Post hoc analysis revealed significant differences in TTB-mean ML between 10s (2.35 ± 0.96 s) and 5s (2.17 ± 0.78 s; $p = 0.04$), and 10s and 2.5s (2.11 ± 0.92 s; $p = 0.008$); TTB-mean AP between 10s (6.81 ± 2.08 s) and 5s (6.36 ± 1.96 s; $p = 0.02$), 10s and 2.5s (5.89 ± 1.94 s; $p = 0.001$), and 5s and 2.5s ($p = 0.006$); TTB-SD ML between 10s (2.17 ± 1.34) and 5s (1.84 ± 0.95 ; $p = 0.04$), and 10s and 2.5s (1.72 ± 1.11 ; $p = 0.001$); TTB-SD AP between 10s (5.26 ± 1.74) and 5s (4.42 ± 1.76 ; $p = 0.005$), and 10s and 2.5s (3.83 ± 1.84 ; $p = 0.008$). **Conclusions:** Greater TTB values were exhibited during the 10s trial duration compared to 5s and 2.5s indicating postural control improved with longer trial durations. During the initial phase of single limb stance, the sensorimotor system may be under greater constraint while restoring equilibrium after moving into single limb stance. This suggests differing aspects of postural control may be examined with different trial durations. Future research should examine the effect of trial duration on clinical postural control assessments and in impaired subjects.

14245MOBI

The Relationship between Static and Dynamic Balance Measures

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Context: Balance is commonly measured in both static and dynamic conditions in order to assess postural steadiness and postural stability, respectively. While previous reports suggest little relationship between the two measures, traditional static measures such as center of pressure excursion and velocity are limited as they focus on spatial or temporal features independently. A newer static measure, time-to-boundary (TTB), assesses both the spatial and temporal characteristics simultaneously. However, it is currently unknown if TTB is associated with a dynamic postural stability measure. **Objective:** To determine the relationship between medial-lateral time-to-boundary (TTB) and medial-lateral postural stability index (MLSI). **Design:** Cross sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-three Division I soccer players (14 females, 19 males, age: 19.85 ± 1.18 years, height: 176.60 ± 7.31 cm, mass: 72.72 ± 9.27 kg). **Interventions:** Participants completed a static and dynamic balance task. For static trials, participants stood as still as possible on their preferred kicking leg for 10 seconds on a force plate. For dynamic trials, participants: 1) stood 70 cm from the center of the force plate, 2) jumped off both legs to a height of 50% of their maximum vertical jump, 3) landed on the force plate using their preferred kicking leg, 4) stabilized their landing as quickly as possible, and 5) held that position for 20 seconds. Three valid trials with 30 seconds rest between trials were completed for each task. **Main Outcome Measures:** The mean, minimum, and standard deviation of the TTB; and the MLSI were calculated during static and dynamic trials, respectively, using custom written software

and methods described by previous investigators. The average value for each dependent variable was then calculated across trials. Relationships between the three TTB measures and the MLSI were assessed using three, separate Pearson correlation coefficients ($\alpha = 0.05$).

Results: MLSI (0.037 ± 0.008 unitless) was not associated with the mean TTB (3.293 ± 1.017 s, $r = 0.012$, $p = 0.948$); the absolute minimum of the TTB (0.039 ± 0.007 s, $r = 0.024$, $p = 0.896$); or the standard deviation of the TTB (5.999 ± 2.754 s, $r = -0.079$, $p = 0.661$).

Conclusions: While time-to-boundary is likely a more sensitive measure of postural steadiness than traditional static balance measures as it evaluates both spatial and temporal characteristics simultaneously, it is not related to dynamic postural stability as quantified using the MLSI. This indicates that static and dynamic balance measures provide unique information, and suggests that it is important to carefully consider the research question when choosing balance measures during the research study design.

Ankle Dorsiflexion Implications For Measuring Postural Control

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Context: Postural control assessments during functional screenings are recommended as baseline measurements to assess for injury risk and objective return to play criteria. The single leg anterior reach (SLAR) evaluates postural control by measuring the distance an individual is able to reach their contralateral foot while maintaining a single leg balanced position. A few considerations for measuring postural control are the task demands, testing instructions, and gender. The effect of ankle dorsiflexion on the various methods of measuring postural control is unknown. **Objective:** To determine the implications ankle dorsiflexion mobility may have on assessing postural stability with two types of SLAR tests. **Design:** Descriptive laboratory study. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** 110 NCAA Division 1 male athletes (1.85 ± 0.07 m, 93.01 ± 18.12 kg, 20.42 ± 1.11 years) and 63 NCAA Division 1 female athletes (1.73 ± 0.01 m, 66.98 ± 10.63 kg, 20.60 ± 1.12 years) participated in this study. **Intervention(s):** A functional assessment was completed prior to the regular season consisting of left and right ankle dorsiflexion measurements and two types of postural control SLAR tests. For the SLAR-constrained test (SLAR-C), the individual is to remain in a constrained, heel-down position with their hands on their hips while reaching out as far as possible with the contralateral foot. The second method is the SLAR-unconstrained test (SLAR-U) whereby the individual is not limited to a heel-down and hands on hip position. Right side was considered as stance limb and utilized for this assessment. **Main Outcome Measure(s):** A linear regression was performed to assess the relationship between left and right ankle dorsiflexion, SLAR-C, and SLAR-U by gender with alpha level set at .05 a priori. A between group independent

samples t-test was used to assess differences in ankle dorsiflexion. **Results:** Ankle dorsiflexion mobility was a significant predictor in males for SLAR-C ($r^2 = 0.373$, $p < .001$) and SLAR-U ($r^2 = 0.130$, $p = .003$). There was no relationship between dorsiflexion and either SLAR-U or SLAR-C in females. Ankle dorsiflexion was significantly lower in men than women (10.36 ± 3.88 cm, 12.37 ± 2.9 cm, respectively, $p < .001$). **Conclusions:** Ankle dorsiflexion mobility is more related to SLAR-C than SLAR-U in male collegiate athletes. Males had a higher incidence of low ankle dorsiflexion measures compared to females, which explains why there was a higher relationship between ankle dorsiflexion and the SLAR-C test where the heel is to remain in contact with the floor. The change in testing methodology is important, as the SLAR-U is less dependent on ankle dorsiflexion range of motion and thus more indicative of postural stability.

Cost-Savings Associated With An Athletic Trainer Administered Balance Training Program

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Context: Evidence is lacking to support the value of healthcare services provided by an athletic trainer (AT). ATs' services are often undervalued because they may not generate revenue via third-party reimbursement. However, ATs can establish the value of their services by examining the cost-effectiveness of their treatments, which may impact cost-savings for the healthcare system. **Objective:** The objective of this study was to demonstrate cost-savings associated with an AT administered balance training program on a functional outcome in patients with chronic ankle instability (CAI). **Design:** Prospective randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty subjects with CAI were randomly assigned to an intervention (age = 20.10 ± 2.33 yrs; height = 1.74 ± 0.10 cm; weight = 75.91 ± 22.72 kg) or control (age = 20 ± 1.15 yrs; height = 1.80 ± 0.11 cm; weight = 76.62 ± 12.51 kg) group. **Intervention(s):** The Ankle Joint Functional Assessment Tool (AJFAT) assessed functional limitations associated with CAI before and after training. Intervention patients participated in 10 minute rehabilitation sessions, 5 days per week for 6 weeks. Patients performed single leg stance on foam, single leg stance circles on a wobble board, and single leg stance with resistance band kicks. The control group did not train. A Receiver Operating Characteristic (ROC) curve plotted sensitivity versus 1-specificity for post-test AJFAT scores to identify an optimal cutoff score that distinguished between intervention and control patients (asymptotic significance = 0.05). Greater scores were indicative of better function. Cost-effectiveness ratios at the optimal cutoff point were computed for medical billing and for an AT's salary.

The cost-effectiveness ratio was defined as the costs for administering the intervention compared to the unit of effectiveness (true-positive minus false-positive cases). Healthcare costs for each rehabilitation session would have been \$31.95 (medical billing for neuromuscular re-education, CPT Code 97112). However, services could not be reimbursed. Thus, \$51,483.00 was used as the salary for the full-time AT (2011 NATA Salary Survey) and \$4.13 was computed as the portion of salary dedicated to each rehabilitation session. A cost-savings value was computed as the difference between cost-effectiveness ratios for medical billing and the AT's salary. **Main Outcome Measure(s):** Outcomes included optimal AJFAT cutoff score, sensitivity, 1-specificity, cost-effectiveness ratios (medical billing, AT's salary), and cost-savings. **Results:** The ROC curve (area-under-the-curve = 0.93; asymptotic significance = 0.001) revealed that the optimal AJFAT cutoff score was ≥ 22 , which identified 9 subjects in the intervention group correctly (sensitivity = 0.90) and 0 subjects in the control group incorrectly (1-specificity = 0). The medical billing cost-effectiveness ratio was \$106.50 and the AT's salary cost-effectiveness ratio was \$13.77. The cost-savings for administering this program was \$92.73. **Conclusions:** ATs may not be able to bill for all medical services, but they can have a significant cost-savings on the healthcare system. The AT administered intervention was a cost-effective treatment for patients' functional limitations and produced an average percent cost-savings of 87%.

The Effect Of Different Rest Intervals On Ankle Muscle Fatigue And Performance During The Star Excursion Balance Test

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Context: The Star Excursion Balance Test (SEBT) has been identified as a measurement of neuromuscular control discriminating healthy individuals from those with chronic ankle instability (CAI). Most researchers have used rest intervals of 15 or 20 seconds between trials. However, it is not known what the optimal time between trials may be. In fact, shorter rest intervals within the SEBT protocol could result in fatigue and decreased performance during the test. **Objective:** To determine whether different rest intervals affect ankle neuromuscular activation and performance during the SEBT. **Design:** Crossover controlled laboratory study. **Setting:** Sport biomechanics laboratory. **Patients or Other Participants:** Twenty subjects (9 male, 11 female; age = 21.7 ± 1.7 years; height = 162.3 ± 9.5 cm; mass = 53.6 ± 11.9 kg) volunteered. Subjects had no history of ankle sprain, known vestibular or balance disorder, or history of head injury in the last 6 months. **Intervention:** The order of rest intervals (10, 20, 40 seconds) and the order of reach direction (AM;anteriomedial, M:medial, PM:posteriomedial) were counterbalanced. A total of three visits were required to the lab. Subjects performed 7 consecutive trials of the SEBT in each of the 3 directions. The final 3 trials were used for analysis. Median frequencies of electromyographic signals from the tibialis anterior (TA), peroneus longus (PER), and medial gastrocnemius (MG) were used to estimate fatigue. Maximum reach distance was measured using a three-dimensional motion analysis system and calculated as the absolute distance between

left and right toe markers. **Main Outcome Measure(s):** Two-factor ANOVAs were used to compare maximum reach distance and median frequency of all three muscles in each direction across the rest interval groups. **Results:** Maximum reach distance was not significantly different across the rest interval groups (10s: 9.06 ± 1.07 vs. 20s: 9.11 ± 1.15 vs. 40s: 8.96 ± 2.99 , $p = 0.424$). However, maximum reach distance was significantly different across directions (AM: 8.05 ± 0.61 vs. M: 8.93 ± 0.62 vs. PM: 10.17 ± 0.70 , $p < 0.001$). Post hoc tests revealed maximum reach distance in PM was greater than both M ($p < 0.001$) and AM ($p < 0.001$), and M was greater than AM ($p < 0.001$). There were no interactions ($p = 0.955$). Median frequency of all muscles was not different across rest intervals (TA: $p = 0.864$, PER: $p = 0.866$, MG: $p = 0.711$). However, median frequency of TA was different across directions (AM: 33.87 ± 17.42 vs. M: 41.94 ± 17.71 vs. PM: 34.51 ± 19.46 , $p = 0.031$). Specifically, median frequency of TA in M was greater than both AM ($p = 0.013$) and PM ($p = 0.031$). There were no interactions between muscles (TA: $p = 0.859$, PER: $p = 0.265$, MG: $p = 0.941$). **Conclusions:** Different intervals of rest ranging from 10 to 40s influenced neither ankle muscle fatigue nor maximum reach distance during the SEBT in a healthy population. Based on our results, clinicians can use rest intervals between 10 and 40s for the SEBT without risk of fatigue. Further, TA activation appears to differ when moving in the medial direction, which may be related to increased demand for medial ankle control in this direction.

No Difference Between ACL Reconstruction Graft Types On Dynamic Balance And Knee Function

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Context: Anterior Cruciate Ligament (ACL) injuries often require reconstructive surgery using a graft from the hamstring or patellar tendon to allow a patient to return to functional activity. Dynamic balance is often used to evaluate a patient's function and has been shown to influence lower extremity injury risk. Limited knowledge exists regarding the effect graft type has on dynamic balance and knee function, which may have implications on a patient's ability to participate in activities at an optimal level and subsequent injury risk. **Objective:** To determine if graft type used during ACL reconstruction affects bilateral dynamic balance and patient-oriented outcomes. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-four patients with a history of a unilateral primary ACL reconstruction volunteered to participate. Twenty-one patients reported having hamstring-tendon grafts (2 male, 19 females, Age: 19 ± 2 years, Height: 167.6 ± 7.6 cm, Mass: 73.0 ± 25.4 kg, Average time from surgery: 40 ± 23 months) and forty-three patients reported having patellar-tendon grafts (8 males, 35 females, Age: 20 ± 3 years, Height: 170.9 ± 8.3 cm, Mass: 72.2 ± 15.7 kg, Average time from surgery: 40 ± 25 months). All participants were cleared by their physician and had returned to high-level sport involving landing and/or cutting at the time of testing. **Intervention(s):** All participants completed a single test session at one of two study testing sites. Participants completed the International Knee Documentation Committee (IKDC) Subjective Knee Form. Dynamic balance was assessed via the modified star excursion balance

test in three directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). All individuals completed 2 or 3 trials (depending on study location) on the involved and uninvolved limbs. Participants were instructed to reach as far as possible while keeping their hands on their hips. **Main Outcome Measure(s):** Reach distances were measured in centimeters (cm) and normalized to limb length (%) in each direction. Separate mixed-model two-way analyses of covariance analyzed differences between limbs (INV, UNINV) and graft types (Patellar, Hamstring) while controlling for testing site for each reach direction ($\alpha < .05$). A univariate analysis of covariance compared IKDC scores between graft type while controlling for testing site. **Results:** No significant differences were observed between limbs or graft types on dynamic balance ability in any direction (ANT reach distance: Patellar = $93.2 \pm 1.4\%$; Hamstring = $92.9 \pm 2.0\%$) ($P > 0.05$). No significant differences in IKDC scores between graft types were observed (IKDC: Patellar: 84 ± 9 ; Hamstring: 88 ± 12) ($P > 0.05$). **Conclusions:** Graft type does not impact dynamic balance ability or knee function in patients after returning to sport. Future research should evaluate if graft type impacts any other clinical factors or other patient-oriented outcomes.

Time From Surgery Influences Dynamic Balance Ability After ACL Reconstruction

Sheldon LN, DiStefano LJ, Martinez JC, Trojian TH, Joseph MF, Kulow SM, Pennuto AP, Bell DR: University of Connecticut, Storrs, CT, and University of Wisconsin-Madison, Madison, WI

Context: Injuries to the anterior cruciate ligament (ACL) often require reconstructive surgery and a lengthy rehabilitation. Dynamic balance deficits are typically addressed in the rehabilitation program for a patient following surgery. These measures are often used to evaluate a patient's function and have been shown to influence lower extremity injury risk. Initial post-surgical deficits may resolve after return-to-sport and activity, however, this relationship is unclear. **Objective:** To determine if dynamic balance in an ACL reconstructed (ACLR) population is affected by time since surgery. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-four participants with a history of ACLR volunteered to participate in the study and were assigned to one of two groups based on their time since surgery. The group demarcation was 36 months, which was the average time since surgery. Thirty-three patients self-reported less than 36 months since surgery (≤ 36 months = 2 males, 31 females; Age: 19 ± 3 yrs, Mass: 73.90 ± 23.30 kg, Height: 168.7 ± 8.1 cm, Months since surgery: 22 ± 7 months). Thirty-one patients reported more than 36 months since surgery (> 36 months = 8 males, 23 females; Age: 21 ± 2 yrs, Mass: 70.9 ± 13.70 kg, Height: 171 ± 8.2 cm, Months since surgery: 59 ± 22 months). **Intervention(s):** All participants completed a single test session at one of two study testing sites. Dynamic balance was assessed via the modified star excursion balance test with two or three trials (testing site dependent) in the following directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). Participants were instructed to reach

as far as possible with their toes in each direction while keeping their hands on their hips. **Main Outcome Measure(s):** Reach distances were measured (cm) and then normalized to each participant's limb length for each direction (% limb length). Separate one-way analyses of covariance analyzed differences between groups (≤ 36 months, > 36 months) while controlling for testing site for each reach direction ($\alpha < .05$). **Results:** The > 36 months group ($99.90 \pm 12.99\%$) reached further than the ≤ 36 months group ($90.86 \pm 10.44\%$) in the posteromedial direction ($p = 0.03$). No other significant differences were observed ($P > 0.05$). **Conclusions:** Dynamic balance ability continues to improve over time after an ACL reconstruction. Clinicians should consider this when developing maintenance rehabilitation programs for individuals after an ACL reconstruction to minimize future injury risk.

Ankle Dorsiflexion And Hip Flexion Range Of Motion And Hurdle Step Scores

Janicki JJ, Switzler CL, Hayes BT, Hicks-Little CA: University of Utah, Salt Lake City, UT

Context: Functional movement screening (FMS) has been gaining popularity in the fields of sports medicine and sports performance. Current research has investigated the relationship FMS has to injury and performance predictions. However, paucity exists in the research examining the effectiveness of FMS screening. Each movement in the FMS involves multiple joints and muscle groups, therefore weakness or instability in any one area could be the cause of a poor FMS score. Without understanding and identifying the specific weakness it is difficult to address with corrective exercises. **Objective:** The objective of this study was to compare participant scores from the FMS hurdle step movement, to goniometric range of motion (ROM) measurements for ankle dorsiflexion and hip flexion. We hypothesized that decreased dorsiflexion and hip flexion will be the primary cause of lower FMS scores on the hurdle step movement. **Design:** Correlation observational study. **Setting:** Sports Medicine research laboratory. **Patients or Other Participants:** Twenty healthy active males (age 21.2 ± 2.4 years, weight 171.5 ± 22.4 lbs, height 71.2 ± 2.7 in) and 20 healthy active females (age 21.3 ± 2.0 years, weight 148.4 ± 19.8 lbs, height 65.9 ± 2.6 in) volunteered to participate in the study. **Intervention(s):** Bilateral goniometric measurements of active ROM of ankle dorsiflexion and hip flexion were taken on all participants. Participants then completed three trials of the standard FMS hurdle step exercise. Hurdle step scoring was based on the FMS scoring criteria. **Main Outcome Measure(s):** Correlations were determined between ROM ($^{\circ}$) and FMS scores for right and left legs. Hurdle step scores (HS) and average hurdle step scores (AHS) were

correlated to ankle dorsiflexion (DF), hip flexion (HF), and total ROM (TR) (calculated: DF + HF), using a Spearman's rho correlation, significance was indicated as $p \leq 0.05$. **Results:** Hip flexion ROM had a weak correlation to FMS scores for females (Right: $r = 0.565$, $p = 0.009$ Left: $r = 0.512$, $p = 0.012$) and a weak negative correlation to FMS scores on the left leg for males ($r = -0.452$, $p = 0.046$). No other statistically significant correlations were found. Descriptive data revealed that on average subjects who scored lower on the FMS exhibited less ROM and overall the males and the dominant limb showed better FMS scores and ROM. **Conclusions:** This study was designed to determine if FMS hurdle step scores are related to ankle and hip ROM. Weak correlation suggests that ROM testing is not predictive of hurdle step scores, although it was evident in our findings that some subjects' scores may have related to diminished ROM. Therefore, subjects who score lower than a 3 on FMS should have ankle and hip ROM screening to determine if deficits exist. More research should be conducted to identify other biomechanical factors that contribute to individual FMS test scores.

Free Communications, Poster Presentations: Patellofemoral Pain

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

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Hip Rotation Range-Of-Motion Is Associated With Hip Internal Rotation Kinematics During A Single-Leg Squat Task In Females With Patellofemoral Pain

Goto S, Padua DA: Sports Medicine Research Laboratory, Human Movement Science Curriculum, Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Excessive hip internal rotation (HIR) angle during functional tasks has been identified in individuals with patellofemoral pain (PFP). Increased HIR is suggested to increase lateral patellofemoral joint contact pressure and contribute to PFP development. Thus, it is important to understand factors that influence HIR during functional tasks. Lower extremity range of motion (ROM) may influence HIR during functional tasks; however, there is a limited research investigating the association between lower extremity ROM and HIR angle in those with PFP. **Objective:** To examine the association between lower extremity ROM and HIR during a single leg squat (SLS) in those with PFP. **Design:** Cross-sectional correlation. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen, physically active females with PFP participated in this study. (Age = 24.7 ± 5.9 years; Height = 164.1 ± 7.8 cm; Mass = 62.0 ± 10.1 Kg). Participants with PFP had at least two months of anterior, lateral or retro patellar pain during walking, running, stair ascent or descent, squatting, and/or sitting for an extended period of time, no other lower extremity injuries within six months prior to the testing, and negative findings on examination of ligaments and menisci. **Intervention(s):** Passive joint ROM of the lower extremity was assessed using a standard goniometer and digital inclinometer. HIR kinematics were assessed using a seven-camera infrared optical motion capture system while participants performed three separate

single-leg squat (SLS) tasks at a standardized speed. **Main Outcome Measure(s):** Hip internal rotation (HIR) angle at the time of maximal knee flexion was averaged across three separate SLS trials. Passive ROM values during ankle dorsiflexion with knee extended (DFKEROM), ankle dorsiflexion with knee flexed (DFKFROM), and hip abduction (HABROM), knee extension (KEXTROM), knee flexion (KFLEXROM), hip internal rotation (HIRROM), hip external rotation (HERROM), and hip extension (HEXTROM) were averaged across three trials. Difference between HIRROM and HERROM was calculated by subtracting HERROM from HIRROM (HIRROM-HERROM). Separate Pearson product moment correlations were performed to identify the association between HIR angle and each ROM measure ($\alpha < 0.05$). **Results:** We observed significant correlations between HIR angle with HERROM ($r = -0.621$, $p = 0.006$), and HIR-HERROM ($r = 0.618$, $p = 0.019$). There were no other significant correlations ($p > 0.05$). **Conclusions:** Increased HIR during the SLS was associated with decreased HERROM and greater HIRROM relative to HERROM. These findings suggest that improving HERROM as well as maintaining balance between HIRROM and HERROM may be an important component to decrease HIR angle in individuals with PFP who demonstrated increased HIR during a SLS.

Patellofemoral Pain Is Associated With Altered Lower Extremity Kinematics And Neuromuscular Functions During Stair Descent

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Context: Patients with patellofemoral pain (PFP) often exhibit various biomechanical alterations, especially in the lower extremity. However, it is unclear whether painful symptoms are more related to kinematic variations or neuromuscular changes. **Objective:** Investigate the associations among pain, neuromuscular, and kinematic measures during stair descent in patients with PFP. **Design:** Descriptive laboratory. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty PFP (13F/7 M, 21.45 ± 3.90 years, 169.96 ± 10.47 cm, 71.30 ± 14.50 kg) volunteered. **Intervention(s):** Participants performed 10 stair descent trials, while recording the lower extremity kinematics and muscle activity of the symptomatic leg, using a 3-D motion capture system (Motion Analysis Corp, Santa Rosa, CA) and telemetric electromyography system (Noraxon USA, Scottsdale, AZ). Mean knee abduction (positive value = knee abduction), hip abduction (positive value = hip abduction) and hip internal rotation (IR) (positive value = hip IR) angles were obtained during the first 30% of the stance phase of stair descent. Electromyographic recording of the vastus medialis oblique (VMO), hip adductors (HAD) and gluteus medius (GMed) were obtained to identify the activation onset relative to footstrike and activation duration. **Main Outcome Measure(s):** Pearson's production moment correlation coefficients were calculated to obtain the correlations among the following variables: Kujala Anterior Knee Pain Scale score (AKPS), the maximum pain during stair descent using a 10-cm Visual Analog Scale (VASD), VMO

activation onset, VMO activation duration, HAD onset, HAD duration, GMed onset, GMed duration, Knee abduction angle, Hip abduction angle, and hip IR angle ($P < 0.05$). **Results:** The AKPS was significantly correlated with HAD activation onset ($r = 0.596$, $P = 0.006$). The VASD was significantly correlated with VMO activation onset ($r = -0.593$, $P = 0.006$), HAD duration ($r = 0.591$, $P = 0.006$), Knee abduction ($r = -0.488$, $P = 0.029$), and hip IR ($r = -0.471$, $P = 0.036$). The VMO onset was significantly correlated with HAD duration ($r = -0.611$, $P = 0.004$) and GMed duration ($r = 0.455$, $P = 0.044$). HAD duration was significantly correlated with Hip IR ($r = -0.471$, $P = 0.036$). Knee abduction angle was significantly correlated to Hip IR ($r = 0.518$, $P = 0.019$) and Hip abduction ($r = -0.527$, $P = 0.017$). **Conclusions:** Increased pain scores were associated with earlier VMO onset, later HAD onset, longer HAD duration, reduced knee abduction, and reduced hip IR. Delayed VMO onset was associated with shorter HAD duration and longer GMed duration, and longer HAD duration was associated with reduced hip IR. While these neuromuscular relationships may further confirm the perplexing nature of PFP, kinematic factors alone more clearly illustrated the association among knee abduction, hip IR and hip adduction. It is possible that PFP participants with more pain utilize compensatory strategies to control patellofemoral joint stress and avoid further increases in pain. However, potential long-term benefits or detrimental effects of this type of compensatory strategy are unknown. Continued research would be warranted to further investigate the effects of pain and/or pain modulation on neuromuscular and kinematic factors.

The Influence Of Flexibility On The Development Of Knee Overuse Injuries: A Meta-Analysis

Johnston A, Elliott T, Andrews C, Kollock RO, Games KE, Sefton JM: Warrior Research Center, Auburn University, Auburn, AL; Northern Kentucky University, Highland Heights, KY; Indiana State University, Terre Haute, IN

Context: Knee overuse injuries are common complaints in physically active persons. Research on causative factors remains conflicting, impeding development of preventative programs. **Objective:** Determine if individuals with knee overuse injuries have decreased flexibility compared to asymptomatic individuals. **Data Sources:** MEDLINE, PubMed, SPORTDiscus, CINAHL and Military and Government Collection from January 1990 to March 2013 using combinations of these terms: flexibility, hamstrings, knee, overuse injuries, quadriceps, prevention, patellofemoral, pain, iliotibial band (ITB), syndrome, anterior knee, hip, external rotators, internal rotators, abductors, adductors, ITB, tendonitis, tensor fascia latae, and ITB friction. Reference lists of identified studies were reviewed for additional citations. **Study Selection:** Studies included: control and treatment groups, means and standard deviations, measurement units, defined pathology, and identified muscle group evaluated. Seven studies met these criteria. **Data Extraction:** Two reviewers evaluated articles for inclusion. Disagreements concerning article eligibility were resolved by arbitration of a third reviewer. Data extracted included number of subjects, sex, and means and standard deviations for measures of joint range of motion. **Data Synthesis:** Overall meta-analysis and separate moderated meta-analyses were performed using a weighted random effects model with a Hedges'

g effect metric and 95% confidence intervals (CI). Moderators included: population (i.e. males, females and studies combining sexes), pathology, and muscle group. Overall meta-analysis indicated that individuals with knee overuse injuries had less flexibility ($P < 0.001$, Hedges' $g = -0.634$, 95% CI = -0.911 to -0.358) compared to asymptomatic individuals. Analysis of studies that combined sexes indicated that those with knee overuse injuries had less flexibility compared to asymptomatic individuals ($P < 0.001$, Hedges' $g = -0.818$, 95% CI = -1.158 to -0.478). In contrast, using only studies that analyzed males and females separately, neither males ($P = 0.590$, Hedges' $g = -0.158$, 95% CI = -0.734 to 0.418) or females ($P = 0.509$, Hedges' $g = -0.110$, 95% CI = -0.435 to 0.216) with knee overuse injuries had less flexibility compared to asymptomatic individuals. Using pathology as a moderator, individuals with patellofemoral pain syndrome had less flexibility ($P < 0.001$, Hedges' $g = -0.504$, 95% CI = -0.732 to -0.284) compared to asymptomatic individuals. Using muscle group as a moderator, individuals with knee overuse injuries had less ITB/tensor fasciae latae ($P < 0.001$, Hedges' $g = -0.853$, 95% CI = -1.271 to -0.434) and hamstrings ($P < 0.001$, Hedges' $g = -0.614$, 95% CI = -0.947 to -0.281) flexibility compared to asymptomatic individuals. **Conclusions:** Individuals with knee overuse injuries had less flexibility of the ITB/tensor fasciae latae and hamstrings compared asymptomatic individuals. Although the overall meta-analysis suggests that individuals with a knee overuse injuries have lower flexibility than those without symptoms, analyses using population as a moderator do not present the same results in males or females separately. Future research should assess the how measures vary between sexes.

Influence Of Muscle Strength On Knee Overuse Injuries: A Meta-Analysis

Kollock RO, Andrews C, Johnston A, Elliott T, Games KE, Sefton JM: Northern Kentucky University, Highland Heights, KY; Warrior Research Center, Auburn University, Auburn, AL; Indiana State University, Terre Haute, IN

Context: Knee overuse injuries are a common occurrence in physically active individuals. Research is conflicting as to possible contributing factors making the development of interventions difficult.

Objective: Determine if individuals with knee overuse injuries have decreased muscular strength at the hip and thigh as compared to asymptomatic individuals.

Data Sources: The relevant scientific literature from January 2000 to January 2013 was searched using MEDLINE, PubMed, Web of Science, SPORTDiscus, CINAHL and Military and Government Collection. Search terms included patellofemoral pain syndrome, iliotibial band syndrome, anterior knee pain, hip, knee, abductor, adductor, internal rotators, external rotators, quadriceps, hamstrings, gluteus maximus, gluteus minimus, gluteus medius, tensor fasciae latae, and strength. The reference lists of identified studies were reviewed for additional citations.

Study Selection: Selected studies included: a control and experimental group, means and standard deviations for control and experimental groups, identified muscles assessed, and a clearly defined a pathology. Thirty-three studies met these criteria.

Data Extraction: Two reviewers evaluated the relevant full text articles for final inclusion. The reviewers resolved disagreements concerning article eligibility by consensus or by arbitration of a third reviewer. The data extracted included: number of subjects, sex, and muscular strength means and standard deviations.

Data Synthesis: Separate meta-analyses were performed for each moderator: strength measurement scale

(absolute or normalized), muscle group, and sex. Each used a weighted random effects model with a Hedges's g effect metric and 95% confidence intervals (CI) to enable comparison across studies. Using measurement scale and muscle group as moderators, individuals with knee overuse injuries had decreases in: absolute muscular strength ($P < 0.001$, Hedges' $g = -0.197$, 95% CI = -0.301 to -0.093); normalized strength ($P < 0.001$, Hedges' $g = -0.678$, 95% CI = -0.812 to -0.544), absolute hip external rotator ($P = 0.046$, Hedges' $g = -0.287$, 95% CI = -0.568 to -0.005), normalized hip extensor ($P < 0.001$, Hedges' $g = -0.611$, 95% CI = -0.862 to -0.361), normalized hip external rotator ($P < 0.001$, Hedges' $g = -0.671$, 95% CI = -0.911 to -0.430), and normalized hip abductor ($P < 0.001$, Hedges' $g = -1.029$, 95% CI = -1.339 to -0.718) as compared to asymptomatic individuals. Individuals with knee overuse injuries also had a greater hip abductor-adductor strength ratio ($P = 0.033$, Hedges' $g = 0.416$, 95% CI = 0.034 to 0.797) compared to asymptomatic individuals. Using sex and measurement scale as moderators, males and females with knee overuse injuries had less absolute and normalized strength as compared to asymptomatic individuals. **Conclusions:** The main finding of this meta-analysis suggests that those with symptoms of a knee overuse injury have lower strength than those without symptoms. Further research is needed to determine if hip strength weakness is a cause or a result of knee overuses injuries.

Effectiveness Of Hip Abductor Strengthening On Patellofemoral Pain Syndrome Patients: A Meta-Analysis

Jeon HJ, Kim BH, Kim SG, Lee SY: Yonsei University, Department of Physical Education, Integrative Sport Sciences Laboratory, Seoul, South Korea

Context: There is a growing number of evidence suggesting that weakness of the hip abductors is associated with chronic knee injuries. Various treatments (e.g., hip abductor strengthening exercise) are used to manage chronic knee injuries such as patellofemoral pain syndrome (PFPS), however no strong evidence exists of whether or not these types of exercises are effective in treating PFPS.

Objective: The purpose of this review was to assess the efficacy of hip abductor strengthening exercises on alleviating pain in PFPS patients and improving lower extremity strength and kinetic/kinematics during gait and running tasks.

Data Sources: Pubmed, Embase, CINAHL, and SPORTDiscus were used to identify studies associated with the review until August 2013. Key words used were "hip abductor", "strengthening", and "patellofemoral pain".

Study Selection: Original research articles that met these criteria were included: 1) randomized controlled trials, cohort designs, case control, or repeated measure designs 2) participants with PFPS 3) evaluating the effectiveness of strengthening programs with a hand-held dynamometer (HHD) or isokinetic device, visual analog scale (VAS) and motion capture system.

Data Extraction: In order to compare the changes before and after the strengthening protocols, means, standard deviations and sample sizes of the outcome measures were extracted to estimate effect sizes (Cohen's d) and 95% confidence intervals. Pain using the VAS; strength/torque, and lower extremity kinetic/kinematics were extracted.

Data Synthesis: A total of seven articles were included. The quality of the selected studies were

assessed using the Physiotherapy Evidence Database scale (mean PEDro score: 5.57 ± 2.64). Torque and force increased through various strengthening protocols (isokinetic ES = 2.52, 95% CI: 1.13 to 3.91; force ES = 11.34, 95% CI: 10.97 to 11.71) and pain was reduced (ES = -20.68, 95% CI: -21.65 to -19.71). In contrast, kinetic and kinematic variables showed partially meaningful outcomes (knee abduction ES = -1.44, 95% CI: -1.77 to -1.10; hip adduction ES = 0.18, 95% CI: 0.01 to 0.35; hip internal rotation ES = 0.44, 95% CI: 0.30 to 0.58; consecutive footfall variability ES = 3.32, 95% CI: 3.31 to 3.33; hip external rotation moment ES = 0.37, 95% CI: 0.21 to 0.54) while other variables were not meaningful. **Conclusions:** In summary, for patellofemoral pain patients, strengthening the hip abductors reduced pain and increased strength within 8 weeks of training. However, no effects, or adverse effects, were found on kinetic and kinematic variables which are considered to be important factors that may prevent patellofemoral pain syndrome. Clinicians should put emphasis on hip muscle strengthening to reduce pain and improve strength however, alternative ways to restore lower extremity biomechanics should be considered as strengthening protocols did not change frontal plane biomechanics of the hip.

Trunk And Lower Extremity Biomechanics In Individuals With Patellofemoral Pain During A Single Leg Drop Landing Pre And Post An Isolated Hip Fatigue Protocol

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Context: The multifactorial nature of patellofemoral pain (PFP) does not limit the pathological presentation to the knee; therefore, gaining an understanding of how the entire lower extremity (LE) kinetic chain responds to differing demands of functional tasks may provide more insight into management strategies for individuals with PFP. **Objective:** To examine differences in LE and trunk landing mechanics from different heights in individuals with PFP following an isolated hip abductor fatigue protocol (HABD). **Design:** Repeated measures. **Setting:** Laboratory. **Patients or Other Participants:** Twenty physically active individuals with PFP (14 Females and 6 Males; age = 24.5 ± 5.8 yrs, Ht = 168.1 ± 8.27 cm, Mass = 65.9 ± 12.4 kg, Kujala = 71.5 ± 12.1) who reported pain for a minimum of 3 weeks during physical activity volunteered to participate in this study. **Intervention:** Each participant performed 5 trials of a single leg drop landing (SLDL) from three different heights (20, 30, and 40cm) pre and post an isolated hip fatigue protocol. The order of testing was randomized for both session and box height. The fatigue protocol consisted of the participant performing a maximal voluntary isometric contraction (MVIC) for standing HABD against a load cell for 15-sec, with a 5-sec rest for 3 repetitions. After 3 repetitions, the participant performed MVIC on the opposite leg for 3 repetitions. This protocol was repeated until the participant was not able to achieve 50% of their baseline MVIC for 2 consecutive trials. **Main Outcome Measurements:**

Independent variables were box height (20, 30, and 40cm) and time (pre and post). Dependent variables included sagittal and frontal plane ankle, knee, hip, and trunk angles, and transverse plane knee and hip angles at maximum knee flexion (MaxKF). Separate 2x3 ANOVAs were performed for each dependent variable. Significant interaction or main effects were further analyzed using Fisher's LSD post-hoc tests ($\alpha < 0.05$). **Results:** At MaxKF there was a main effect for box height for ankle dorsiflexion ($P = 0.001$) with post-hoc differences between 20cm and 30cm ($13.9 \pm 6.26^\circ$ vs. $15.63 \pm 6.66^\circ$; $P = 0.014$) and 20cm and 40cm ($13.9 \pm 6.26^\circ$ vs. $16.43 \pm 5.9^\circ$; $P > 0.001$); for knee flexion ($P = 0.001$) with post-hoc differences between 20cm and 30cm ($-44.55 \pm 9.88^\circ$ vs. $-47.13 \pm 10.37^\circ$; $P = 0.003$) and 20cm and 40cm ($-44.55 \pm 9.88^\circ$ vs. $-47.67 \pm 10.86^\circ$; $P > 0.001$); for trunk flexion ($P > 0.001$) with post-hoc differences between 20cm and 30cm ($-5.34 \pm 4.96^\circ$ vs. $-7.6 \pm 5.5^\circ$; $P = 0.01$), 20cm and 40cm ($-5.34 \pm 4.96^\circ$ vs. $-10.68 \pm 5.99^\circ$; $P > 0.001$) and 30 cm and 40 cm ($-7.6 \pm 5.5^\circ$ vs. $-10.68 \pm 5.99^\circ$; $P = 0.002$). There were no significant main effects for time or significant time x box height interactions ($P > 0.05$). **Conclusions:** Individuals with PFP appear to increase sagittal plane motion at the ankle, knee, and trunk in response to changes in height of the landing task. Isolated hip abductor fatigue does not appear to influence landing mechanics in individuals with PFP. Future studies should investigate the influence of more demanding fatigue protocols on landing mechanics in this population.

Free Communications, Poster Presentations: Lower Extremity Biomechanics

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14100DOBI

Effects Of Exercise On Vertical Ground Reaction Force Asymmetry In Active Individuals

Pennuto AP, Gill PG, Walden CE, Gire CD, Kulow SM, Bell DR: University of Wisconsin-Madison, Madison, WI

Context: Increased vertical ground reaction forces (VGRF) while landing from a jump may be related to higher risk of anterior cruciate ligament (ACL) injury. During landing it is assumed that both limbs contribute equally to the dispersal of VGRF. However, this may not be the case as certain factors are known to influence asymmetry between limbs, such as limb dominance and injury history. Another factor that may contribute to asymmetry between limbs is exercise, though this factor has not been investigated. **Objective:** To determine the influence of exercise on VGRF asymmetry between limbs and to investigate the relationship between VGRF asymmetry pre- and post-exercise. **Design:** Repeated Measures. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-nine active participants reporting to exercise for at least 20 minutes three times per week (20M 19F, 174.4 ± 8.69 cm, 75.37 ± 8.48 kg, 21.05 ± 1.34 yr). **Intervention(s):** All individuals completed five jump landings from a 30cm high box placed 50% of their height away from force plates. Subjects jumped onto the force plates and immediately jumped for height. VGRF was recorded by force plates on each limb sampled at 1440Hz. Participants then completed an exercise protocol consisting of a repeated circuit of short sprints, lateral shuffling, wall-sits, vertical jumps, and prone planks. Following each circuit, subjects were asked to provide a rating of perceived exertion (RPE). When subjects reached an RPE level of 17, participants then completed one final circuit. Participants returned to the laboratory for post-testing consisting of a final RPE measurement and five additional jump landings. **Main**

Outcome Measure(s): VGRF collected at the impact peak (initial peak) during landing and normalized to bodyweights. Limb asymmetry was calculated similarly to Herzog et al. $ABS((Right - Left)/(Right + Left).5)100$. VGRF asymmetry between limbs was compared pre- to post-exercise. Paired samples t-tests were used to analyze VGRF variables pre- to post-exercise. A bivariate correlation was used to analyze VGRF asymmetry between limbs pre- and post-exercise. Statistical significance was set a-priori at $p < .05$. Results: The following variables increased from pre- to post-exercise: RPE (Pre: 6.69 ± 1.15 , Post: 18.54 ± 0.99 , $t = -51.28$, $p < .001$) and VGRF Asymmetry (Pre: $19.95 \pm 11.36\%$, Post: $24.90 \pm 18.03\%$, $t = -2.06$, $p = .046$). VGRF at impact peak also increased for both the left (Pre: $1.68 \pm .39\%$ BW, Post: $1.80 \pm .44\%$ BW, $t = -2.14$, $p = .039$) and right limbs (Pre: $1.69 \pm .43\%$ BW, Post: $1.83 \pm .52\%$ BW, $t = -3.24$, $p = .003$). There was a significant correlation between pre- and post-exercise VGRF between limbs ($r = .56$, $p < .001$). **Conclusions:** The exercise protocol successfully increased exertion and participants landed with more force and more asymmetrically post-exercise. Additionally, the correlation analysis supports the notion that individuals with greater levels of asymmetry pre-exercise are associated with greater levels of asymmetry post-exercise. Clinicians should be aware of this response to exercise. Interventions to reduce injury should focus on symmetrical force distribution when landing. Funded by the Wisconsin Athletic Trainers' Association.

14107DOGA

Vector Coding Assessment Of Ankle Joint-Coupling During Gait: A Comparison Of Calculations With 3 Strides Versus 10 Strides

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Context: The assessment of joint-coupling variability of the shank internal/external rotation and rearfoot inversion/eversion has shown differences in intersegmental motion variability in patients with chronic ankle instability (CAI) compared to healthy controls during walking and jogging. The vector coding method of joint-coupling variability estimates may be highly dependent on the number of strides analyzed during a cyclical task. **Objective:** To compare joint-coupling variability assessed using a vector coding analysis in CAI patients and healthy controls using 3 strides and 10 strides during a walking and jogging task. **Design:** Descriptive Laboratory Study. **Setting:** Gait Laboratory. **Patients or Other Participants:** 15 healthy (age: 21.8 ± 1.8 yr, mass: 75.34 ± 8.21 kg, height: 162.81 ± 29.97 cm) and 15 CAI (age: 23.6 ± 4.2 yr, mass: 77.92 ± 4.49 kg, height: 185.16 ± 32.00 cm) subjects participated. **Intervention(s):** Subjects walked then jogged on a treadmill at speeds of 4.83 km/hr and 9.66km/hr. Three 15-second periods of gait were collected for analysis at each speed. **Main Outcome Measure(s):** The joint-coupling variability (VCV) between the shank internal/external rotation and rearfoot inversion/eversion kinematics was assessed using the Mullineaux vector coding method across 3 strides and then 10 strides for each subject. Group means and 90% confidence intervals were compared between the two analysis techniques for each group (CAI, healthy) across the entire gait cycle in both walking and jogging. Periods where confidence intervals did not overlap for at least 3 consecutive percentage points of the gait cycle were considered significant. **Results:** In the CAI group during walking there was a period of significant

difference with the 3 stride VCV being higher from 68-70% (3 stride: 0.53 ± 0.05 , 10 stride: 0.42 ± 0.04) of the gait cycle. During jogging, there were no differences between 3 strides and 10 strides in CAI patients. In controls, during walking the 10 stride comparison was higher from 17-25% (3 stride: 0.12 ± 0.03 , 10 stride: 0.20 ± 0.01) and from 53-60% (3 stride: 0.08 ± 0.01 , 10 stride: 0.14 ± 0.01) of the gait cycle. During jogging, there were no significant differences between the different analysis methods in the control group.

Conclusions: There were significant differences in both CAI and control groups between VCV measures using 3 strides and 10 strides while walking but not jogging. These findings are consistent with dynamical systems theory of task specificity. A more challenging task, such as jogging, may be more deterministic and create very rigid motor control pattern of the lower leg during gait. This would explain our finding in jogging, that regardless of the number of strides compared and injury history, the joint-coupling of the shank and rearfoot was consistent stride-to-stride within each group. In contrast, differences were found during walking in both CAI and controls. Analysis of movement variability in cyclical tasks should take into account the number of trials performed and demands of specific tasks. In analysis of joint coupling variability during walking, we recommend the use of at least 10 strides.

Correlation Of Tibial Accelerations With Knee Kinematics And Kinetics During Single-Leg Landings

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Context: Anterior cruciate ligament (ACL) injuries remain a serious problem in competitive and recreational sports. To date there have been many studies investigating potential risk factors for this injury, however, there has not been any documented decline in injury rates. A portable, cost effective, and easy to use device that is correlated to biomechanical measures of ACL risk factors will be helpful in the prospective examination of risk factors for ACL injury and injury preventative measures. **Objective:** Examine the relationship between tibial accelerations (TA) and kinematic and kinetic measures at the knee. **Design:** Descriptive correlational study. **Setting:** University research laboratory. **Patients or Other Participants:** Ten highly active varsity and club level college female athletes (Age = 20.3 ± 0.8 years, Mass = 63.3 ± 6.2 kg, Height = 168.6 ± 9.0 cm). **Intervention(s):** Two landing tasks including a single-leg drop landing from a 12 inch box and a single-leg stop-jump from a distance equal to 40% of the participant's body height. During these tasks TA was collected using a tri-axial accelerometer attached to the proximal tibia (medial plateau) and knee kinematics and kinetics were measured using a 3D video based motion analysis system. Additionally, tibiofemoral kinematics were measured using hi-speed dynamic stereo x-ray (DSX) video. **Main Outcome Measure(s):** Pearson product moment correlation coefficients were used to determine the linear relationship between peak TA and the following: peak knee angles; peak proximal anterior tibial shear force; peak ground reaction forces (GRFs); and peak tibiofemoral motion during

landing. **Results:** Peak TA was significantly correlated to peak knee flexion in axis three (anterior-posterior/medial-lateral direction) during the stop-jump task ($r = -0.79$, $p = 0.007$). Peak TA was significantly correlated to peak vertical GRFs in the vertical axis during the stop-jump and drop-landing task ($r = 0.80$ and 0.67 , $p = 0.006$ and $p = 0.033$). Vertical GRFs during the stop-jump task were also correlated to peak TA in the transverse plane and resultant directions ($r = 0.78$, $p = 0.007$ and $p = 0.008$). Among DSX measures, knee flexion was correlated with axis three of the accelerometer ($r = -0.70$, $p = 0.022$) and peak tibial translation magnitude was correlated with vertical and resultant directions of the accelerometer ($r = 0.68$, 0.67 , $p = 0.045$ and $p = 0.049$). All other variables had low and non-significant correlation coefficients. **Conclusions:** The results of this study demonstrate that TAs have moderate but significant correlations with landing GRFs, knee flexion, and tibial translation. Tibial acceleration may be a good measure of landing impact at the knee and may provide some information related to knee flexion and tibial translation magnitude during landing. The use of such a device may help facilitate the prospective evaluation of ACL risk factors. More studies are needed to further investigate these relationships in different populations and during different tasks.

Increasing Forward Trunk Flexion Reduces Sagittal Plane Knee Loading But Not Angle During A Side-Step Cutting Task

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Context: Trunk positioning during athletic tasks is a commonly theorized risk factor for anterior cruciate ligament (ACL) injury. Thus, training to improve trunk positioning is commonly incorporated during ACL injury prevention programming (IPP). However, the influence of altering trunk position on knee biomechanics associated with ACL injury is not well understood. **Objective:** To determine the effects of altering sagittal plane trunk position on sagittal plane knee biomechanics during a side-step cutting task (SSCT). **Design:** Cross-sectional; repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** 14 physically active females (168.5 ± 7.7 cm, 59.5 ± 8.7 kg, 20.9 ± 0.9 yrs) volunteered for this study. **Intervention(s):** Participants performed 3 SSCT trials during 3 different trunk position conditions: 1) preferred (PRF; instructed to cut in typical manner), 2) forward trunk flexion (FLX; instructed to increase amount of forward trunk flexion when cutting) and 3) trunk extension (EXT; instructed to increase amount of trunk extension when cutting). During each SSCT trial the participant landed on their dominant (kicking) limb and immediately cut 60° in the opposite direction of the dominant limb. **Main Outcome Measure(s):** Data were collected from the participant's dominant leg using a force plate (1200 Hz) and 7-camera motion analysis system (120 Hz). Peak knee flexion angle, proximal anterior tibial shear force (ATSF) and internal knee extension moment during the first 50% of the stance phase of the SSCT were calculated and averaged across trials for each SSCT condition

(PRF, FLX, EXT). Dependent variables were compared across the SSCT conditions using a repeated measures ANOVA ($\alpha < 0.05$). Post-hoc analyses were performed using dependent t-tests with a Bonferroni correction ($\alpha < 0.01$). **Results:** Significant main effects for SSCT condition were revealed for peak ATSF ($F_{2,26} = 18.21$, $P < 0.001$, $\eta^2 = 0.58$) and peak knee extension moment ($F_{2,26} = 48.06$, $P < 0.001$, $\eta^2 = 0.79$). However, peak knee flexion angle was not different between SSCT conditions ($F_{2,26} = 2.27$, $P = 0.123$; PRF = $49.5 \pm 6.2^\circ$, FLX = $50.4 \pm 7.2^\circ$, EXT = $52.7 \pm 7.0^\circ$). Post-hoc testing revealed peak ATSF was significantly less during the FLX (0.91 ± 0.13 N/Body Weight) condition compared to the PRF (1.12 ± 0.13 N/Body Weight), $P < 0.001$) and EXT (1.07 ± 0.12 N/Body Weight, $P < 0.001$) conditions. Peak knee extension moment was significantly less during the FLX (0.11 ± 0.03 Nm/Body Weight/Body Height, $P < 0.001$) and PRF (0.13 ± 0.03 Nm/Body Weight/Body Height, $P < 0.001$) conditions compared to the EXT (0.17 ± 0.03 Nm/Body Weight/Body Height) condition. Peak knee extension moment was also less during the FLX compared to the PRF condition ($P = 0.014$). **Conclusions:** Increasing forward trunk flexion reduced sagittal plane knee loading during a SSCT without concomitant changes in knee flexion position. Thus, increasing trunk flexion is an effective training method to acutely reduce sagittal plane knee loading. Future research should investigate the long-term effects of training to increase trunk flexion position during athletic tasks on knee biomechanics and ACL injury rates.

Sagittal Plane Knee Moment During Gait Is Predictive Of Knee Cartilage Thickness

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Context: Knee osteoarthritis (OA) onset and progression is associated with cartilage thinning. Greater internal knee extensor moments are commonly associated with greater quadriceps forces which in turn are associated with increased joint compressive forces. While relative frontal plane knee joint loading patterns during walking can influence articular cartilage thickness patterns, it is unknown if sagittal plane biomechanics associated with increased joint compressive forces are related to thicker articular cartilage which is commonly associated with healthier cartilage. **Objective:** Determine the relationship of medial femoral condyle cartilage thickness at the knee to sagittal gait biomechanics in healthy individuals. **Design:** Cross-sectional. **Setting:** Controlled Laboratory. **Patients or Other Participants:** 28 healthy participants (15 females: 1.63 ± 0.07 m, 64.6 ± 9.9 kg, 21.1 ± 2.1 yrs & 13 males: 1.79 ± 0.05 m, 75.2 ± 9.6 kg, 22.1 ± 2.9 yrs) with no current orthopedic injury or history of surgery in left limb. **Intervention(s):** On a single day participants underwent goniometric assessment of lower limb alignment, ultrasound measurement of medial femoral condyle articular cartilage, and completed 10 trials of over ground walking at a self-selected pace with simultaneous acquisition of 3D biomechanics. All testing was performed on the left limb. **Main Outcome Measure(s):** Tibiofemoral angle (TFA) represented the angle formed in the frontal plane by the anatomic axes of the femur and tibia. Medial femoral condyle cartilage thickness was obtained via ultrasound imaging. Lower extremity joint biomechanics during the stance phase of gait were normalized to 100

points and ensemble averaged over the 10 trials. Peak internal knee extensor moment was extracted from the first 50% of stance phase. Linear regression examined the extent to which peak internal knee extensor moment predicted cartilage thickness, after accounting for TFA and sex. **Results:** After accounting for TFA ($12.3 \pm 3.2^\circ$) and sex ($R^2\Delta = 1.1\%$, $P\Delta = 0.872$), greater internal knee extensor moment ($0.0148 \pm 0.0131\text{Nmbw-1ht-1}$) predicted increased cartilage thickness ($2.0 \pm 0.3\text{mm}$) ($R^2\Delta = 30.7\%$, $P\Delta = 0.003$). **Conclusions:** Given the connection of greater knee extensor moments to associated increased quadriceps' forces contributing to joint compressive forces, the results suggest that after controlling for confounding factors of frontal plane alignment and sex, individuals utilizing a gait pattern with greater knee extensor contribution have a cartilage structure that is generally considered healthier. Helping to establish these baseline relationships in non-pathological populations may help us to better understand potential factors related to maladaptive gait patterns that may predispose one to osteoarthritic changes.

Reliability Of 2-Dimensional Video Analysis For Assessing ACL Risk Factors Across A Basketball Season

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Context: The drop vertical jump(DVJ) is used for identifying individuals who go into a dynamic valgus collapse(DVC) at the knee upon landing. DVC is considered a risk factor for anterior cruciate ligament (ACL) injury. To quantify DVC during a DVJ, both three-dimensional(3D) and two-dimensional(2D) motion analysis are identified as valid and reliable methods. Further, 3D analysis is sensitive to changes over time. While there is good short-term reliability of 2D analysis, for 2D analysis to be useful to detect long-term changes, the stability of the measure must be assessed. **Objective:** Assess long-term reliability of 2D video analysis over the course of 1 basketball season. **Design:** Methodological pre-post study. **Setting:** High school. **Patients or Other Participants:** Nineteen female high school basketball athletes(ages 14-18yrs). **Intervention(s):** Each participant completed three two-footed DVJ tasks, pre- and post-season. The DVJ consisted of the subject dropping from a 31-cm platform, landing on 2 feet, and immediately jumping vertically with arms elevated. A DVJ was considered successful if the subject dropped from the platform and landed with 2 feet equally and immediately jumped upon contact with the floor. Each DVJ was recorded with a standard video camera placed anteriorly (distance = 345cm, height = 21cm) to the subject. For each DVJ captured, 2 still images were extracted for processing: just prior to weight acceptance (INITIAL) and final downward motion (FINAL).

Main Outcome Measure(s): Medial knee displacement (MEDIAL-DISP [cm]) and medial angular knee velocity (VELOCITY [$^\circ/\text{s}$]) were determined; downward vertical knee displacement (DOWN-DISP [cm]) was also determined, but not a primary variable. For VELOCITY, the MEDIAL-DISP and DOWN-DISP vectors were used to create a right triangle, with the hypotenuse representing translation of the knee center during landing. The angle adjacent to a vertical plumb line was determined. VELOCITY was calculated as the change in adjacent angle from the vertical divided by the time that lapsed from INITIAL to FINAL angular t- ce needed)ard video camera placed ble. also to contributions from both the frontal and transverse planes Intraclass correlation coefficients (ICCs) were used to test the stability across the season between pre- and post-testing. Pre-post Mean Differences (MD), Standard Error Measure (SEM) and the 95% Mean Detectable Change (MDC) were also determined. **Results:** Fair correlation was observed for MEDIAL-DISP ($\text{ICC} = 0.40$, $p = 0.09$; $\text{MD} = -1.4\text{cm}$, $\text{SEM} = 3.5\text{cm}$, $\text{MDC} = 4.91\text{cm}$). Good correlation was observed for VELOCITY ($\text{ICC} = 0.65$, $p = 0.002$, $\text{MD} = 14.0^\circ/\text{s}$, $\text{SEM} = 56.8^\circ/\text{s}$, $\text{MDC} = 80.8^\circ/\text{s}$). **Conclusions:** The anterior view of 2D video analysis is difficult due to capturing movement contributions from both frontal and transverse planes. Angular velocity, as quantified by the use of the medial and vertical displacements is novel, and may provide additional information regarding injury risk. These results support the use of 2D analysis of DVJ as a fairly reliable screening tool to help identify individuals who demonstrate DVC. In combination with other screening tools, this method may serve a contributor to a test battery designed to identify those at risk for ACL injury.

14091DOBI

Sagittal-Plane Landing Kinematics Are Predicted With Lower Extremity Muscular Power Tests

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Context: Anterior cruciate ligament (ACL) injuries remain a frequent occurrence in female collegiate athletes. Existing methods to predict ACL injury risk from landing kinematics require sophisticated equipment, expertise and time that prohibit large scale use. Utilization of field based tests to predict landing behaviors would create a practical risk identification method. **Objective:** To develop a predictive model for sagittal plane tibiofemoral landing kinematics from the results of several muscular power tests. We hypothesized linear regression models would explain a substantial amount of the variance associated with sagittal plane landing kinematics. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty nine female, NCAA D1 college athletes (age = 19.03 ± 1.09 years; weight = 66.56 ± 13.47 kg; height = 171.16 ± 7.92 cm) from the sports of soccer (n = 14), basketball (n = 3) and lacrosse (n = 12) participated. **Intervention(s):** Participants performed five unilateral lower extremity (LE) landings with their dominant LE from a 35cm (13.78in) platform onto a force plate (Bertec Corporation; Columbus, OH). LE 3D kinematics during the landing trials were captured with electromagnetic sensors (Ascension Technology; Milton, VT) which were interfaced with motion analysis software (Innovative Sports Training; Chicago, IL). Then in a randomized order, participants performed three trials of three standardized field-based tests of LE power: single-limb triple hop (SLTH), countermovement vertical jump (CMVJ) and the Margaria-Kalamen (MK) test. The kinematic trials were signal averaged. Sagittal plane initial contact (IC) and excursion (EXC) values in the first 0.1seconds after IC were retrieved for

each participant. Data were subsequently entered into a statistical software package where descriptive statistics and two separate linear regression models that used the results from the LE power tests were created. **Main Outcome Measure(s):** The linear regression analysis produced two separate models to predict the dependent variables of sagittal plane IC and EXC. Additionally, the coefficient of determination (R^2) and analysis of variance of regression from each model were examined along with an analysis of residuals and outliers. Alpha levels were set a-priori at $P \leq .05$. **Results:** Mean sagittal plane IC was $-1.80^\circ \pm 10.69^\circ$ (range -23.40° to 15.60°) while mean sagittal plane EXC was $34.59^\circ \pm 5.90^\circ$ (range 22.94° to 46.35°). Mean values for the three power tests were SLTH 536.98 ± 48.41 cm, CMVJ 42.79 ± 5.08 cm, and MK 1035.92 ± 193.26 Watts. The linear regression model to predict EXC was significant ($R^2 = .274$, $P = .043$) however the model to predict IC was not ($P = .121$). **Conclusions:** The results from our investigation show a significant amount of variance for sagittal plane EXC, but not sagittal plane IC may be explained with the three field power tests using a linear regression model. Additional study is necessary to validate our findings before these models can be recommended for clinical use.

14352UOBI

Trunk, Hip, And Knee Contributions To Peak Ball Velocity During A Soccer Penalty Kick

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Context: In soccer, it is advantageous to achieve high ball velocity during a penalty kick attempt. While numerous studies have examined the influence of specific lower extremity and trunk kinematics on ball velocity, there has been limited investigation on the contributions of the entire kinetic chain to ball velocity. A goal of functional rehabilitation is to approximate the demand of sport activity. This investigation of the kinetic chain requirements to achieve high performance can help guide treatment strategies. **Objective:** To determine the contribution of peak trunk rotary velocity, peak hip flexion acceleration, and peak knee extension velocity to peak ball velocity. **Design:** Descriptive laboratory study. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** 14 female NCAA Division I soccer athletes (19.57 ± 0.85 years, 1.70 ± 0.07 m, 65.10 ± 8.87 kg). **Intervention(s):** Three-dimensional movements of the lower extremities and trunk were collected using a passive optical motion capture system sampled at 300 Hz. Participants performed a soccer penalty kick task, starting from a self-preferred approach distance that averaged 2 meters. They then kicked a soccer ball into a target net placed 3 meters directly in front of the ball. Lower extremity and trunk kinematics were calculated using Visual3D software. A radar gun was used to collect peak ball velocity. **Main Outcome Measure(s):** Pearson correlations were performed to assess the relationships between peak trunk rotary velocity, peak hip flexion acceleration, peak knee extension velocity, and peak ball velocity, with an alpha level set at .05. A regression model was completed to determine the best predictors of peak ball velocity. **Results:** Peak ball velocity (19.9 ± 2.6 m/s) was correlated

with peak knee extension velocity (1545.9 ± 307.8 m/s, $r = .663$, $p < .001$), peak hip flexion acceleration (20678 ± 5274 m/s², $r = .0445$, $p = .020$), and peak trunk rotary velocity (289.4 ± 109.7 m/s, $r = .443$, $p = .026$). A regression model with all three correlated measures to predict ball velocity resulted in only peak knee extension velocity as a significant predictor of peak ball velocity ($r^2 = .464$). Peak trunk rotary velocity ($r = .542$, $p = .004$) and peak hip flexion acceleration ($r = .76$, $p < .001$) were collinear with peak knee extension velocity, resulting in their exclusion from the regression model.

Conclusions: Peak knee extension velocity predicts ball velocity during a soccer penalty kick. Peak trunk rotary velocity and peak hip flexion acceleration contribute to peak knee extension velocity, demonstrating a combined effort of trunk and lower extremities to generate ball velocity. This suggests that athletic trainers engaging in rehabilitation of athletes who use their extremities to impart power on objects (e.g. soccer ball) may find it advantageous to train the body as a kinetic chain.

Drop Vertical Jump Knee Valgus Kinematics Predict Basketball Rebound Knee

Valgus Kinematics

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Context: Jump landing mechanics are a traditional measure of injury risk factors and neuromuscular control. However, a lack of data exists to quantify the ability of these measures to predict sport specific landing mechanics. **Objective:** To determine the relationship between landing kinematics in a drop vertical jump task to those during a game simulated basketball rebounding task.

Design: Experimental crossover study.

Setting: Biomechanics research laboratory.

Patients or Other Participants: 9 female NCAA Division 1 basketball athletes (20.11 ± 0.93 years, $1.83 \pm .11$ m, 83.61 ± 13.71 kg)

Intervention(s): Participants wore retro-reflective markers utilizing a Helen Hayes marker set to track their motion. Drop vertical jump was completed by having the athletes stand on a 12 inch plyometric box and lean forward till falling, landing then immediately jumping up to a target set at 10% of their maximum vertical jump height. The rebound was started on the ground with a ball bounced off the back board and instructions to jump and catch the ball at the highest point possible, land then immediacy jump again to shoot. 3-D motion capture was collected using a Vicon passive optic motion capture system at a sampling rate of 300 Hz during the tasks. Data were processed using Visual 3D software to assess knee valgus angles of the dominant leg during the initial landing off the box and after catching the ball. **Main Outcome Measure(s):** Knee valgus angles at initial contact and peak knee valgus angles during landing were compared between the drop vertical jump and a basketball rebounding task for the dominant leg (defined as best kicking leg), which were averaged across three trials. A linear regression was performed to assess if drop vertical jump kinematics could predict

rebound kinematics. An alpha level of $< .05$ was set a priori. **Results:** Drop vertical jump initial contact knee valgus (0.43 ± 4.76) was a significant predictor of rebound initial contact knee valgus (1.86 ± 3.96 , $r^2 = .96$, $p < .001$). Drop vertical jump peak valgus during landing (7.71 ± 5.54) was a significant predictor of rebound peak knee valgus during landing (6.95 ± 7.11 , $r^2 = .66$, $p = .008$). **Conclusions:** The drop vertical jump task was a good predictor of landing mechanics during a basketball rebounding task. Therefore, the drop vertical jump task can be utilized as a predictor of knee valgus during a more functional sport specific laboratory based task. Future studies are needed to evaluate the ability of the drop vertical jump tasks to predict knee frontal plane control during actual game situations.

Gait Mechanics And Proprioceptive Adaptations From Minimalistic “Five-Finger” Shoe Use

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Context: Barefoot running is a growing phenomenon in the running community and has spurred the popularity of minimalist shoe use. Little is known about how minimalist shod running effects gait mechanics and relatively no research has been performed to analyze how the habitual use of these shoes effects proprioception. **Objective:** To determine the proprioceptive and gait differences of traditional shod individuals (TRAD) compared to their counterparts with habitual minimalist five-finger shoe use (MIN). Specifically comparing measures of time to stabilization, gait mechanics and kinematics, as well as any transfer of potential adaptations back to the normal shod condition. **Design:** Cross-sectional comparative study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Two groups of subjects were recruited: eight TRAD subjects (6 M, 2 F: age: 23.4 ± 2.3 years, height: 177.7 ± 7.8 cm, mass: 74.2 ± 10.8 kg) and seven MIN individuals (5 M, 2 F: age: 26.1 ± 4.7 years, height: $176.07.7$ cm, mass: 79.7 ± 13.3 kg) who had been running in minimalist “five-finger” shoes for a minimum of six months. All subjects ran at least ten miles per week for six continuous months or more. **Intervention(s):** Each subject performed a time to stabilization test (TTS), involving a jump over a hurdle and landing on his/her right foot, holding the landing position for 20 seconds. Subjects also completed 10 over ground running tests at a self-selected running pace. These two tests were conducted under three different footwear conditions; barefoot (BF), normal running shoes/minimalistic five-finger shoes (SHOE), and in

standardized laboratory footwear (LAB). **Main Outcome Measure(s):** Gait mechanics were captured using a Motion Capture System and analyzed by Cortex Motion Analysis Software. Ground reaction forces were collected on a force platform. TTS was calculated using previously published methods. Separate 2x3 mixed model ANOVAs were conducted for stride length, stride frequency, maximum stance phase sagittal plane angles at the ankle, knee, and hip, impact force, peak force, anterior-posterior TTS, and medial-lateral TTS in each of the three conditions. Foot strike pattern (forefoot, rearfoot) was analyzed using a Chi squared test ($\alpha \leq 0.05$). **Results:** MIN group demonstrated greater stride frequency (MIN: 0.52 ± 0.18 sec/stride, TRAD: 0.67 ± 0.14 sec/stride, $F(1, 26) = 6.330$, $p = 0.026$), greater maximum hip flexion (MIN: $36.02 \pm 7.34^\circ$, TRAD: $25.89 \pm 5.61^\circ$, $F(1, 24) = 9.026$, $p = 0.011$) and less extension (MIN: $-9.27 \pm 4.43^\circ$, TRAD: $-13.32 \pm 2.34^\circ$, $F(1, 24) = 5.326$, $p = 0.040$) compared to TRAD. One difference was observed between the 3 footwear conditions: hip extension ($F(2, 24) = 3.708$, $p = 0.040$). Bonferroni pairwise comparisons revealed that BF ($-11.93 \pm 3.60^\circ$) resulted in greater hip extension than SHOE ($-10.79 \pm 3.58^\circ$) ($p = 0.044$). **Conclusions:** This study yielded few significant differences in gait mechanics between MIN and TRAD and no difference in dynamic TTS. The three conditions (BF, SHOE, LAB) were also similar. However, the differences in stride frequency and hip angles suggest alterations in gait, possibly as a result of minimalist shoe use. These alterations suggest that new minimalist shoe users should take time to adapt to new gait parameters in order to prevent injury.

Free Communications, Poster Presentations: Lower Extremity Neuromuscular Function

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14203FONE

The Influence Of Estrogen Levels On Presynaptic Inhibition

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Context: Estrogen has been suggested as a contributor to the multifactorial problem of female ACL injuries. The focus of estrogen's contribution has been its effect on ligament laxity and little attention has been given to estrogen's role as a neurosteroid. Specifically the influence of estrogen fluctuations on spinal-control mechanisms has not been studied. **Objective:** To determine the influence of estrogen on presynaptic inhibition (PI) in a leg muscle at menses and ovulation. **Design:** Quantitative Original Research. **Setting:** Research Laboratory. **Patients or Other Participants:** Individuals between 18 and 35yrs were recruited. Twelve females and 13 males were analyzed. Subjects reported no history of knee ligament injury requiring the use of crutches. Females had regular menstrual cycles (28 to 32 days with variation less than 3 days over the previous 3 cycles) and were free from hormone based contraceptive for at least one year. **Intervention(s):** Females were tested at menses (session1) and ovulation (session2). Ovulation was identified via urine strip. Males were tested twice (14 days between sessions). The soleus, TA, and lateral malleolus were prepared for EMG electrodes. EMG was sampled at 2000 Hz. To measure PI, soleus h-reflex were elicited at 10% Mmax and conditioned. Conditioning occurred through stimulation to common peroneal nerve at an intensity of 25% of TA Mmax. Ten conditioned and unconditioned reflexes were collected and averaged. Subjects provided a blood sample prior to reflex testing in both sessions. **Main Outcome Measure(s):** Estradiol (pg/ml) EST and soleus PI [PI = 1- (conditioned reflex/unconditioned reflex)]. A 2 [sex] x2 [session] mixed design ANOVA (alpha = 0.05) was used. **Results:**

EST (pg/ml): significant sex main effect ($p = 0.028$) females = 72.44 ± 41.56 , males = 33.85 ± 46.87 , and significant main effect for session ($p = 0.003$); session 1 = 38.42 ± 33.54 , session 2 = 66.31 ± 65.89 , significant interaction effect ($p = 0.002$). Post hoc analysis showed differences for females ($p = 0.007$) between session1 (41.95 ± 48.08) and 2 (102.9 ± 81.03) and no differences for males (session 1 = 35.17 ± 10.34 , session 2 32.5 ± 9.47). PI (%inhibition) significant sex main effect ($p = 0.001$) females = 0.581 ± 0.194 ; males = 0.862 ± 0.191 , and non-significant main effect for session ($p = .166$); session 1 = 0.769 ± 0.25 ; session 2 = 0.675 ± 0.35 and a significant interaction effect ($p = 0.007$). Post hoc analysis didn't show differences for females ($p = 0.054$) between session1 (0.723 ± 0.327) and 2 (0.439 ± 0.363) despite the 40% PI decrease. The males were different between sessions ($p = 0.005$) (session 1 = 0.813 ± 0.144 , session 2 = 0.911 ± 0.078). **Conclusions:** Estrogen is known to interact with GABA (an inhibitory neurotransmitter) at several locations in the nervous system. Despite the lack of a significant difference in female PI between menses and ovulation, which is likely the result of the high variability associated with the outcome measures, the data suggest estrogen may act to influence spinal-control mechanisms. Specifically, increased estrogen during ovulation may serve to reduce PI and ultimately motor control. However, future research is necessary to evaluate this notion in the context of ACL injury.

14201FONE

Generalized Joint Hypermobility Alters Muscle Activation Patterns In Division 1 Female Athletes

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Context: The degree of generalized joint hypermobility (GJH) varies among individuals, with greater joint laxity associated with more frequent and serious injuries. Differences in muscle activation patterns have been noted during gait in the population of GJH individuals, but the effect of GJH in athletes is unknown. **Objective:** To determine the effects of GJH on lower extremity muscle activation patterns during a single leg land and cut task in D1 collegiate soccer and volleyball female athletes. **Design:** Controlled Laboratory Study. **Setting:** University Biomechanics Laboratory. **Patients or Other Participants:** All healthy athletes from both teams were screened for GJH level using Beighton's signs, a clinical assessment of 9 movements to determine GJH. Three of 19 soccer players, and 3 of 11 volleyball players were identified for the experimental group with 4 or more positive Beighton's signs ("GJH" age = 19.1 ± 1.2 yrs, height = 171.2 ± 5.4 cm, mass = 65.2 ± 12.1 kg) and 6 matched controls with 0 out of 9 Beighton's signs from those sports ("CTRL" age = 19.0 ± 0.9 yrs, height = 169.3 ± 2.2 cm, mass = 62.4 ± 4.3 kg). All GJH group participants had "knee hyperextension past 10 degrees" as two of their positive signs. **Intervention:** Participants performed 5 trials of a single leg land and cut task off of a box, which was normalized to jump height and placed one stride length away from the force plate, while EMG data were collected from 6 lower extremity muscle groups: Gluteus Medius (GMD), Gluteus Maximus (GMX), Rectus Femoris (RF), Vastus Lateralis (VL), Vastus Medialis (VM) and Biceps Femoris (BF). **Main Outcome Measure(s):** Muscle activation level, normalized to MVIC. Variables were analyzed between groups with independent t-tests. **Results:** Mean muscle activation levels were lower for the

GJH group during the landing phase for the VL (GJH: 0.47 ± 0.38 ; CTRL: 1.47 ± 0.51 ; $p = 0.026$) and the RF (GJH: 0.33 ± 0.24 ; CTRL: 0.077 ± 0.23 ; $p = 0.031$). Activation levels were not statistically different for the BF, GMX, GMD, or VM. No differences were noted during the 10ms prior to landing (pre-activation). **Conclusions:** Participants with higher GJH exhibited lower muscle activation levels for two quad muscle groups. This was unexpected. However, if individuals with GJH do not utilize increased muscle activation to enhance joint stability during athletic events, this may explain the higher general knee injury rates among individuals with GJH. Alternatively, GJH individuals may decrease quad activation levels during landing to prevent higher loads on the ACL. The current investigation was limited by small numbers of GJH individuals and is thus worthy of continued exploration as more participants in the GJH group are identified.

Effect Of Localized Muscle Fatigue On Knee Joint Position Sense In Soccer And Basketball Players

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Context: Epidemiological studies indicate the occurrence of ACL injuries are higher in soccer than in basketball players. Differences in the levels of fatigue between sports may play a role in joint position sense, which might contribute to the higher ACL injury rate in soccer. **Objective:** The purpose of this study was to examine the effect of increasing levels of fatigue on active joint reproduction sense (AJRS) at the knee in soccer and basketball players. **Design:** Repeated measures design. **Setting:** Laboratory setting. **Patients or Other Participants:** 18 participants (8 basketball [20.6 ± 0.9 yrs. old, 182.5 ± 19.3 cm, 81.6 ± 21.7 kg] and 10 soccer [19.7 ± 1.6 yrs. old, 173.0 ± 8.7 cm, 73.2 ± 12.5 kg]). **Intervention(s):** Fatigue was operationalized as a percentage decrease in peak hamstring torque. Concentric knee extension and flexion was performed through 90 degrees of motion at angular velocities of $90^\circ \cdot s^{-1}$ for 10 repetitions, $180^\circ \cdot s^{-1}$ for 15 repetitions, $240^\circ \cdot s^{-1}$ for 20 repetitions, and $300^\circ \cdot s^{-1}$ for 25 repetitions, and at $180^\circ \cdot s^{-1}$ until the hamstring peak torque value dropped 10%, 30%, and 50% below peak isokinetic torque for three consecutive repetitions. **Main Outcome Measure(s):** AJRS was tested on the same isokinetic dynamometer, with the subject blindfolded to eliminate visual cues. A starting angle of 60° of knee flexion was used for each trial. The subject's leg was passively extended to one of the test angles (45° , 30° , or 15° of knee flexion), and concentrated on for 3 seconds. The subject's leg was returned to the starting position. Following a 3 second rest period; the subject had 5 seconds to actively reproduce the presented joint angle. This procedure was repeated 2 more times. Mean absolute angular error (AAE) values for AJRS were used for data analysis. A repeated measures analysis of variance was

utilized to determine statistical significance. **Results:** A significant main effect for fatigue (pretest AAE = $2.18^\circ \pm 0.12$, 10% fatigue = $3.31^\circ \pm 0.38$, 30% fatigue = $3.14^\circ \pm 0.37$, and 50% fatigue = $3.51^\circ \pm 0.45$) was found ($F_{3,48} = 6.94$, $p = 0.001$). Pairwise comparisons for fatigue showed that AAE at 10% fatigue and 50% fatigue were significantly different from the pretest AAE measure ($p = 0.024$ and 0.027 respectively). A main effect for sport (soccer AAE = $3.12^\circ \pm 0.39$ and basketball AAE = $2.94^\circ \pm 0.44$) was not found ($F_{1,16} = 0.09$, $p = 0.765$), nor was an interaction effect between sport and fatigue ($F_{3,48} = 2.87$, $p = 0.06$). **Conclusions:** Results from this study indicate that fatigue may contribute to decrease joint reposition sense in both soccer and basketball players. Fatigue, however, did not effect one sport more than the other.

Lower Extremity Muscle Volumes In ACL-Deficient Patients

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Context: Anterior cruciate ligament (ACL) injuries are common in active populations often leading to persistent muscle weakness and functional limitations. Magnetic Resonance Imaging (MRI) is a novel approach used to quantify muscle volume and is able to detect subtle morphologic changes in individual muscles in the lower extremity. **Objective:** To quantify the distribution of lower extremity muscle volumes in ACL deficient patients using MRI-based muscle modeling. **Design:** Case series. **Setting:** Research laboratory and University MRI facility. **Patients or Other Participants:** Five ACL-deficient participants (3 men, 2 women; age = 25.2 ± 7.3 years; height = 172.5 ± 10.1 cm; mass = 77.6 ± 17.6 kg; time since injury = 0.7-24.3 months) volunteered. **Intervention(s):** Participants completed one study session in which a bilateral lower extremity 3T closed MRI was obtained. **Main Outcome Measure(s):** Bilateral individual muscle and lower extremity muscle group volumes were the primary outcomes of interest. All volumes were calculated from MRI muscle modeling software and normalized to subject heightmass. We calculated Z-scores with [95% confidence intervals] for each muscle to describe volume differences compared to normative data in healthy, age-matched individuals. We calculated a symmetry index within each subject as a percent difference in muscle volume between injured and contralateral uninjured limbs. Data are reported descriptively. Any z-score confidence interval not crossing zero was statistically significant. Negative z-scores indicate atrophy, positive z-scores indicate hypertrophy. Negative percent differences indicate the injured side was smaller. **Results:** We observed significant reductions in gluteus medius muscle ($Z = -.78 [-.46, -1.1]$), gluteus minimus muscle ($Z = -1.1 [-.25, -1.9]$), obturator internus muscle

($Z = -.76 [-.08, -1.4]$), quadratus femoris muscle ($Z = -.88 [-.11, -1.64]$), piriformis muscle ($Z = -1.3 [-.68, -1.9]$), iliacus muscle ($Z = -1.3 [-.41, -2.2]$), pectineus muscle ($Z = -.93 [-.41, -1.5]$), popliteus muscle ($Z = -1.3 [-.64, -2.0]$), lateral gastrocnemius muscle ($Z = -.8 [-.22, -1.4]$), tibialis posterior muscle ($Z = -1.1 [-.5, -1.7]$), tibialis anterior muscle ($Z = -1.6 [-.87, -2.2]$), and phalangeal extensors ($Z = -1.7 [-1.1, -2.4]$) as demonstrated by z-scores with confidence intervals not crossing zero. No other significant increases or decreases were observed in the other lower extremity muscles. The largest magnitude differences in side-to-side comparisons of muscle volume were in the piriformis muscle (-14.6 ± 10.0 %), rectus femoris muscle (-27.1 ± 36.6 %), tibialis anterior muscle (-24.8 ± 17.9 %), and toe extensors (-18.8 ± 15.2 %). **Conclusions:** Reduced muscle volumes were observed after ACL injury when compared to healthy individuals and between limbs. Muscle atrophy is observed following knee injury in muscles that are proximal and distal to the injury site.

The Relationship Between Rate Of Torque Development Of The Triple Extensors At Different Time-Critical Intervals

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Context: The lower extremity triple extensors work in concert to propel the body during explosive movements. Therefore, the capacity of these three muscle groups to rapidly generate torque is likely important for optimal performance. However, it is not known whether individuals who exhibit greater rate of torque development (RTD) at one joint do so across all three extensor muscle groups, or if RTD is joint-specific. **Objective:** To assess the relationships between RTD of the triple extensors during the initial 50 and 250 ms of contraction. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty healthy, physically active volunteers (15 females, 15 males, age: 22.9 ± 2.5 years, height: 172.8 ± 9.5 cm, mass: 72.2 ± 14.0 kg). **Intervention(s):** Isometric hip extension (HE), knee extension (KE), and ankle extension (AE) torque-time curves of the dominant limb were recorded using a Biodex System3 dynamometer. Testing positions were: 1) HE – prone with hip flexed at 30° and knee flexed at 90° , 2) KE – seated with knee flexed at 70° , and 3) AE – seated with knee flexed at 15° and ankle in neutral position. 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 in a counterbalanced order. **Main Outcome Measure(s):** RTD was calculated by taking the line of best fit of the torque-time curve from torque onset (2.5% of peak torque) to 50 and 250 ms, respectively. Mean RTD for each joint was calculated across trials and normalized to (Body Mass) 0.67. Relationships between RTD of the triple extensors during each time interval were assessed using separate, Pearson correlation coefficients ($\alpha = 0.05$). **Results:** Mean \pm SD

values for RTD ([Nm/s]/kg (.67)) were: HE50 = 20.76 ± 11.00 , HE250 = 29.32 ± 11.99 , KE50 = 38.10 ± 24.14 , KE250 = 26.78 ± 10.67 , AE50 = 19.47 ± 8.94 , and AE250 = 17.59 ± 7.63 . Hip, knee, and ankle extensor RTD were significantly correlated during both the 0-50 ms (HE50 and KE50: $r = 0.719$, $p < 0.001$; HE50 and AE50: $r = 0.767$, $p < 0.001$; KE50 and AE50: $r = 0.758$, $p < 0.001$) and 0-250 ms (HE250 and KE250: $r = 0.452$, $p < 0.001$; HE250 and AE250: $r = 0.563$, $p < 0.001$; KE250 and AE250: $r = 0.803$, $p < 0.001$) time intervals. **Conclusions:** During the initial 50 ms of contraction, 51.7-58.8% of the variance in extensor RTD was explained by the RTD relationships between joints. However, the magnitude of shared variance was not as consistent during the 0-250 ms time interval. While the knee and ankle extensors continued to display a high explained variance (64.5%), the HE250 and AE250 and HE250 and KE 250 decreased to 31.7 and 20.4%, respectively. This suggests the RTD pattern of the hip extensors diverges from that of the knee and ankle extensors when assessed over longer time intervals from onset of contraction. Future research should investigate the potential functional significance of this different pattern and possible reasons for differences.

Comparison Of Hamstring Strength And Functional Performance Measures Between Previously Injured And Matched-Control Physically Active Individuals Following A Fatigue Protocol

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Context: Fatigue has been implicated as one of the main contributors for hamstring injuries, and is a limiting factor for hamstring eccentric strength and functional performance. **Objective:** To compare the effect of a Slow Linear Oxidative Fatigue Protocol (SLO-FP) on hamstring strength and functional performance measures between previously injured and matched control non-injured physically active individuals. **Design:** Cross-Sectional. **Setting:** University Research Laboratory. **Patients or Other Participants:** Fifteen physically active individuals with a unilateral hamstring injury in the past two years (age = 25.87 ± 9.81 yrs; height = 169.00 ± 11.00 cm; mass = 68.64 ± 22.33 kg) and 15 non-injured matched-control (age = 24.33 ± 7.97 yrs; height = 169.00 ± 10.00 cm; mass = 69.13 ± 20.14 kg) participated in two testing sessions. Participants were matched by age, height, mass, gender and side (matched-control to the injured side). **Intervention(s):** The initial session consisted of a voluntary maximal oxygen uptake (VO₂max) test and familiarization with the functional and strength assessments. Hamstring functional performance tests included the single leg vertical jump (SLVJ) (cm), single leg hop test (SLH) (cm), cross-over hop for distance (CH4D) (cm), and, a six-meter timed hop test (6MH) (sec) and T-agility (sec). All functional tests were counterbalanced. Isokinetic strength assessment included seated knee flexion and extension (concentric and eccentric) at

60, 180, and 240 deg/sec. The second session consisted of functional and strength testing followed by the SLO-FP. The SLO-FP was used to induce fatigue based on each subject's individual treadmill VO₂max test and consisted of a maximum of 30 minutes of alternating speeds and grades of incline until volitional exhaustion (average time of protocol = 7.91 ± 1.78 minutes). Functional and strength tests were conducted immediately following the SLO-FP. **Main Outcome Measure(s):** Dependent variables included average peak torque per body weight (PT/BW) (Nm/kg) from five trials, functional and conventional Hamstring:Quadriceps (H:Q) ratios, average distance and time from five trials for SLVJ, SLH, CH4D, and 6MH and T-agility, respectively. The independent variables were side (injured and matched-control non-injured) and time (pre-fatigue and post-fatigue). Separate 2x2 repeated measures ANOVAs were used for each strength and functional performance measure. Significance was set a priori at $P < .05$. **Results:** There was a main effect for side (injured = $.60 \pm .12$ vs. matched-control = $.75 \pm .20$) for H:Q conventional ratio at 60deg/sec ($F(1,28) = 6.370$, $P = .018$). There were no significant differences for all remaining strength measures (range of P values = .085 to .877). There were no main effects for time (pre-fatigue and post-fatigue) or side (injured and matched-control non-injured) measures for all functional performance tests (range of P values = 0.067 to .761). **Conclusions:** The SLO-FP had minimal effects on strength measures and no effect on functional performance and may not have been demanding enough to affect these variables. This protocol may produce more central process fatigue, rather than peripheral/muscular fatigue and should be examined in individuals with an increased level of physical fitness.

Comparison Of Gluteal And Hamstrings Activation During Five Commonly Used Plyometric Exercises

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Context: Plyometric exercises are commonly included in ACL injury prevention programs to increase muscle activation and alter movement patterns. However, previous ACL prevention programs have incorporated a variety of exercises with little justification for their inclusion. Because enhancement of gluteal and hamstrings activity likely decreases ACL loading, identifying exercises which target these muscles is important for appropriate development of ACL injury prevention programs. **Objective:** To compare gluteal and hamstrings muscle activity between commonly used plyometric exercises. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Forty-one healthy, recreationally active individuals (20 males, 21 females; mass = 70.3 ± 13.4 kg; height = 70.32 ± 10.2 cm) with no current injury or history of lower extremity surgery. **Intervention(s):** The independent variable was plyometric exercise type (single-leg sagittal plane hurdle hop, double-leg sagittal plane hurdle hop, frontal plane hurdle hop, split squat jump, and 180° jump). Exercises were chosen by identifying the most common exercises in the literature used to alter ACL loading and injury risk. Electromyography (EMG) data were sampled from the gluteus maximus, gluteus medius, medial hamstrings, and lateral hamstrings muscles throughout each exercise and normalized to maximum voluntary isometric contractions. Ground reaction forces were sampled from a force plate to identify the preparatory and loading phases of each task. EMG activity for each muscle was compared across plyometric exercises using one-way repeated-measures ANOVAs. **Main Outcome Measure(s):**

The dependent variables were mean EMG amplitudes of each muscle during the preparatory (150ms before ground contact) and loading (100ms after ground contact) phases. **Results:** Subjects displayed differences in muscle activity for both hamstrings ($p < .001$) and both gluteal muscles ($p < .001$) during the preparatory and loading phases. The single-leg sagittal plane hurdle hops produced the greatest gluteal and hamstrings activity in both phases, and the 180° jump produced less gluteal and hamstrings activity than all other exercises in both phases. The double-leg sagittal plane hurdle hop produced greater medial hamstrings preparatory activation ($25.02 \pm 12.92\%$) than the frontal plane hurdle hop ($18.05 \pm 10.67\%$) and 180° jump ($16.97 \pm 11.74\%$). The double-leg sagittal plane hurdle hop also produced greater loading phase gluteus medius ($60.48 \pm 31.53\%$) and gluteus maximus (62.96 ± 53.58) activity than the frontal plane hurdle hop (39.56 ± 18.48 and 39.51 ± 43.30 , respectively). **Conclusions:** Single and double-leg sagittal plane hurdle hops may be the most effective plyometric exercises to target activation of the gluteals and hamstrings. Given the potential for those muscles to control knee motion and loading, the single and double-leg sagittal plane hurdle hops may be important to include in ACL injury prevention programs. 180° jumps may have limited utility for these programs because of their inability to produce substantial gluteal and hamstrings activation, but more research is needed to determine if 180° jumps impact other potential injury risk factors.

Free Communications, Poster Presentations: Chronic Ankle Instability

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14153DOTE

Effects Of 2 Ankle Destabilization Devices On Electromyography Measures During Functional Exercise In Young Adults With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have been shown to have deficits in neuromuscular control. Ankle destabilization devices can increase peroneus longus muscle activation during walking in individuals with CAI, which may provide greater joint stability. However, it is unclear whether these devices have similar effects on muscle activity during functional exercise. **Objective:** To compare EMG activation of lower extremity muscles during lateral hopping while wearing 2 different ankle destabilization devices. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen adults with CAI (height = 173 ± 11 cm, mass = 72 ± 14 kg, age = 23 ± 4 years, sex = 5 males, 10 females) participated. **Intervention(s):** Surface EMG electrodes were placed over the anterior tibialis (AT), peroneus longus (PL), and lateral gastrocnemius (LG). Subjects performed lateral hops while wearing shoes, an ankle destabilization boot (ADB), and an ankle destabilization sandal (ADS) in random order. The protocol consisted of 15 seconds of lateral hopping at a rate of 110 hops per-minute in each condition. **Main Outcome Measure(s):** Normalized amplitudes (50ms pre- and 100ms post-initial foot contact) were analyzed for six hops. Each dependent variable was compared using a repeated measures ANOVA and post-hoc t-tests if appropriate. To adjust for multiple comparisons, a Bonferroni-corrected P-value of < 0.017 was utilized for post-hoc t-tests. Cohen's d effect sizes with 95% confidence intervals (CIs) were calculated to compare the magnitude of differences between the ADB and shod conditions, and the ADS and shod conditions for each measure. **Results:** The pre-contact amplitude of

the PL was significantly greater in the ADB (0.74 ± 0.31 , $P = 0.003$) and ADS (0.69 ± 0.29 , $P = 0.013$) conditions when compared to shod (0.50 ± 0.17). When comparing the ADB to shod, the PL had a large effect size of 1.43 with a CI that did not cross 0. In addition, when comparing the ADS to shod, the PL had a large effect size of 1.09 with a CI that did not cross 0. All other effect sizes had CIs that crossed 0. The post-contact amplitude of the AT was significantly higher in the ADB (0.60 ± 0.46 , $P = 0.002$) and the ADS (1.03 ± 0.95 , $P = 0.002$) conditions when compared to shod (0.45 ± 0.44). In addition, the post-contact amplitude of the PL and LG was significantly greater in the ADS (PL: 1.58 ± 0.62 , $P < 0.001$; LG: 1.84 ± 0.99 , $P < 0.001$) when compared to shod (1.21 ± 1.18). When comparing the ADB to the shod condition, all effect sizes had CIs that crossed 0. However, when comparing the ADS to the shod condition, the AT and PL had large effect sizes (AT = 1.34; PL = 2.93) that did not cross 0. **Conclusions:** Both ankle destabilization devices caused an increase in PL activity during lateral hopping. The ankle destabilization devices provide a method to increase activity in ankle dynamic stabilizers during functional exercises.

14154DOTE

Lower Extremity Muscle Activation During Functional Exercises In Patients With And Without Chronic Ankle Instability

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Context: Patients with chronic ankle instability (CAI) exhibit altered neuromuscular control compared to healthy controls during walking and jump landing but such impairments have not been evaluated during common rehabilitation exercises. **Objective:** To determine if CAI patients exhibit altered neuromuscular control as demonstrated by surface electromyography (sEMG) amplitudes compared to controls during unipedal eyes closed balance, Star Excursion Balance Test (SEBT), forward lunge, and lateral hop exercises. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen young adults with CAI (height = 173 ± 10.8 cm, mass = 72.4 ± 14.0 kg, age = 23.0 ± 4.2 years, 5 males, 10 females) and 15 healthy controls (height = 173.0 ± 9.4 cm, mass = 70.8 ± 18.0 kg, age = 22.9 ± 3.4 years, 5 males, 10 females). **Intervention(s):** Subjects performed exercises while sEMG signals were recorded from the tibialis anterior (TA), peroneus longus (PL), lateral gastrocnemius (LG), rectus femoris (RF), biceps femoris (BF), and gluteus medius (GM). **Main Outcome Measure(s):** Normalized sEMG amplitudes (root mean square area) for each individual muscle, shank muscles (TA+PL+LG), thigh muscles (RF+BF+GM), and total muscle activity (sum of all six muscles) were compared between groups. Lunges (lead limb) and lateral hop exercises (hopping limb) were analyzed during the 50ms prior to initial contact (pre-IC) and 100ms following initial contact (post-IC). SEBT trials (stance limb) in the anterior, posteromedial, and posterolateral directions were analyzed during the 300ms prior to maximal excursion, as was the middle 3 seconds of the

unipedal eyes closed balance trial (stance limb). Independent t-tests were performed for each dependent variable to compare groups. Alpha was set a priori at $P \leq 0.05$. Cohen's d effect sizes were calculated to estimate the magnitude of group differences. **Results:** CAI patients demonstrated significantly less sEMG activity during all four exercises. For lunges, CAI patients had less muscle activity pre-IC in the thigh (CAI = 0.36 ± 0.16 , Control = 0.56 ± 0.32 , $P = 0.05$) and post-IC for the AT, shank, and total muscle activity (AT: CAI = 0.44 ± 0.13 , Control = 0.61 ± 0.18 , $P = 0.01$; Shank: CAI = 1.11 ± 0.32 , Control = 1.64 ± 0.71 , $P = 0.02$; Total: CAI = 1.63 ± 0.48 , Control = 2.30 ± 0.99 , $P = 0.03$). CAI patients had less muscle activity in the TA, RF, and total muscle activity during unipedal eyes closed balance (AT: CAI = 0.35 ± 0.18 , Control = 0.49 ± 0.19 , $P = 0.05$; RF: CAI = 0.09 ± 0.10 , Control = 0.19 ± 0.11 , $P = 0.02$; Total: CAI = 1.37 ± 0.42 , Control = 1.75 ± 0.56 , $P = 0.05$). CAI patients had less TA muscle activity during the SEBT in the anterior and posteromedial directions (anterior: CAI = 0.40 ± 0.22 , Control = 0.71 ± 0.45 , $P = 0.03$; posteromedial: CAI = 0.50 ± 0.19 , Control = 0.68 ± 0.28 , $P = 0.05$). CAI patients had less shank and total muscle activity pre-IC during the lateral hop exercise (Shank: CAI = 1.57 ± 0.68 , Control = 2.43 ± 1.12 , $P = 0.03$; Total: CAI = 2.57 ± 0.99 , Control = 3.77 ± 1.61 , $P = 0.03$). Effect sizes for significant differences between groups ranged from -0.75 to -1.08, none of which had 95% confidence intervals that crossed zero, indicating moderate to large decreases in muscle activity in CAI patients compared to healthy controls. **Conclusions:** CAI patients demonstrated decreased muscle activity of ankle, knee, and hip musculature during rehabilitation exercises. Clinicians may benefit from implementing rehabilitation for CAI patients that target both distal and proximal lower extremity muscles.

Surface Electromyography Variability Measures During Walking: Effects Of Chronic Ankle Instability And Prophylactic Bracing

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Context: The rate of recurrent ankle sprain in patients with chronic ankle instability (CAI) can be reduced with the application of prophylactic ankle braces. Ankle braces have been shown to alter neuromuscular control during walking in patients with CAI. However, motor recruitment variability between patients with and without CAI and the effect ankle bracing has on motor recruitment variability has not been previously explored. **Objective:** To determine if measures of variability in muscle activation patterns differ between subjects with and without CAI and to examine the effect prophylactic bracing has on measures of variability. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen young adults with CAI (height: 173 ± 10.8 cm, mass: 72.4 ± 14 kg, age: 23 ± 4.2 years, 5 males, 10 females) and 15 healthy controls height: 173 ± 9.4 cm, mass: 70.8 ± 18 kg, age: 22.9 ± 3.4 years, 5 males, 10 females). **Intervention(s):** Subjects performed shod treadmill walking trials with and without prophylactic lace-up ankle braces. Surface electromyography (sEMG) signals were recorded for the anterior tibialis (AT), peroneus longus (PL), lateral gastrocnemius (LG), rectus femoris (RF), biceps femoris (BF), and gluteus medius (GM). **Main Outcome Measure(s):** The standard deviation (SD) of the time of activation relative to initial contact (IC), the SD of the percent of activation time across the stride cycle, and the coefficient of variation (COV) of activation amplitude pre-IC (100 ms prior to IC) and post-IC (200 ms following IC) were used to quantify the extent of muscle recruitment variability between groups and between brace conditions for all muscles tested. For each measure, a 2x2 (group by

brace condition) mixed model ANOVA was performed. **Results:** There were no significant group by brace condition interaction or group main effects for any of the measures (all P 's > 0.05) indicating that there were no differences between groups with and without CAI. There were, however, several significant brace condition main effects. Specifically, bracing significantly increased the SD in time of activation relative to IC in the PL and decreased it in the RF (PL: No Brace = 92.0 ± 68.2 ms, Brace = 119.0 ± 50.0 ms, $P = 0.05$; RF: No Brace = 66.9 ± 64.4 ms, Brace = 39.0 ± 29.0 ms, $P = 0.02$). COV of activation amplitude pre-IC was significantly decreased in the AT, PL, and BF and increased in the RF and GM in the braced condition. (AT: No Brace = 0.31 ± 0.08 , Brace = 0.24 ± 0.03 , $P = 0.001$; PL: No Brace = 0.38 ± 0.19 , Brace = 0.26 ± 0.09 , $P = 0.004$; BF: No Brace = 0.33 ± 0.07 , Brace = 0.29 ± 0.05 , $P = 0.003$; RF: No Brace = 0.30 ± 0.08 , Brace = 0.88 ± 0.59 , $P = 0.001$; GM: No Brace = 0.36 ± 0.11 , Brace = 1.35 ± 0.54 , $P < 0.001$). **Conclusions:** Muscle recruitment variability did not differ between groups with and without CAI, prophylactic ankle bracing altered measures of muscle recruitment variability in muscles acting on the ankle, knee and hip in both groups. Clinicians should be aware that lace-up ankle bracing can affect the variability of muscle activation patterns in the entire lower extremity.

Effects Of Prolonged Exercise On Shank-Rearfoot Coupling In Young Adults With And Without Chronic Ankle Instability

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Context: Altered joint-coupling between tibial internal/external rotation and rearfoot inversion/eversion during gait has been identified in chronic ankle instability (CAI) patients in a rested state. It is unknown if these deficits are exacerbated by prolonged exercise. **Objective:** To measure the joint-coupling behavior using a vector coding technique between CAI patients and controls before and after prolonged exercise. **Design:** Descriptive laboratory study. **Setting:** Gait laboratory. **Patients or Other Participants:** 15 healthy (6 males, 9 females, age: 21.8 ± 1.8 yr, weight: 75.34 ± 8.21 kg, height: 162.81 ± 29.97 cm) and 15 CAI (5 males, 10 females, age: 23.6 ± 4.2 yr, weight: 77.92 ± 4.49 kg, height: 185.16 ± 32.00 cm) subjects participated. **Intervention(s):** Subjects walked and jogged on a treadmill at speeds of 4.83 km/hr and 9.66 km/hr before and after a 36-minute exercise program consisting of alternating bouts of inclined treadmill walking and plyometric exercises. **Main Outcome Measure(s):** Frontal plane rearfoot and transverse plane shank motion were measured across 12 strides at each speed. The Mullineaux vector coding technique was used to analyze coupling between the joint segments, comparing stride-to-stride variability (VCV), the magnitude of motion between segments (m), and the ratio of one segment's motion to the adjacent segment (θ). Group means and associated 90% confidence intervals (CI) for each measure were calculated across the gait cycle. Periods where group CIs did not overlap for at least 3 consecutive percentage points of the stride cycle were considered significant. **Results:** Walking: Prior to exercise there were no significant between group differences. Following exercise, the CAI group has lower θ values (CAI: $69.98^\circ \pm 10.12^\circ$,

Control: $79.01^\circ \pm 7.47^\circ$) at 62-66%, lower m values at 24-35% (CAI: $0.37^\circ \pm 0.08^\circ$, Control: $0.47^\circ \pm 0.11^\circ$), and greater m values from 68-72% (CAI: $0.44^\circ \pm 0.22^\circ$, Control: $0.32^\circ \pm 0.15^\circ$) of the gait cycle compared to controls. When comparing before and after exercise measures, the CAI group had higher m from 10-12% (CAI Pre: $0.30^\circ \pm 0.16^\circ$, CAI Post: $0.46^\circ \pm 0.21^\circ$) and lower m from 22-27% (CAI Pre: $0.54^\circ \pm 0.07^\circ$, CAI Post: $0.44^\circ \pm 0.09^\circ$) of the gait cycle. No differences in θ or VCV were found before or after exercise in either group during walking and no differences in m were found in the control group. Jogging: Prior to exercise, the CAI group had higher m values at 97-100% (CAI: $0.32^\circ \pm 0.11^\circ$, Control: $0.22^\circ \pm 0.08^\circ$) than the control group. No differences in θ or VCV were found between groups before exercise. After exercise, the CAI group had greater θ from 37-46% (CAI: $76.70^\circ \pm 10.98^\circ$, Control: $57.51^\circ \pm 21.16^\circ$) and lower θ values from 86-94% (CAI: $36.51^\circ \pm 18.01^\circ$, Control: $57.51^\circ \pm 21.47^\circ$) compared to controls. There were no m or VCV differences found following exercise between groups, nor when comparing before and after exercise measures within each group. **Conclusions:** Following prolonged exercise, there were pronounced changes in joint-coupling behavior between the shank and rearfoot in the CAI group but not the control group. Alterations in joint-coupling seen prior to exercise in CAI patients may be further exacerbated by prolonged exercise and may be related to heightened recurrent injury risk.

Effects Of Ankle Instability On Ground Reaction Force During A Stop-Jump Task

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Context: Many people who sustain a lateral ankle sprain develop chronic ankle instability (CAI), while others have no residual symptoms and are known as ankle sprain copers. Altered jumping and landing kinetics during a functional task may help explain the high recurrence rate of lateral ankle sprains. **Objective:** To determine if there is a difference in ground reaction force (GRF) during a stop jump task between participants with CAI, ankle sprain copers, and participants with no history of an ankle sprain. **Design:** Case control laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Forty one volunteers (age = 21.24 ± 1.32 years; mass = 76.99 ± 14.78 kg; height = $1.74 \text{ m} \pm 0.12 \text{ m}$), which included 16 with CAI, 12 ankle sprain copers, and 13 with no previous ankle injury/sprain (NI). CAI participants had sustained one moderate ankle sprain with a recurrent sprain within past 6 months with an average score on the Cumberland Ankle Instability Tool (CAIT) of 19.4 ± 5.11 . Ankle sprain copers had sustained one moderate ankle sprain and had an average CAIT score of 28.0 ± 0.87 . **Intervention(s):** The independent variable was injury history (CAI, Coper, NI). The participants performed a stop jump task onto a force platform. The task involved running forward 4-5 steps, jumping off one foot and landing on both feet (with the test foot landing on the force platform), and then performing a vertical jump. GRF was measured with an AMTI force platform. Four trials were performed with the previously injured leg (CAI and Coper group) or matched control leg (NI group) landing on the force platform. **Main Outcome Measure(s):** The dependent variables were the peak vertical, peak anterior/posterior and peak medial/lateral component

of the ground reaction force (GRF), normalized to multiples of body weight (BW). These variables were analyzed separately with a one way ANOVA for all three phases of the task: the first landing phase, the upward phase of the vertical jump, and the landing phase of the vertical jump. **Results:** For the peak vertical GRF, peak anterior/posterior GRF, and peak medial/lateral GRF, there were no significant differences between the groups for any of the three phases of the stop jump task ($P > .05$). The means (\pm SD) for the first landing phase are as follows. For the peak vertical GRF: NI = 1.94 ± 0.48 BW; Coper = 1.85 ± 0.44 BW; CAI = 1.93 ± 0.64 BW. For the peak anterior/posterior GRF: NI = 0.46 ± 0.20 BW; Coper = 0.42 ± 0.14 BW; CAI = 0.43 ± 0.25 BW. For the peak medial/lateral GRF: NI = $0.08 \pm .12$ BW; Coper = $0.09 \pm .16$ BW; CAI = $0.02 \pm .13$ BW. **Conclusions:** The results revealed that there were no differences in GRF between the three groups for any phase of the stop jump task, indicating that the CAI group's residual symptoms did not affect GRF during the current task. While this is a potentially positive finding, more research is needed to determine the specific clinical implications.

Accuracy, Sensitivity, And Specificity Of Functional Performance Tests In Detecting Deficits Associated With Chronic Ankle Instability

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Context: Although the Star Excursion Balance Tests (SEBT), side hop test, and figure-of-8 hop test are reported to be reliable, detect differences between stable and unstable ankles, and be responsive to change, there are no established cutoff scores for these tests to identify chronic ankle instability (CAI). **Objective:** To identify the cutoff scores defining CAI and the sensitivity/specificity of the associated scores for the SEBT, figure-of-8 hop and side hop tests.

Design: Cross sectional design. **Setting:** Research laboratory. **Patients or Other**

Participants: 209 subjects from a convenience sample (males: $n = 74$, height = 178.79 ± 9.58 cm, weight = 82.75 ± 17.73 kg; females: $n = 134$, height = 165.26 ± 7.28 cm, weight = 65.75 ± 14.54 kg) with a mean age of 23.02 ± 3.72 years were included. 172 ankles were classified as chronically unstable (>3 sprains or > 1 sprain with subjective reports of chronic symptoms) and 246 as stable (< 3 sprains and no reports of chronic symptoms).

Intervention(s): Data from 418 ankles were compiled from multiple studies and analyzed. Subjects performed the SEBT, side hop, and figure-of-8 hop tests bilaterally. Areas under the curve (AUC) for receiver operating characteristic curves were used to estimate the accuracy of each test. Youden's index was used to identify the cutoff score that maximized sensitivity and specificity for each test. Sensitivity, specificity, and the numbers needed to diagnose (NND) were calculated for each cutoff score. **Main Outcome**

Measure(s): SEBT reach distances were normalized to height and leg length for analysis. For the hop tests, time for completion was analyzed. **Results:** All of the tests demonstrated poor accuracy or failed to identify deficits associated with CAI

(AUC = $0.52 - 0.61$, $p = 0.004 - 0.666$). The most accurate test was the side hop test (AUC = 0.612 , 95% CI [$0.538, 0.687$], $p = 0.004$). The sensitivity for each test ranged from 19% (anterior reach normalized to leg length, cutoff score = 62.57%) to 77% (lateral reach normalized to height, cutoff score = 41.59%) and specificity ranged from 38% (lateral reach normalized to height) to 96% (anterior reach normalized to leg length). The NND was least for the posterior medial reach, normalized to leg length (cutoff = 85.71%, NND = 4.55). **Conclusions:** These data raise concern about the clinical utility of these tests when used among a large sample if normative values are used as a reference. Given the poor accuracy and great variability between subjects' performances in this study, these tests may be better interpreted when compared to baseline scores or scores of contralateral limb performance. Future research is necessary to identify more appropriate tests to screen for CAI or to explore how these tests may be interpreted more effectively.

Changes In Spinal Reflexive Excitability Of Leg Musculature Following Acute Ankle Sprain Over A 7-Day Period

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Context: Reflexive control of ankle musculature has been hypothesized to influence the development of chronic ankle instability (CAI) following an acute lateral ankle sprain (LAS). Previous experiments have demonstrated changes in spinal reflexive excitability (SRE) of leg musculature immediately following LAS, as well as patients with CAI; yet, little is known about how SRE changes within the first week following LAS. Understanding the fluctuations of SRE within the first week following LAS is imperative for developing neuromuscular interventions following LAS to limit potential disability that may lead to CAI. **Objective:** Determine the differences in fibularis longus (FL), tibialis anterior (TA) and soleus (SOL) SRE between LAS patients and healthy controls, within 36 hours (h) of LAS and 7 days (d) post LAS. **Design:** Case-Control. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen LAS patients (4M, 11F, 20.67 ± 1.72 yrs, 174.58 ± 11.58 cm, 70.08 ± 15.79 kg) and 10 healthy controls (5M, 5F, 21.20 ± 2.78 yrs, 176.28 ± 9.52 cm, 76.45 ± 16.63 kg) volunteered. **Intervention(s):** SRE was assessed via the Hoffmann (H) reflex technique in all three muscles within 36h of sustaining a LAS during intercollegiate or recreational sports, and again 7d later at approximately the same time of day. Electrical stimuli of progressive intensity were delivered to the sciatic nerve complex in order to individually collect maximal H-reflexes and muscle (M) response from the FL, TA and SOL. Over the 7d period between testing, LAS patients underwent traditional unstandardized treatment as directed by their individual healthcare

professional. Healthy volunteers reported for two sessions separated by 7d. **Main Outcome Measure(s):** Three peak-to-peak maximal H-reflex and M-response amplitudes were recorded and averaged for the FL, TA and SOL. H-reflexes were normalized to M-responses, with the resulting H:M ratios quantifying SRE. Greater H:M ratios denote greater SRE. Separate, 2x2 (group by time) repeated measures analyses of variance were performed to examine differences in SRE. Alpha level was set a priori at $P < 0.05$. **Results:** FL SRE in the LAS group was significantly greater compared to controls at both 36h and 7d (LAS_36 h: 0.261 ± 0.244 , Healthy_36 h: 0.077 ± 0.052 , LAS_7d: 0.246 ± 0.175 , Healthy_7d: 0.064 ± 0.034 ; $F_{1,23} = 8.696$, $P = 0.007$). TA SRE in the LAS group was greater but not statistically different than the healthy group (LAS_36h: 0.130 ± 0.249 , Healthy_36h: 0.025 ± 0.011 , LAS_7d: 0.144 ± 0.175 , Healthy_7d: 0.028 ± 0.011 ; $P = 0.07$). No SOL SRE group differences were identified (LAS_36h: 0.446 ± 0.255 , Healthy_36h: 0.440 ± 0.287 , LAS_7d: 0.517 ± 0.293 , Healthy_7d: 0.465 ± 0.222). No time effects or interactions were found for any muscle. **Conclusions:** FL SRE was significantly greater in the LAS group compared to a healthy population throughout a 7d period following injury, which may be indicative of an attempt to reflexively stabilize the ankle in response to LAS. The lack of a change in SRE over 7d suggests that current treatment practices following LAS do not influence FL, TA or SOL SRE. Future investigations should determine if therapeutic interventions targeting SRE alter physical function following LAS.

Approximate Entropy In Physically Active Individuals With Unilateral And Bilateral Chronic Ankle Instability

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Context: Postural stability deficits are present in those with Chronic Ankle Instability (CAI). CAI may be considered a constraint on the system, but it is unclear if centrally mediated changes contribute to deficits. **Objective:** To determine if differences in Approximate Entropy (ApEn) measures exist between individuals with unilateral and bilateral CAI. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Twenty-four volunteer recreational athletes divided into Unilateral (5 males, 7 females, age 20.8 ± 1.7 yrs, height 168.8 ± 9.2 cm, mass 68.5 ± 16.4 kg) and Bilateral groups (6 males, 6 females, age 21.2 ± 1.3 yrs, height 167.2 ± 7.9 cm, mass 74.2 ± 15.9 kg). Both groups reported history of previous moderate-severe ankle sprains: the unilateral group to 1 ankle and the bilateral group to both ankles. Cumberland Ankle Instability Tool (CAIT) scores were ≤ 24 on both limbs in the bilateral group, indicating poor function, with the lower score designating the "worst limb," compared to the "other limb." The unilateral group had "involved limb" score ≤ 24 , while the "uninvolved limb" scored ≥ 29 , indicating good function. **Intervention(s):** Participants completed the CAIT and underwent three 10-second trials of single limb stance with eyes closed on a force platform (1200Hz) for both limbs in a randomized order. **Main Outcome Measure(s):** A 4th order, low-pass Butterworth filter was applied with a cut-off frequency of 200Hz. ApEn was calculated using Center of Pressure in the anterior-posterior and medial-lateral directions and averaged across trials for each limb. Independent samples t-tests

and mixed model ANOVAs with post-hoc pairwise-comparisons were applied ($\alpha=0.05$). **Results:** Groups were not different in age, height, mass, or CAIT score on the unilateral involved (20.1 ± 3.1) versus bilateral worst limb (17.2 ± 6.6 , $P \geq 0.40$). CAIT scores were significantly lower in the bilateral group's other limb (20.0 ± 4.3 ; $P < 0.001$) than the unilateral group's uninvolved limb (29.8 ± 0.4), indicating decreased function. Within-subjects effects were non-significant, indicating no differences between limbs in any ApEn measure within either group. Between-subjects effects were significant in anterior-posterior ApEn. The bilateral group's worst limb (0.15 ± 0.03 ; 95% CI 0.13-0.18) demonstrated lower values than the unilateral group's involved limb (0.21 ± 0.04 ; 95% CI 0.19-0.23; $P = 0.001$). The bilateral group's other limb (0.16 ± 0.04 ; 95% CI 0.14-0.19) demonstrated lower values compared to the unilateral group's uninvolved limb (0.21 ± 0.03 ; 95% CI 0.18-0.23; $P = 0.03$). There were no significant between-subjects effects in medial-lateral ApEn. **Conclusions:** There were no differences in regularity of postural control responses between limbs, even though the unilateral group had only 1 injured ankle. Despite similar self-reported function, the bilateral group's worst limb demonstrated less complex postural control responses than the unilateral group's involved limb. When ankle function was different, the bilateral group's other limb had less complex responses, compared to the unilateral uninvolved limb. Deficits in central motor processing may exist in CAI, represented as a decreased ability to adapt postural responses to the constraints on the system.

Comparison Of Excitability Measures And Ankle Laxity Between Ankle Sprain Copers And Participants With Chronic Ankle Instability

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Context: Mechanical and neuromuscular deficiencies are commonly studied in participants with chronic ankle instability (CAI). Recent evidence suggests mechanical laxity alone may not characterize the condition of CAI. Alterations in the central nervous system (CNS) following ankle sprains are likely to characterize the condition of CAI, yet few studies have quantified CNS alterations directly in CAI populations. Ankle sprain copers are individuals that do not present with prolonged dysfunctions following an initial ankle sprain. There have been limited examination of CNS alterations in patients with ankle sprain history, and to our knowledge none that have attempted to comprehensively consider CNS and mechanical differences between CAI, ankle copers, and healthy control groups. **Objective:** Determine if differences exist in spinal reflex excitability and ankle laxity between ankle sprain copers, CAI patients, and healthy controls. **Design:** Case control study. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen participants with CAI (11M, 8F; 22.74 ± 4.41 yrs; 171.55 ± 9.31 cm; 77.73 ± 15.45 kg), 14 participants categorized as ankle sprain copers (5M, 9F; 20.29 ± 3.66 yrs; 168.19 ± 12.20 cm; 72.09 ± 21.19 kg) and 15 healthy control participants (6M, 9F; 21.33 ± 3.84 yrs; 167.73 ± 7.65 cm; 69.51 ± 12.88 kg) volunteered. **Intervention(s):** Spinal reflex excitability was assessed using Hoffman reflex (H-reflex) testing. Participants' ankle laxity was measured with an ankle arthrometer. **Main Outcome Measure(s):** Spinal reflex excitability was assessed for the maximal

H-reflex and muscle-response, from which the H:M ratio was calculated. Ankle laxity was measured as the total displacement in the anterior-posterior directions (mm) and total motion in the eversion-inversion directions (degrees). One-way ANOVAs were used to make groups comparisons for each dependent variable. Significance was set a priori at $P < 0.05$. Cohen's d effect sizes with associated 95% confidence intervals (CI) were calculated using the pooled standard deviations. **Results:** Spinal reflex excitability (H:M ratio) was diminished in CAI participants ($CAI = 0.38 \pm 0.19$) compared to copers ($Coper = 0.53 \pm 0.22$) and control participants ($Control = 0.52 \pm 0.18$) ($F_{2, 47} = 3.038$, $P = 0.058$, $d_{CAI-Coper} = -0.71$, 95% CI: -1.42, 0.00; $d_{CAI-control} = -0.72$, 95% CI = -1.42, -0.03,). No statistical differences were seen between any of the groups for anterior-posterior laxity ($F_{2, 47} = 0.338$, $P = 0.715$, $CAI = 21.47 \pm 6.11$ mm, $Coper = 20.24 \pm 5.60$ mm, $Control = 19.99 \pm 5.07$ mm) nor inversion-eversion laxity ($F_{2, 47} = 1.096$, $P = 0.343$, $CAI = 58.26 \pm 14.01^\circ$, $Coper = 62.24 \pm 13.00^\circ$, $Control = 53.29 \pm 21.16^\circ$). **Conclusions:** Spinal reflex excitability was decreased within the soleus in the CAI compared to the control group; but no differences existed between the copers and control participants. Neuromuscular changes that likely impact dynamic ankle stability were seen only in the CAI group, yet no mechanical differences were noted between any of the groups. These findings support the importance of finding effective ways to increase spinal reflex excitability for the purpose of treating neuromuscular dysfunction in CAI patients. Further research should determine if diminished H:M ratios will predict those who will go on to develop CAI following an ankle sprain. This project was supported by a 2013 NATA-REF Malacrea Masters Grant.

Lower Extremity Joint Coupling Variability During Jogging In Young Adults With And Without Chronic Ankle Instability

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Context: Recurrent lateral ankle sprains, prolonged symptoms, and repeated ankle giving way following initial sprain are characterized as chronic ankle instability (CAI). Joint coupling variability differences in transverse plane shank and frontal plane rearfoot motion have been found between CAI and healthy groups during walking and jogging; however, research in joint coupling variability between the ankle and more proximal joints has yet to be explored in the context of CAI. **Objective:** To analyze the joint coupling variability between the ankle and knee, and the ankle and hip in young adults with and without CAI during treadmill jogging. **Design:** Descriptive laboratory study. **Setting:** Gait laboratory. **Patients or Other Participants:** 14 healthy subjects (5 males, 9 females, age = 21.8 ± 2 years, height = 170.9 ± 8.5 cm, mass = 66.0 ± 12.0 kg) and 13 subjects with CAI (5 males, 8 females: age = 23.5 ± 4 years, height = 170.4 ± 10.2 cm, mass = 72.2 ± 12.9 kg) participated. **Intervention(s):** For each participant, lower extremity kinematic data were collected for three 15 second periods while subjects jogged at 9.66 km/hr on an instrumented treadmill. A 12-camera motion analysis system captured lower extremity kinematics. **Main Outcome Measure(s):** Four joint coupling pairs were analyzed: ankle sagittal – knee sagittal, ankle frontal – knee sagittal, ankle sagittal – hip frontal, and ankle frontal – hip frontal. The Mullineaux vector coding technique was used to quantify joint coupling variability (VCV) for each coupling pair. For each measure, group means and 90% confidence intervals were calculated across the entire gait cycle. Significant differences were identified where the group confidence intervals did

not overlap for at least 3 consecutive percentage points of the gait cycle. **Results:** For ankle sagittal-knee sagittal coupling, the CAI group had significantly lower VCV from 19-25% (CAI: 0.18 ± 0.03 , Control: 0.20 ± 0.04) and 60-80% (CAI: 0.11 ± 0.02 , Control: 0.21 ± 0.02) of the gait cycle. For ankle frontal-knee sagittal coupling, the CAI group had significantly lower VCV values (CAI: 0.12 ± 0.02 , Control: 0.19 ± 0.02) from 20-23% of the gait cycle. For ankle sagittal-hip frontal coupling, the CAI group had significantly lower VCV from 46-48% (CAI: 0.25 ± 0.01 , Control: 0.38 ± 0.03), 51-53% (CAI: 0.20 ± 0.02 , Control: 0.33 ± 0.03) and 61-70% (CAI: 0.12 ± 0.01 , Control: 0.20 ± 0.01) of the gait cycle. Lastly, for ankle frontal-hip frontal coupling, the CAI group had significantly lower VCV compared to controls (CAI: 0.26 ± 0.02 , Control: 0.41 ± 0.04) from 45-49% of the gait cycle. **Conclusions:** The CAI group demonstrated lower stride-to-stride variability in coupling patterns involving the ankle - knee and ankle - hip joint coupling pairs compared to healthy controls. This behavior may be related to a more rigid and less adaptable motor control patterns during gait in CAI patients. Alterations in gait mechanics in individuals with CAI are not limited to the ankle, but may affect the entire lower extremity. These results may have implications for the rehabilitation of CAI patients.

Effects Of CAI And Altered Visual Focus On Sensorimotor Control During A Drop-Landing

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Context: Chronic ankle instability (CAI) and altered visual focus separately have been shown to alter lower extremity kinematics and dynamic stability during a jump-landing task. However, little research has examined the compensatory strategies for dynamic stability in individuals with CAI when visual input is reduced. It is important to assess how the interplay with altered visual input influences the pre-and post-landing functional movements and dynamic stability in individuals with CAI. Specific changes in jump-landing mechanics may place an individual at risk for injury or perpetuate poor movement patterns that influence episodes of instability. **Objective:** Examine the combined effects of CAI and altered visual focus on lower extremity sagittal- and frontal-plane kinematics as well as dynamic stability during a drop-jump task. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen participants with self-reported CAI (11M, 8F; 21.68 ± 4.82 yrs; 171.82 ± 9.30 cm; 75.33 ± 14.81 kg) and 19 healthy participants volunteered (6M, 13F; 20.58 ± 2.32 yrs; 168.05 ± 9.55 cm; 71.30 ± 15.37 kg). **Intervention(s):** Participants performed single-leg drop-jump tasks in a looking-up and looking-down conditions. For the looking-up condition, participants looked up and read a random number that flashed on a suspended computer monitor while performing the drop-jump. For the looking-down condition, participants focused their vision on the force plate upon which they were landing. Kinematics and kinetics were measured using an electromagnetic tracking system interfaced with a non-conductive force plate. **Main Outcome Measure(s):** Sagittal- and frontal-plane kinematics in the hip, knee,

and ankle were calculated at the time points of 100ms pre-initial contact (IC), at IC, and 100ms post-IC. Ground reaction force data were used to calculate the resultant vector time to stabilization (RVTTS). A 2 x 2 repeated-measures ANOVA was utilized for each dependent variable. Significance was set a priori at $P < 0.05$. **Results:** There were group main effects for hip kinematics 100ms pre-IC ($F_{1,36} = 13.52$, $P = 0.001$) as well as hip ($F_{1,36} = 4.89$, $P = 0.03$) and knee kinematics at IC ($F_{1,36} = 4.23$, $P = 0.047$). The CAI group had significantly decreased hip flexion at the point of 100 ms pre-IC ($CAI = 24.09 \pm 5.30^\circ$, $Control = 32.56 \pm 8.66^\circ$), as well as decreased hip flexion ($CAI = 21.70 \pm 5.29^\circ$, $Control = 27.23 \pm 9.56^\circ$) and decreased knee flexion ($CAI = 5.84 \pm 3.42^\circ$, $Control = 9.68 \pm 7.35^\circ$) at IC compared to control participants. There were no significant kinematic differences or RVTTS in either looking-up or looking-down conditions. **Conclusions:** We found that altered visual focus did not influence lower extremity kinematics during the drop-jump task, but the presence of CAI did. The current data supports previous findings that centrally-mediated changes associated with CAI may lead to global alterations in the sensorimotor control. These findings suggest the need for clinicians to assess for proximal joint kinematic pattern alterations during a functional task in individuals with CAI that may contribute to functional deficits.

Relationship Between Mechanical Stability And Sensory Function In Individuals With Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) have demonstrated alterations in ankle mechanical stability as well as deficits in plantar cutaneous sensation and joint position sense (JPS). However, relationships between mechanical stability and sensory function have not been examined. **Objective:** To determine the relationship between 1) mechanical stability and plantar cutaneous sensation and 2) mechanical stability and ankle JPS. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty adults with CAI (13 males, 27 females, age = 23.25 ± 4.79 years, height = 168.85 ± 9.20 cm, mass = 72.04 ± 14.36 kg) volunteered to participate. Participants reported ≥ 1 ankle sprain, ≥ 2 episodes of “giving way” in the past three months, scored < 24 on the Cumberland Ankle Instability Tool, and answered “yes” to ≥ 5 questions on the Ankle Instability Instrument. **Intervention(s):** In a single testing session, participants completed one mechanical and two sensory assessments on the involved ankle in a counterbalanced order. An instrumented, ankle arthrometer was used to assess mechanical stability. Three anterior/posterior displacement trials and three inversion/eversion rotation trials were recorded and averaged for analysis. Semmes-Weinstein Monofilaments (SWM) were used to assess plantar cutaneous sensation at the heel. The lightest weighted monofilament identified by the participant was considered the detection threshold. SWM index values ranged from 1.65-6.65 (smaller values indicated greater sensitivity). JPS was measured using a bubble inclinometer attached to the lateral side of the foot. The involved ankle was placed in a preset position of 20° plantarflexion.

After a 5 second hold, participants actively moved through the entire range of motion and then attempted to recreate the preset position. Three trials were recorded, and the absolute error of each trial was averaged for analysis.

Main Outcome Measure(s): Dependent variables included anterior and posterior displacement (mm), inversion and eversion rotation ($^\circ$), SWM index values, and JPS absolute error ($^\circ$). Spearman's Rho correlations examined the relationships between mechanical stability measures and plantar cutaneous sensation. Pearson product-moment correlations examined the relationships between mechanical stability and JPS. Descriptive statistics for plantar cutaneous sensation were reported as Median (Range) and Mean \pm SD for all other outcomes. Alpha was set a priori at $p < 0.05$ for all analyses. **Results:** No significant correlations were identified between plantar cutaneous sensation (4.08 ($3.61 - 5.46$)) and anterior displacement (8.43 ± 2.28 mm, $r = -0.16$, $p = 0.32$), posterior displacement (4.49 ± 2.00 mm, $r = -0.01$, $p = 0.95$), inversion rotation ($30.92 \pm 6.43^\circ$, $r = -0.26$, $p = 0.11$), or eversion rotation ($20.73 \pm 5.29^\circ$, $r = -0.06$, $p = 0.72$). No significant correlations were identified between JPS ($5.58 \pm 2.77^\circ$) and anterior displacement ($r = -0.10$, $p = 0.55$), posterior displacement ($r = 0.02$, $p = 0.92$), inversion rotation ($r = 0.06$, $p = 0.70$), or eversion rotation ($r = 0.10$, $p = 0.54$). **Conclusions:** Very weak relationships were identified between mechanical stability and sensory function in individuals with CAI. The weak relationship between measures suggests that individuals with greater mechanical instability do not display greater sensory deficits. Therefore, the underlying cause of impairments in plantar cutaneous sensation and JPS in individuals with CAI requires further investigation.

The Prevalence Of Chronic Ankle Instability In Army Reserve Officer Training Corps Cadets

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Context: Due to increased physical demands placed on cadets, military personnel often suffer from a high prevalence of injuries. The majority of these injuries occur in the lower extremity. **Objective:** To identify the prevalence of Chronic Ankle Instability (CAI) in an Army Reserve Officer Training Corps (ROTC) population. **Design:** Cross-sectional survey. **Setting:** Army ROTC training session. **Patients or Other Participants:** One hundred questionnaires were collected. Two surveys were excluded due to a history of fracture leaving 98 surveys for analysis (82 males and 16 females, 19.99 ± 2.36 years). **Intervention(s):** All Army ROTC cadets received a questionnaire packet which included a general demographics questionnaire and the Identification of Functional Ankle Instability (IdFAI) questionnaire for each limb. The demographic questionnaire included questions regarding limb dominance, age, sex, years participating in ROTC, and history of ankle fracture. A score of 11 or higher on the IdFAI was used to identify CAI. As part of the IdFAI we also captured data about whether the cadet sought medical care for their ankle injury. If they did seek care, the grade of ankle sprain was documented (mild, moderate, or severe). **Main Outcome Measure(s):** Presence or absence of CAI were the dependent variables. Frequencies were calculated to determine the overall prevalence and percentage of unilateral and bilateral CAI. A non-parametric chi-squared (χ^2) test of independence was used to evaluate the association between CAI and years of Army ROTC participation, whether they sought medical care, and severity of initial ankle sprain. **Results:** Of all Army ROTC cadets surveyed 40.8% ($n = 40/98$) had CAI and of these, almost one-third (12/40) had unilateral CAI while the remaining two-thirds (28/40) had bilateral CAI. A total of 66 (67.3%) of Army ROTC cadets indicated a history of a previous ankle sprain. Of

those cadets who had a history of an ankle sprain, 60.6% developed CAI. Results of the chi-squared test indicated that individuals participating in only one year of Army ROTC were more likely to have CAI than the cadets who were in ROTC for more than one year ($\chi^2(2) = 17.4$, $p < .001$). We also identified a significant association between developing CAI in the cadets who did not seek medical care ($\chi^2(1) = 16.2$, $p < .001$). Eighteen of the 40 cadets who had CAI (45%) did not seek medical care. Additionally, there was a significant association between developing CAI in those who were diagnosed with either a moderate ($\chi^2(1) = 14.6$, $p < .001$) or a severe ($\chi^2(1) = 13.5$, $p < .001$) ankle sprain. **Conclusions:** These results illustrate lateral ankle sprains commonly occur in individuals participating in Army ROTC and approximately 40% could develop CAI following a lateral ankle sprain. The presence of CAI can create a long-term health problem for anyone; however, it is important to educate cadets to seek medical care after sustaining an ankle sprain to hopefully prevent CAI.

Effect Of Acute Lateral Ankle Sprain On Dynamic Postural Control Over A One-Week Period

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Context: Diminished dynamic postural control is common following acute and chronic injury ankle injury. The Star Excursion Balance Test (SEBT), a measure of dynamic postural control, has demonstrated the ability to distinguish between healthy people and patients with chronic ankle instability, as well as predict athletes at greater risk for incurring an ankle sprain. Little is known about how dynamic postural control changes during the first week following acute lateral ankle sprain (LAS), which is critical knowledge for the development of return to play criteria and likely to improve long-term LAS outcomes.

Objective: Examine differences in dynamic postural control following LAS, compared to healthy controls, over a one-week period. **Design:** Case-Control. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen LAS patients (5M, 10F, 20.53 ± 1.76 yrs, 174.41 ± 11.42 cm, 71.47 ± 17.06 kg) and ten healthy controls, without a history of LAS, (5M, 5F, 21.20 ± 2.78 yrs, 176.41 ± 9.51 cm, 76.45 ± 16.63 kg) volunteered. **Intervention(s):** Patients sustaining a LAS during intercollegiate or recreational sports completed the anterior (AR), posteromedial (PM), and posterolateral (PL) reach directions of the SEBT within 36 hours(h) of the initial injury and at 7days(d) following injury. LAS patients underwent treatment and rehabilitation exercises as directed by their individual healthcare professional. Healthy volunteers completed the SEBT on one day, equating with the 36h time point in the LAS group, and returned 7 days later (7d) to repeat the measures. **Main Outcome Measure(s):** Distances of three trials in each SEBT direction were averaged, and normalized as a percentage of limb length for each participant. Separate 2x2 (group by time) repeated measures

ANOVAs were performed to determine differences for each SEBT direction. Alpha level was set a priori at $P \leq .05$. **Results:** For the AR, LAS demonstrated significantly shorter reach distances at both time points (LAS_36h: $60 \pm 10\%$, Healthy_36h: $66 \pm 6\%$, LAS_7d: $61 \pm 8\%$, Healthy_7d: $68 \pm 4\%$, $F_{1, 23} = 4.283$, $P = 0.050$). For the PM, both groups significantly improved from 36h to 7d (LAS_36h: $78 \pm 12\%$, Healthy_36h: $90 \pm 10\%$, LAS_7d: $83 \pm 11\%$, Healthy_7d: $92 \pm 6\%$, $F_{1, 23} = 6.088$, $P = 0.021$), although LAS demonstrated significantly shorter reach distances at both time points ($F_{1, 23} = 6.324$, $P = 0.019$). For PL, there were no group differences ($P = 0.118$), however, both groups significantly improved from 36h to 7d (LAS_36h: $74 \pm 11\%$, Healthy_36h: $79 \pm 14\%$, LAS_7d: $76 \pm 11\%$, Healthy_7d: $85 \pm 12\%$, $F_{1, 23} = 5.809$, $P = 0.024$). **Conclusions:** LAS patients performed worse on the AR than healthy participants at 36h and at 7d, and there was no change in AR distance from 36h to 7d. A lack of improvement in the AR over the first 7d following LAS suggests the current standard of care does little to improve dynamic postural control 7d post injury, which may increase risk of sequela injury. Future studies should evaluate when AR distances improve post LAS and if time between LAS and AR improvement will predict risk of future sprain.

Free Communications, Poster Presentations: Quality of Life/Outcomes: Knee and Ankle

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

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Current Patient-Reported Outcome Instruments Lack Specificity For Collegiate And Junior League Athletes: An Example Using The Original FADI

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Context: Although many outcome instruments exist, there is no consensus as to the specific functional components to address when measuring foot and ankle injury outcomes in athletic training clientele.

Objective: The purpose of this study was to identify the functional limitations that are reported by athletes following foot and ankle injury and compare them to a common outcome instrument. **Design:** Observational, individual interviews. **Setting:** NCAA Division I FCS institution and USHL amateur junior ice hockey league. **Patients or Other Participants:** Nineteen (10 female, 9 male) athletes from an NCAA Division IAA institution ($n = 15$) and a USHL amateur junior ice hockey team ($n = 4$), participated in this study. The athletes were in various stages of recovery following a foot or ankle injury and represented nine different sports. **Data Collection and Analysis:** Participants completed the Foot and Ankle Disability Index (FADI) and were interviewed. The interview questions addressed: 1) FADI item specificity and difficulty relative to recovery, 2) daily activity limitations (ADL) and sport participation, 3) tasks they found most difficult, and 4) peak performance indicators. The interview data was analyzed descriptively, categorized for common themes, and compared to FADI-total scores. Interview data was checked by the research team to minimize bias and protect authenticity. **Results:** The FADI-Total scores ranged from 27 to 136 of a maximum 136. Three athletes who had returned to full participation without limitations presented the highest FADI scores (> 134). Relative to our interview question categories: 1) Although the athletes suggested that the

FADI adequately addressed their functional limitations, the limitations they subsequently described were very specific and different from the FADI; 2) Limitations in ADLs were diverse and in some cases severe enough to impact eating and socializing. Sport participation limitations were multifaceted and influenced by a physician's or athletic trainer's permission rather than just personal desire or recovery, as well as the athlete's willingness to participate while in pain; 3) Although the most difficult tasks during recovery were relative to each athlete's weight bearing status, those that were transitioning back into sport participation indicated that re-establishing movement patterns or "fluid motion" was most problematic and confidence was a common challenge; and 4) Peak performance indicators were relative to each sport, varied between upper and lower extremity specific tasks, and in most cases were measurable (e.g. time, distance, weight). **Conclusions:** Functional limitations following foot or ankle injury vary between sport participants and are dependent on the patient's weight-bearing status and willingness to participate with pain. Although current outcome instruments are useful in tracking outcomes during the early stages of recovery, they may lack the specificity to accurately measure outcomes as individuals return to higher level functional activities, such as sports participation.

The Relationship Between Personality And Functional Ability Following Anterior Cruciate Ligament Injury

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Context: Anterior cruciate ligament (ACL) injury occurs often and is commonly the result of a non-contact mechanism of injury. Certain neuropsychological characteristics and changes in cerebral cortex activation have been linked to this mechanism. Personality may contribute to the risk of non-contact injury and restoration of function. This emerging area of research may disclose new results that compliment current rehabilitation given the central nervous system's ability to undergo plastic changes. **Objective:** To evaluate constructs including locus of control, grit, mental toughness, sensation seeking, and kinesiophobia in ACL deficient and healthy samples. **Design:** Post-test only control group design. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one male and female recreationally active adults (20.8 ± 2.6 yrs, 170.7 ± 8.4 cm, 69.9 ± 10.5 kg) with no history of knee injury volunteered for this study. Seven physically active male and female adults (27.2 ± 10.4 yrs, 175.8 ± 11.43 cm, 76.7 ± 14.2 kg) who recently suffered non-contact ACL injury also participated. Injuries were sustained during physical activity prior to participation ($= 42.8$ days). **Intervention(s):** Each participant completed the Multidimensional Health Locus of Control, Grit Scale, Mental Toughness 18-Item Questionnaire, Sensation Seeking Scale-V, and Tampa Scale of Kinesiophobia. The ACL deficient subjects additionally reported the number of incidences of "giving way" and completed the Knee Outcome Survey-Activities of Daily Living and the global rating of knee function. **Main Outcome Measure(s):** Independent samples t-tests were used to

determine construct differences between the ACL deficient and healthy samples. Pearson's correlation coefficient was conducted to explore the relationship between the constructs and incidences of "giving way" in the ACLD sample. **Results:** ACL deficient patients demonstrated significantly greater ($p = .017$) sensation seeking (17.0 ± 3.8) compared to the controls (22.5 ± 7.2). Fear was related to the number of episodes of "giving way" in this sample ($r = .67$). **Conclusions:** Our results indicate psychological constructs may contribute to the dynamic restraint mechanism and functional instability of ACL deficient patients. Personality constructs and perceptions can influence decisions, such as risk taking, but it is unclear whether this sensation seeking heightened risks for ACLD patients, or changed following injury. High sensation seekers may falsely believe that they can successfully navigate complex surroundings, thus exposing themselves to increased injury risk. Episodes of instability or "giving way" correlate with fear and may behaviorally manifest as moments of hesitation or uncertainty when executing functional tasks, thereby creating barriers to successful rehabilitation. Funded by the NATA/REF and DJO, LLC.

Factors That Influence Patient Expectations For Recovery Following Cartilage Repair Of The Knee

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Context: Patient expectations have been shown to be a major predictor of outcomes. Furthermore, fulfilled expectations have been linked to increased patient satisfaction and compliance with post-operative rehabilitation. Expectations may be influenced by a variety of factors, including patient characteristics, pre-operative function, or disease characteristics. However, it is currently unknown what factors and to what degree they may influence patient expectations prior to knee surgery. **Objective:** To identify factors that influence patient expectations prior to undergoing cartilage repair of the knee. **Design:** Cross-sectional. **Setting:** Orthopaedic Clinic. **Patients or Other Participants:** Seventeen patients (8 males, 9 females, age: 30.3 ± 11.0 years, height: 172 ± 13 cm, weight: 91 ± 27 kg) scheduled to undergo cartilage repair of the knee, including autologous chondrocyte implantation, osteochondral allograft transplantation, or meniscal transplant were included. **Intervention:** During their pre-operative visit, patients were asked to complete a survey regarding their expectations for recovery. Additionally, self-report measures and demographic information were obtained at this visit, including, surgical procedure, sex, age, activity level (Tegner Scale), and time from onset to surgery. **Main Outcome Measure(s):** Expectations were assessed using the Hospital for Special Surgery (HSS) Knee Surgery Expectations Survey. This self-administered questionnaire is a 23-item survey addressing patient expectations regarding pain, physical activity, and psychological well-being following knee surgery. Item responses are measured on a 5-point Likert scale, with 1="complete improvement" and 5="I do not have this expectation". Scores are transformed to a scale which ranges from 0-100, with

higher scores representing greater expectations for recovery. The KOOS was used to assess pre-operative functional ability. The KOOS produces separate scores within five sub-domains (pain, symptoms, activities of daily living (ADL), sport-and-recreation, and knee-related quality-of-life (QOL)), with lower scores representing worse function in each area. Pearson correlation coefficients were used to determine relationships between expectations and patient characteristics (age, activity level, time from onset to surgery) or KOOS scores. **Results:** The average pre-operative expectation score was 70.1 ± 16.0 . There were no significant associations between patient expectations and age ($r = -0.25$, $p = 0.33$), activity level ($r = 0.19$, $p = 0.46$), or time from onset to surgery ($r = -0.21$, $p = 0.42$). Furthermore, there were no significant associations between patient expectations and the KOOS sub-domains of pain ($r = 0.46$, $p = 0.06$), symptoms ($r = -0.03$, $p = 0.91$), or sport-and-recreation ($r = 0.29$, $p = 0.25$). However, there was a significant positive relationship between patient expectations and the KOOS sub-domains of ADL's ($r = 0.48$, $p = 0.05$) and QOL ($r = 0.52$, $p = 0.03$). **Conclusions:** Patient expectations appear to be a separate construct that should be captured independently in patients undergoing knee surgery. Patient self-reported symptoms do not appear to influence patient expectations. Conversely, patients with higher scores on the KOOS sub-domains of QOL and ADL had higher expectations for recovery suggesting that quality-of-life may influence patient expectations and therefore must be assessed independently from patient self-report measures that evaluate pain, symptoms, and physical function.

Relationship Between Generic And Region-Specific Patient Reported Outcomes In Collegiate Athletes With History Of Lower Extremity Injury

Hoch JM, Druvenga BG, Ferguson BA, Houston MN, Hoch MC: Old Dominion University, Norfolk, VA

Context: Patient-reported outcome instruments (PROs) are tools available to measure the effectiveness of treatments and assess health-related quality of life (HRQOL) in clinical practice. There are different types of PROs, such as generic or region-specific, that assess different dimensions of HRQOL. At this time it is unknown if a relationship exists between generic and lower extremity region-specific PROs in collegiate athletes with a history of lower extremity injury. **Objective:** To determine if a relationship exists between scores on generic and region-specific PROs in soccer athletes with a history of lower extremity injury. **Design:** Cross-sectional. **Setting:** Athletic facility. **Patients or Other Participants:** Twenty-two Division I soccer athletes (males = 11, females = 11, age: 19.7 ± 1.0 years; height: 176.6 ± 10.2 cm; mass: 69.8 ± 10.7 kg) participated. Subjects were included if they were members of the soccer team, able to participate in the 2013 spring season, and had a history of knee and/or ankle injury. **Intervention(s):** One week prior to the spring soccer season, all participants completed the Disablement in the Physically Active (DPA) scale, the Foot and Ankle Ability Measure-Sport (FAAM-S) and the Knee Injury Osteoarthritis and Outcome Score (KOOS). **Main Outcome Measure(s):** The DPA is a generic PRO with scores ranging from 0-64, with higher scores indicating greater disablement. The FAAM-S is a region-specific PRO with scores ranging from 0-100%, with lower scores representing lower levels of function. The KOOS is a region-specific scale comprised of five individually scored subscales with scores ranging from 0-100, with lower scores representing lower levels of function. The dependent variables (DV) were scores

on the DPA, FAAM-S, KOOS-Quality of Life (QOL), KOOS-Sport, KOOS-Activities of Daily Living (ADL), KOOS-Pain and KOOS-Symptoms subscales. Descriptive statistics (Median(range)) were calculated for each DV. Spearman correlations (r) and the coefficient of determination (r^2) were used to determine the relationship between all PROs. Alpha was set a priori at $p < 0.05$. **Results:** Median(range) scores for the DPA, FAAM-S, KOOS-QOL, KOOS-Sport, KOOS-ADL, KOOS-Pain and KOOS-Symptoms were 11.5 (0-33), 100% (52%-100%), 96.9 (31.3-100), 92 (35-100), 99.3 (39.7-100), 97.2 (69.4-100), and 91.1 (39.3-100) respectively. Significant correlations were found between the DPA and FAAM-S ($r = -0.443$, $r^2 = 0.196$, $p = 0.039$) and the DPA and KOOS-Sport ($r = -0.454$, $r^2 = 0.206$, $p = 0.034$). No other significant relationships were identified ($p > 0.05$). **Conclusions:** Moderate relationships were identified between the DPA and the region-specific PROs related to sport activity. Interestingly, no other significant relationships were discovered for the non-sport related KOOS subscales. The 20% of the variance that can be explained between DPA scores and sport-related region-specific PROs indicates there is a level of redundancy in the information collected while using these PROs. However, because 80% of the variance between PROs is unexplained, clinicians should continue to utilize both types of instruments in clinical practice to accurately assess effectiveness of treatments and all dimensions of HRQOL in their patients.

Patient-Reported Outcomes Over The Course Of A Spring Soccer Season

Ferguson BA, Druvenga BG, Houston MN, Hoch MC, Hoch JM: Old Dominion University, Norfolk, VA

Context: During an athletic season, athletes participate in many activities that may influence health-related quality of life (HRQOL). Patient-reported outcome instruments (PROs) are commonly used to assess HRQOL following injury. Examining PRO scores over the course of an athletic season may provide insight into additional considerations for interpreting these measures in clinical practice. **Objective:** To determine if PRO scores change over the course of an athletic season. **Design:** Repeated measures. **Setting:** Athletic facility. **Patients or Other Participants:** Fourteen Division-I soccer athletes (males = 9, females = 5, age: 19.93 ± 1.01 years; height: 178.89 ± 10.53 cm; mass: 72.01 ± 11.07 kg) participated. Participants were participating in all spring 2013 soccer related activities. **Intervention:** Data was collected on the first day of practice (T1), twice during the season (T2, T3), and one week post-season (T4). Participants completed the Disablement in the Physically Active (DPA) scale, the Foot and Ankle Ability Measure-Sport (FAAM-S) and the Knee Injury Osteoarthritis and Outcome Score (KOOS). **Main Outcome Measure(s):** The DPA is a generic PRO with scores ranging from 0-100%, with higher scores indicating greater disablement. The FAAM-S is a region-specific PRO with scores ranging from 0-100%, with lower scores representing lower function. The KOOS is comprised of five individually scored subscales with scores ranging from 0-100, with lower scores representing lower function. The dependent variables (DV) were DPA, FAAM-S, KOOS-Quality of Life (QOL), KOOS-Symptoms, KOOS-Activities of Daily Living (ADL), KOOS-Pain, and KOOS-Sport scores. Median (Range) were calculated for each DV. Separate Friedman's tests determined change over time on each

PRO ($p < 0.05$). Post-hoc comparisons were performed using Wilcoxon signed rank tests with a corrected p -value ($p < 0.0125$).

Results: There was a significant time effect for the DPA ($p = 0.007$); with a difference between T1 (7.8% (0-35.9%)) and T4 (0 (0-9.4%), $p = 0.005$). A significant time effect was detected for KOOS-QOL ($p = 0.038$); however, there were no differences between T1 (100 (56-100)), T2 (100 (50-100)), T3 (100 (63-100)), and T4 (100 (56-100), $p < 0.125$). There was a significant time effect for KOOS-Symptoms ($p = 0.022$); however, there were no differences between T1 (95 (54-100)), T2 (98 (64-100)), T3 (100 (57-100)), and T4 (100 (61-100), $p > 0.0125$). A significant effect for time was found for the KOOS-ADL ($p = 0.010$); however, there were no differences between T1 (99 (72-100)), T2 (99 (91-100)), T3 (99 (82-100)), and T4 (100 (96-100), $p > 0.0125$). There was a significant time effect for KOOS-Pain ($p = 0.027$); however, there were no differences between T1 (97 (64-100)), T2 (100 (69-100)), T3 (100 (72-100)), and T4 (100 (81-100), $p > 0.0125$). There were no main effects for the FAAM-S ($p = 0.362$) or KOOS-Sport ($p = 0.222$). **Conclusions:** Athletes demonstrated increased disablement, as measured by the DPA, at the beginning of the season compared to one week following the season. Although this difference was statistically significant, it may not be clinically relevant. In addition, while there was an overall time effect for several KOOS-subscales, there were no significant differences between time-points. Cumulatively, these findings suggest that the point in the athletic season in which PROs are collected does not create a confounding variable when capturing these outcomes in clinical practice. Therefore, changes in HRQOL are likely associated with other factors such as injury.

Predictors Of Health-Related Quality Of Life In Those With Chronic Ankle Instability

Houston MN, Hoch JM, Gabriner ML, Kirby JL, Van Lunen BL, Hoch MC: Old Dominion University, Norfolk, VA

Context: Individuals with chronic ankle instability (CAI) have exhibited functional and mechanical impairments and reported health-related quality of life (HRQOL) detriments in comparison to healthy individuals. However, it remains unclear how mechanical and functional impairments contribute to the HRQOL detriments associated with CAI.

Objective: To determine if functional and mechanical impairments are capable of predicting HRQOL scores in participants with CAI.

Design: Cross-sectional. **Setting:** Laboratory.

Patients or Other Participants: Forty participants with CAI (13 males, 27 females, age = 23.3 ± 4.8 years, height = 168.9 ± 9.2 cm, mass = 72.0 ± 14.4 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 "yes" to ≥ 5 questions on the Ankle Instability Instrument, and scored < 24 on the Cumberland Ankle Instability Tool. **Intervention(s):** Participants reported for a single testing session to complete HRQOL, postural control, strength, sensory, and mechanical assessments. HRQOL was assessed using the Short Form-12 (SF-12). The SF-12 contains 12 items with physical (SF-12PCS) and mental (SF-12MCS) component scores. All other assessments were completed in a counterbalanced order on the involved limb. Postural control was measured using the modified Star Excursion Balance Test (SEBT) and single-limb balance on a force plate. Eversion isometric strength was assessed using a handheld dynamometer. Plantar cutaneous sensation was assessed at the heel using Semmes-Weinstein Monofilaments. Anterior joint laxity was measured using an instrumented ankle arthrometer, and dorsiflexion range of motion (DROM) was measured using the weight-bearing

lunge test. **Main Outcome Measure(s):**

All predictor variables were selected based on deficits previously reported in individuals with CAI. Predictor variables included normalized SEBT-anterior reach distance, mean minima time-to-boundary anterior-posterior, eversion strength, plantar cutaneous sensation, anterior displacement, and DROM. Two separate backward multiple linear regression models were used with SF-12PCS and SF-12MCS scores as criterion variables. Norm-based measures for the SF-12 have a population mean of 50 ± 10 with higher scores indicating greater well-being. Descriptive statistics were reported as Median (Range) for plantar cutaneous sensation and as Mean \pm SD for all other outcomes. Alpha level was set a priori at $p < 0.05$ for all analyses. **Results:** SEBT-anterior reach distance ($81.19 \pm 5.52\%$), plantar cutaneous sensation (4.08 (3.61-5.46)), and DROM (7.79 ± 3.48 cm) were significant predictors of SF-12PCS scores (55.59 ± 5.79 , $p = 0.03$, $R^2 = 0.22$). No significant regression models ($p > 0.05$) were observed for SF-12MCS scores (52.19 ± 6.98). **Conclusions:** SEBT-anterior reach distance, plantar cutaneous sensation, and DROM explained 22% of the variance in SF-12PCS scores. Utilizing rehabilitation strategies that focus on these impairments may be a good starting point to address the physical components associated with HRQOL detriments in patients with CAI. Other variables should be examined to address mental components of HRQOL as there were no significant predictors. These findings suggest that each individual may have a unique combination of impairments that contribute to mental components of HRQOL.

Patient-Reported Outcome Instruments Can Differentiate Between Individuals With And Without Chronic Ankle Instability
Hoch MC, Houston MN, Van Lunen BL, Hoch JM: Old Dominion University, Norfolk, VA

Context: Chronic ankle instability (CAI) has been associated with decreased health-related quality of life based on region-specific and generic patient-reported outcome (PRO) instruments, as well as, dimension-specific instruments that measure injury-related fear. Despite these findings, the extent to which PRO instruments can differentiate between people with and without CAI is unknown. **Objective:** To determine the diagnostic utility and cutoff scores of PRO instruments for differentiating between individuals with and without CAI. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-five participants with CAI (7 males, 18 females, age = 21.9 ± 2.5 years, height = 170.8 ± 8.6 cm, mass = $69.8.0 \pm 11.7$ kg) were gender and limb matched to 25 healthy participants with no history of ankle sprain (7 males, 18 females, age = 22.0 ± 2.1 years, height = 167.4 ± 9.1 cm, mass = 64.8 ± 11.2 kg). Participants with CAI reported ≥ 1 ankle sprain, ≥ 2 episodes of “giving way” in the past three months, and answered “yes” to ≥ 5 questions on the Ankle Instability Instrument. **Intervention(s):** Within a single testing session all participants completed the Foot and Ankle Ability Measure-Sport (FAAM-Sport), Disablement in the Physically Active (DPA) scale, and the Fear-Avoidance Beliefs Questionnaire (FABQ). **Main Outcome Measure(s):** The FAAM-Sport is an 8-item region-specific PRO with scores that range from 0-100% with lower scores indicating lower foot and ankle function. The DPA is a 16-item generic PRO with scores that range from 0-64 with higher scores indicating increased disablement. The FABQ is a 16-item dimension-specific PRO which focuses on fear-avoidance with scores that range from 0-66 with higher scores indicating increased fear. Dependent

variables included FAAM-Sport, DPA, and FABQ scores and the independent variable was group (CAI, healthy). Receiver operating characteristic (ROC) curves determined the cutoff score, sensitivity, and specificity of each PRO instrument for differentiating between groups. Accuracy values were determined by calculating the area under the ROC curves (AUC) with corresponding asymptotic 95% confidence intervals (CI). The asymptotic level of significance was set at $p \leq 0.05$ for all analyses. **Results:** Descriptive statistics (mean \pm standard deviation) were calculated for the FAAM-Sport (CAI: $90.23 \pm 12.94\%$, Healthy: $100.00 \pm 0.00\%$), DPA (CAI: 14.36 ± 6.58 , Healthy: 0.52 ± 1.32), and FABQ (CAI: 16.12 ± 10.42 , Healthy: 1.20 ± 2.12). Cutoff scores for differentiating between CAI and healthy subjects were 96.88% (sensitivity = 1, specificity = 1), 2.5 (sensitivity = 1, specificity = 0.96), and 6.5 (sensitivity = 0.88, specificity = 0.96) for the FAAM-Sport, DPA, and FABQ, respectively. The AUC was 1.0 (95% CI = 1.0, 1.0), 0.95 (95% CI = 0.98, 1.00), and 0.99 (95% CI = 0.88, 1.00) for the FAAM-Sport, DPA, and FABQ, respectively. The asymptotic significance was $p < 0.001$ for all measures. **Conclusions:** All three PROs were excellent assessment tools for differentiating between participants with and without CAI based on the diagnostic utility scores. The cutoff scores provide preliminary values to identify relevant levels of health-related quality of life deficits for classifying individuals with CAI when using each PRO instrument. These findings should be re-examined with ankle sprain copers and confirmed through prospective studies.

Do College Athletes Differ From College Nonathletes In Their Sleep Quality?

Dettl MG, Divers CK, Russell JA, Horton D, Ragan BG: Ohio University, Athens, OH

Context: Self-reported sleep questionnaires provide an inexpensive way to measure subjective sleep quality (ie, ‘good’ or ‘bad’ sleep) in large populations. Research has previously shown that physically-active individuals report more ‘good’ sleep whereas college students report more ‘bad’ sleep. The college athlete is both a physically-active individual and a college student; resulting in contrasting sleeping patterns. Current research of sleep quality in the college athlete population is limited. **Objective:** To use self-reported questionnaires to measure sleep quality and overall health in the college athlete population and compare to a college non-athlete population. **Design:** Cross-sectional. **Setting:** The setting occurred via online using the Assessment Center created by the Patient-Reported Outcomes Measurement System (PROMIS), college/university classrooms, as well as the online social media, Facebook. **Patients or Other Participants:** There were 285 subjects ($n = 166$ athletes, $n = 119$ nonathletes) who completed this study (age: mean \pm SD: 20.85 ± 1.9). The minimum sample size of 280 was determined by a power analysis (effect size = 0.25, $p < 0.05$ and the power set at 0.8). There were 100% ($n = 149/149$) and 71.2% ($n = 136/191$) return rates for paper surveys and online surveys, respectively. **Intervention(s):** Participants completed four different instruments measuring sleep quality (PROMIS Sleep Disturbance (SD); Pittsburgh Sleep Quality Index (PSQI)), daytime sleepiness (PROMIS Sleep-Related Impairment (SRI), Epworth Sleepiness Scale (ESS)), three instruments measuring daytime functioning (Perceived Stress Scale (PSS), Cohen-Hoberman Inventory of Physical Symptoms (CHIPS), and SF-12v2), physical activity levels and a basic demographic form. **Main Outcome Measure(s):** The dependent variables are

the sleep instrument scores: PROMIS SD and SRI, PSQI, and ESS. Independent T test measures were used to compare mean differences between college athletes and non-athletes. **Results:** There were significant differences between the two groups on four of the seven instruments: SRI ($t_{283} = -2.29$; $P = 0.02$); PSQI, ($t_{283} = -1.99$; $P = 0.05$); PSS ($t_{283} = -2.25$; $P = 0.03$); CHIPS ($t_{283} = 2.10$; $P = 0.04$); The athlete population scored (mean \pm SD) on SRI (T score, 53.94 ± 6.36), SD (T score, 50.35 ± 7.58), PSQI (5.38 ± 3.35), ESS (7.87 ± 3.92). The nonathlete population scored (mean \pm SD) on SRI (T score, 55.66 ± 6.16), SD (T score, 50.10 ± 6.81), PSQI (6.14 ± 3.35), ESS (7.68 ± 3.74). **Conclusions:** This study identified a group difference in sleep quality between college athletes and nonathletes. Sleep quality in the college athlete does differ significantly from a college nonathlete sample: the college athlete has 'good' or 'better' sleep than the college nonathlete. Further research is needed to complete a sleep profile of college athletes and the effects sleep has on academic and athletic performances.

Comparison Of Standard Goniometry Versus An iPhone Goniometry Accelerometer Application To Measure Elbow Flexion And Extension Motion

Pollard-McGrandy AM, Albrecht AJ, Berry DC: Saginaw Valley State University, University Center, MI

Context: Range of motion (ROM) is standard practice when conducting an injury evaluation. ROM is quantified using a standard goniometer (SG); but due to technological advances, alternative methods using iPhone (Apple, Cupertino, CA) applications may offer clinicians a more effective and convenient means of measuring ROM. **Objective:** To compare the relationship and inter-rater reliability between elbow flexion (EF) and extension (EE) active ROM (AROM) using SG and the iPhone application Goniometer (App). **Design:** Quasi-experimental. **Setting:** Clinical research room. **Patients or Other Participants:** Thirty-one (17 males, 14 females) healthy, college-aged participants, (age = 21.2 ± 1.5 years; height = 149.3 ± 8.4 cm; mass = 77.9 ± 19.3 kg) free of dominant side upper extremity injuries and surgery/pain for 6 months. **Intervention(s):** Participants were supine for a single session measurement of EF/EE AROM by two independent raters (not blinded) using the subjects' dominant arm (used to throw a ball). To control measurement error, a towel was placed underneath the posterior humerus to maintain the arm at a neutral position. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was measured using referenced landmarks: lateral epicondyle (axis), long axis of humerus (stationary arm), and radial styloid process (moveable arm) while participants maximally flexed and extended the elbow. iPhone App (Goniometer, Jinfra) landmarks included: 1" distal to antecubital fossa (P1) and along the posterior forearm 1" distal to the Olecranon process (P2). Once maximal joint movement was obtained the iPhone was placed horizontally along P1 and

"Start" was pressed. This was repeated at the P2 position with "End" pressed in order to calculate ROM. **Main Outcome Measure(s):** Dependent variable were EF and EE AROM (measured in degrees); independent variables were SG and App. Person Correlation Coefficients were calculated to determine the relationship between SG and the App. An intraclass correlation (ICC2,1) measured EF and EE inter-rater reliability. Alpha level was set a priori at $p < 0.05$. **Results:** Combined SG and App mean (SEM) rater scores for EF were 142.4° (1.0°) and 155.7° (1.5°), respectively. Combined EE rater mean (SEM) scores for SG and App were -2.5° ($.44^\circ$) and -1.7° ($.43^\circ$), respectively. Significant relationships were also found between combined rater SG and App for EF, $r(29) = .624$, $p < .001$ and EE, $r(29) = .509$, $p = .003$. ICC measurements for inter-rater reliability values for EF and EE were .262 (95% CI: -.049, .544) and .067 (95% CI: -.163, .338) respectively. **Conclusions:** Significant relationships (moderate) existed between the App and SG; however, inter-rater reliability values were poor for EF and EE. The iPhone Goniometry Accelerator app is an unreliable tool to measure motion and should be avoided when measuring a patient's elbow ROM. Variation in joint structure or body mass (ie., increased adipose, muscle hypertrophy, atrophy) will affect the measured value. Further research is necessary to evaluate the effects of the Accelerator app at other joints.

A Comparison Of Standard Goniometry Versus The Dr Goniometer iPad/iPhone App For Measuring Elbow Flexion And Extension Motion

Albrecht AJ, Pollard-McGrandy AM, Berry DC: Saginaw Valley State University, University Center, MI

Context: When conducting a patient assessment, range of motion (ROM) measurements are documented by using a standard goniometer (SG). However, SG measurements have demonstrated inconsistent and unreliable results; prompting the use of alternative or new technological applications (ie., iPad/iPhone), many which have not been evaluated.

Objective: Compare the relationship and inter-rater reliability between elbow flexion (EF) and extension (EE) active ROM (AROM) using SG and the iPad/iPhone paid application Dr.Goniometer (DGA).

Design: Quasi-experimental. **Setting:** Clinical research room. **Patients or Other**

Participants: Thirty-one (17 males, 14 females) healthy, college-aged participants, (age = 21.2 ± 1.5 years; height = 149.3 ± 8.4 cm; mass = 77.9 ± 19.3 kg) free of dominant side upper extremity injuries and surgery/pain for 6 months. **Intervention(s):** Participants were supine for a single session measurement of EF/EE AROM by two independent raters (not blinded) using the subjects' dominant arm (used to throw a ball). To control measurement error, a towel was placed underneath the posterior humerus to maintain the arm at a neutral position. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was measured using referenced landmarks: lateral epicondyle (axis), long axis of humerus (stationary arm), and radial styloid process (moveable arm) while participants maximally flexed and extended the elbow. Dr.Goniometer referenced landmarks included: lateral epicondyle (axis), long axis of humerus (stationary arm), and radial styloid process (moveable arm). Once maximal joint movement was

obtained a digital photograph using the app was recorded. Motion was calculated by the app by manually manipulating three markers so a crosshair was placed on the landmarks above. No visual markers were used to identify the landmarks. To maintain positioning the app provided a dotted line that connected individual reference points to ensure alignment. **Main Outcome Measure(s):** Dependent variables were EF and EE AROM (in degrees); independent variables were SG and DGA. Person Correlation Coefficients were calculated to determine the relationship between SG and DGA. An intraclass correlation (ICC2,1) measured EF and EE inter-rater reliability. Alpha level was set a priori at $p < 0.05$. **Results:** Combined DGA and SG mean (SEM) rater scores for EF were 145.2° (1.0°) and 142.4° (1.0°), respectively. Combined DGA and SG mean (SEM) rater scores were -1.1° ($.63^\circ$) and -2.5° ($.44^\circ$), respectively. Significant relationships were found between combined rater SG and DGA for EF, $r(29) = .670$, $p < .001$ and EE, $r(29) = .862$, $p < .001$. ICC measurements for inter-rater reliability values of DGA for EF and EE were .835 (95% CI: .685, .917) and .595 (95% CI: .309, .782), respectively. **Conclusions:** Significant relationships existed between the Dr.Goniometer app and SG while inter-rater reliability values were good (EF) to fair-to-good (EE). The Dr.Goniometer app is a simple and effective tool to measure ROM. Data can be collected, stored, synced with other mobile devices, and shared with the patient. Intra- and interrater reliability should be investigated further.

Test-Retest Reliability And Precision Of Hip, Knee And Ankle Extensor Rate Of Torque Development

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Context: Rate of torque development (RTD) is an indicator of muscle performance which quantifies the ability of an individual to generate joint torque during a specific time period. It is often calculated during the initial 50 and 200 milliseconds (ms) of isometric contraction in studies related to injury prevention and athletic performance, respectively. Despite widespread use of RTD, the within-subject reliability and precision of this measure for the hip, knee, and ankle extensors has not been comprehensively reported. **Objective:** To assess test-retest reliability and measurement precision of RTD calculated during the initial 50 and 200 ms of isometric hip (H50 and H200), knee (K50 and K200), and ankle (A50 and A200) extension contractions.

Design: Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty recreationally active volunteers (15 Males and 15 Females: Age = 22.9 ± 2.5 years; Height = 172.8 ± 9.5 cm; Mass = 72.2 ± 14.0 kg). **Intervention(s):** Dominant leg hip, knee, and ankle extension joint torques were recorded using a Biodex System3 dynamometer interfaced with a Biopac MP100 system. Participants were placed in standardized testing positions and contracted isometrically as hard and fast as possible following the presentation of a light stimulus. Three valid trials for each joint were recorded in a counterbalanced order during a single testing session. **Main Outcome Measure(s):** RTD was calculated by fitting a line of best fit to the recorded torque-time curves of the hip, knee, and ankle between onset and 50 or 200 ms after onset, respectively. Onset was defined as the instant when the torque signal exceeded 2.5% of the recorded peak torque. RTD was then

normalized using an allometric scaling technique. Intraclass correlation coefficients (ICCs) were used to assess within-session test-retest reliability. Standard error of the measurements ($SEM = SD\sqrt{(1-ICC)}$) and intra-subject coefficients of variation ($ICV = \sqrt{(MSE)/100}$) were used to assess agreement of individual RTD values across trials. **Results:** Mean values for RTD ($[Nm/s]/kg(.67)$) were $H50 = 20.99 \pm 11.80$, $H200 = 37.53 \pm 18.17$, $K50 = 38.10 \pm 25.63$, $K200 = 31.09 \pm 13.86$, $A50 = 19.30 \pm 9.63$, $A200 = 19.94 \pm 9.23$. Test-retest reliability was generally good with ICCs greater than 0.78 ($H50 = 0.78$, $H200 = 0.87$, $K50 = 0.82$, $K200 = 0.90$, $A200 = 0.86$) except $A50$ (0.73). However, SEMs ($[Nm/s]/kg(.67)$) were large relative to mean RTD values across trials ($H50 = 5.54$, $H200 = 6.55$, $K50 = 10.87$, $K200 = 4.38$, $A50 = 5.00$, $A200 = 3.45$), and resulted in large ICV(%) ($H50 = 29.5\%$, $H200 = 19.4\%$, $K50 = 28.5\%$, $K200 = 13.9\%$, $A50 = 26.1\%$, $A200 = 16.9\%$). **Conclusions:** While the calculated ICCs suggest that hip, knee, and ankle extension RTD measures were consistent, the high SEMs and ICV values indicate that participants demonstrated significant fluctuations in these measures across repeated trials. It is likely that the relatively high test-retest reliability was driven by a high degree of inter-subject variability in the sample population. Despite the apparent reliability of the RTD measure, the large ICV suggest that using a single maximal value is likely more indicative of subject's maximum hip, knee and ankle extension RTD ability than the mean value across trials.

Inter-Rater Reliability Of The Functional Movement Screen

Moffatt MD, Johnson BS, Stephensen CH, Switzler CL, Hayes BT, Hicks-Little CA: The University of Utah, Salt Lake City, UT

Context: The Functional Movement Screen (FMS) is a tool used to evaluate gross movement patterns and identify limitations. The FMS founders provide plentiful training material and an official certification exam, yet both certified and non-certified professionals administer FMS screens with collegiate athletes and interpret scores accordingly. **Objective:** This study investigated the inter-rater reliability of FMS scoring between FMS certified raters versus non-certified raters when completing an FMS screening on collegiate athletes. We hypothesized that FMS certified raters will yield higher inter-rater reliability than non-certified raters. **Design:** Three way inter-rater reliability analysis. **Setting:** Sports Medicine research laboratory. **Patients or Other Participants:** Twenty-nine NCAA-Division I healthy collegiate athletes (15 female, 14 male) volunteered to participate in the study. All participants reported not having sustained any musculoskeletal injury within the last 6 months resulting in loss of practice or competition time. **Intervention(s):** Participants completed all seven standard movements of the FMS under video recording in front of two FMS-certified live raters. Each participant completed three attempts of each movement during testing. Two video cameras recorded the movements from both anterior and lateral viewpoints. At the conclusion of testing, videos were spliced together using software, showing both viewpoints in sync as participants completed the movements. A second group of five non-certified raters conducted video scoring on the video recordings. The two FMS-certified live raters also conducted video scoring. All scorers recorded their scores on a provided rubric. **Main Outcome Measure(s):** Individual

scores reported by each rater were entered into statistical analysis software (STATA) and used to calculate inter-rater reliability using weighted kappa (K_w) and percent agreement calculations. **Results:** FMS certified raters demonstrated $\geq 80\%$ agreement during live scoring on 11/17 categories, 70-79% agreement on 3/17 categories, and 60-69% agreement on 3/17 categories. K_w was 'good' to 'high' on 16/17 categories, with 1 'fair' category (trunk stability push up). Video scoring from the FMS certified raters demonstrated $\geq 80\%$ agreement on 3/14 categories, 70-79% agreement on 8/14 categories, and 60-69% agreement on 3/14 categories. K_w was 'good' to 'high' on 10/17 categories, 'moderate' on 2/14 categories, and 'poor' on 2/14 categories. Non-certified FMS raters demonstrated $\geq 80\%$ agreement during video scoring on 1/14 categories, 70-79% agreement on 4/14 categories, 60-69% agreement on 7/14 categories, and 50-59% agreement on 2/14 categories. K_w was 'good' to 'high' on 13/14 categories and 'moderate' on 1/14 categories. **Conclusions:** FMS certified raters agreed more on participant scores than non-certified raters. When considering the common practice use of FMS in collegiate athletics during pre-participation evaluations, our study results suggest that FMS screening performed by FMS certified raters is more reliable than that performed by non-certified raters. Inadequate training may lead to rater error and lack of identification of the functional limitations and asymmetries present.

Free Communications, Poster Presentations: Patient-Reported Outcomes

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14F22MOIN

Normative Data For The Pediatric Quality Of Life Instrument In Adolescent Athletes

Cozzi AL, Snyder Valier AR, Bay RC, Welch CE, Molzen E, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Interest in the impact of sport-related injury on adolescent health-related quality of life (HRQOL) has increased in recent years. Prior research has identified that HRQOL of athletes differs from established general population norms. Documentation of normative values for quality of life instruments, such as the Pediatric Quality of Life Instrument (PedsQL), would assist clinicians in interpreting instrument scores for adolescent athletes pre- and post-injury. **Objective:** To determine normative values for the PedsQL among adolescent athletes in complimentary male and female sports. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of interscholastic adolescent athletes (males: $n = 1003$; females: $n = 807$) participating in soccer (male: $n = 220$; female: $n = 235$), basketball (male: $n = 279$; female: $n = 188$), or baseball/softball (male: $n = 504$; female: $n = 384$) were included. **Intervention(s):** Participants were stratified according to complimentary male and female sports (ie, soccer, basketball, and baseball/softball). Participants completed the PedsQL (internal consistency = .68-.88) during one testing session at the start of their respective sport season. **Main Outcome Measure(s):** Dependent variables included the PedsQL total score (TS) and 5 subscale scores [physical functioning (PF), psychosocial functioning (PSF), emotional functioning (EF), social functioning (SOF), school functioning (SCF)]. Descriptive statistics were used to report normative total and subscale scores per sport and are reported as mean \pm SD (range). **Results:** Normative values for male soccer athletes were TS = 93.6 ± 7.6 (59.8-100); PF = 95.7 ± 7.7 (37.5-100); PSF = 92.4 ± 8.7

(55-100); EF = 93.9 ± 10.7 (35-100); SOF = 93.8 ± 11.1 (45-100); SCF = 89.8 ± 11.4 (55-100), while values for female soccer athletes were TS = 90.6 ± 9.4 (44.6-100); PF = 92.8 ± 9.1 (56.3-100); PSF = 89.4 ± 10.8 (35.0-100); EF = 88.6 ± 15.6 (15.0-100); SOF = 93.8 ± 10.1 (45.0-100); SCF = 85.6 ± 13.4 (35.0-100). Normative values for male basketball athletes were TS = 91.4 ± 8.7 (57.6-100); PF = 93.0 ± 9.1 (56.3-100); PSF = 90.5 ± 9.9 (50.0-100); EF = 92.5 ± 11.5 (45.0-100); SOF = 93.9 ± 10.2 (55.0-100); SCF = 85.1 ± 14.8 (30.0-100), while values for female basketball athletes were TS = 89.7 ± 10.4 (29.4-100); PF = 91.9 ± 10.6 (37.5-100); PSF = 88.4 ± 11.4 (25.0-100); EF = 87.7 ± 15.5 (10.0-100); SOF = 93.8 ± 10.5 (35.0-100); SCF = 83.9 ± 14.8 (25.0-100). Normative values for male baseball athletes were TS = 92.5 ± 7.9 (45.7-100); PF = 94.8 ± 7.3 (43.8-100); PSF = 91.3 ± 9.5 (43.3-100); EF = 92.7 ± 11.8 (35.0-100); SOF = 94.5 ± 9.7 (25.0-100); SCF = 86.5 ± 14.1 (25.0-100), while female softball athletes were TS = 90.0 ± 9.7 (27.2-100); PF = 91.7 ± 9.9 (25.0-100); PSF = 89.1 ± 11.1 (28.3-100); EF = 88.7 ± 15.3 (0.0-100); SOF = $94.1-10.2$ (45.0-100); SCF = 84.2 ± 14.6 (15.0-100). **Conclusions:** Our results provide the first report on normative data regarding the PedsQL in male and female adolescent athletes. These normative scores provide clinicians with reference values that can be used to compare athlete scores pre- and/or post-injury to determine if the scores are within expected ranges. PedsQL scores below the normative value (mean) suggest that the athlete has lower HRQOL in the respective domain than the average adolescent athlete participating in that sport. Low PedsQL scores should be considered in an athletes care plan. Future research should measure the impact of sport-related injury on adolescent HRQOL. Funded by the National Athletic Trainers' Association Research and Education Foundation.

14330OONE

Females Demonstrate Decreased Hip Strength, Balance, And Functional Outcome Scores At Time Of Return To Sport Following Anterior Cruciate Ligament Reconstruction

Decker MN, Garrison JC, Bothwell J, Conway JE: Texas Health Ben Hogan Sports Medicine, Fort Worth, TX

Context: Gender differences have been seen in patients with knee pain before and after injury. It is unclear what differences are present at time of return to sport following anterior cruciate ligament (ACL) reconstruction. **Objective:** To determine if gender differences are present in strength, balance, and outcome scores at time of return to sport following ACL reconstruction. **Design:** Cross-sectional study design. **Setting:** Hospital-based outpatient sports medicine clinic. **Patients or Other Participants:** Fifty-one participants (26 males = 17.8 ± 4.9 y/o; 25 females = 16.8 ± 2.4 y/o) who were attempting to return to sport following ACL reconstruction. Each participant volunteered and was enrolled in the study during rehabilitation following ACL reconstruction. **Intervention(s):** Participants averaged two times per week in a formal rehabilitation process until the time of testing for return to sport (6.4 ± 1 months). At the time of testing, participants completed a battery of tests to determine readiness for return to sport that included components of hip abduction (HipAbd), extension (HipExt), and external rotation (HipER) strength, Y Balance Test™, and International Knee Documentation Subjective Knee Form (IKDC). **Main Outcome Measure(s):** Limb symmetry indices (LSI) were computed for HipAbd, HipExt, and HipER. Side to side differences (involved to uninvolved) were calculated for the Y Balance Test™ in the anterior, posteromedial, and posterolateral directions. One-way ANOVAs were performed to determine mean differences between groups for strength, balance, and

outcome scores with statistical significance set at $P < 0.05$. **Results:** Females ($97.8 \pm 9.7\%$) demonstrated significantly lower ($P = 0.045$) HipER strength indices than males ($104.4 \pm 12.8\%$). No significant differences were seen in HipExt (males: $101.8 \pm 11.4\%$, females: $105.7 \pm 10.3\%$, $P = 0.203$) or HipAbd (males: $105.1 \pm 17.3\%$, females: $102.1 \pm 10.3\%$, $P = 0.462$). For Y Balance Test, females (2.3 ± 2.5 cm) demonstrated greater ($P = 0.043$) side to side reach differences in the posterolateral direction than males (1.0 ± 1.8 cm). No significant differences were seen in the anterior (males: 1.2 ± 1.4 cm, females: 2.7 ± 3.7 cm, $P = 0.067$) or posteromedial (males: 1.0 ± 2.0 cm, females: 1.5 ± 1.5 cm, $P = 0.368$) directions. Outcome scores for the IKDC were significantly lower for females compared to males (males: 94.8 ± 5.3 , females: 91.0 ± 7.3 , $P = 0.38$). **Conclusions:** Females attempting to return to sport following ACL reconstruction exhibit decreased hip external rotation strength, Y Balance Test posterolateral reach distance, and lower patient reported outcome scores than their male counterparts. These deficits could inhibit a safe return to sport and may require further attention during the rehabilitation process.

The Relationships Between Upper Extremity Pain, Injury History, And Health-Related Quality Of Life Of Collegiate Baseball Players During Late-Season

Heichelbech MD, Lam KC, Bay RC, Sauers EL: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

Context: Collegiate baseball players suffer a large number of upper extremity (UE) injuries that lead to significant disability. However, the effect of present UE pain and UE injury history on health-related quality of life (HRQOL) during late-season has not been assessed in collegiate baseball players. **Objective:** To examine the relationships between present rating of UE pain, UE injury history, and region-specific HRQOL in collegiate baseball players during late-season. **Design:** Cross-sectional. **Setting:** Two collegiate athletic training facilities. **Patients or Other Participants:** Fifty healthy collegiate baseball players ($n = 24$ pitchers and 26 position players, $19.7 \pm .84$ years, 184.8 ± 6.3 cm, 86.4 ± 9.0 kg, 14.0 ± 2.2 years experience). **Intervention(s):** Present rating of UE pain, self-report UE injury history, and region specific HRQOL were assessed during the late-season. Correlational analyses were used to evaluate the relationship between UE present rating of pain, UE injury history, and 3 region-specific patient self-report scales. Spearman correlations were calculated to estimate the associations between variables ($p < .05$, two-tailed). **Main Outcome Measure(s):** A self-report questionnaire of present rating of UE pain (0- to-10) and UE injury history (+ or -) was used, and HRQOL was assessed via three region-specific patient self-report scales: The Disabilities of the Arm, Shoulder, and Hand (DASH) total score and sports module, the Kerlan-Jobe Orthopedic Clinic (KJOC) scale, and the Functional Arm Scale for Throwers (FAST) total score, subscales

(Throwing, Activities of Daily Living, Psychological, Advancement, Pain), and pitching module. **Results:** Forty-six percent (23/50) of respondents reported the presence of mild-to-severe pain of the UE. Present rating of pain scores for the shoulder demonstrated moderate-to-good correlations with the DASH total ($r = .61$, $P < .001$), DASH Sports Module ($r = .44$, $P < .001$), KJOC ($r = -.61$, $P < .001$), and FAST scales ($r = .47$ to $.68$, $P < .001$). Present rating of pain scores for the arm were also significantly correlated with the DASH total ($r = .32$, $P = .03$), DASH Sports Module ($r = .35$, $P = .01$), KJOC ($r = -.43$, $P = .002$), FAST total ($r = .43$, $P = .002$), and FAST subscales: Throwing ($r = .38$, $P = .007$), Activities of Daily Living ($r = .40$, $P = .007$), Psychological ($r = .39$, $P = .005$), Advancement ($r = .32$, $P = .02$) and Pitching Module ($r = .41$, $P = .003$). Sixty percent (30/50) of respondents disclosed a positive upper extremity injury history, of which 40% ($n = 12$) were considered "severe" (> 10 days of time loss). A positive history of upper extremity injury demonstrated fair correlation with the DASH Sport Module ($r = -.36$, $P = .01$), FAST total score ($r = -.35$, $P = .01$), FAST Throwing subscale ($r = -.32$, $P = .02$), and FAST Advancement subscale ($r = -.42$, $P = .002$), suggesting that a positive history of injury is related to a lower HRQOL. **Conclusions:** These data suggest that present UE pain and UE injury history are common among collegiate baseball players during the late-season. Despite full participation, collegiate baseball players may be experiencing pain or other impairments from past injuries that negatively impact their health status.

Establishing Pre-Season Self-Reported Functional Outcome Scores For The Knee, Shoulder, And Elbow In Athletes

Sciascia AD, Haegele L, Lucas J, Uhl TL: Shoulder Center of Kentucky, Lexington, KY, and University of Kentucky, Lexington, KY

Context: The goal of rehabilitation is to return the athlete to pre-injured levels; however, prospective pre-injured levels of function for athletes have not been documented. It is unknown if previously injured athletes perceive that they are functioning at optimal levels prior to the competitive season. **Objective:** To compare perceived measures of function between sexes and between athletes with and without a history of previous shoulder or knee injury. **Design:** Cross-Sectional Study. **Setting:** Pre-participation physical examinations at physician offices and athletic facilities. **Patients or Other Participants:** 875 high school and collegiate athletes (age 18 ± 2 years) comprised of 598 males and 276 females. **Intervention(s):** Participants were administered questionnaires after receiving medical clearance to participate in their sport during pre-season physical examinations. **Main Outcome Measure(s):** Self-reported function of athletes with and without a history of shoulder or knee injury as assessed by the Knee-Related Quality of Life section of the Knee Injury and Osteoarthritis Outcome Score (KOOSQL) and Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC). Both tools are scored from 0-100 (low function to high function). Non-parametric analysis was performed to determine if scores differed within and between sexes and history of injury. **Results:** 513 of 875 athletes reported a history of injury. 54 females reported previous shoulder injury and perceived their level of function via the KJOC (79 ± 20) lower than the 205 females (97 ± 4) with no previous shoulder injury ($p < .001$). 152 males reported previous shoulder injury and perceived their level of function (88 ± 17) lower than the 411 males ($97 \pm$

7) with no previous shoulder injury ($p < .001$). 84 females reported previous knee injury and rated their KOOSQL (76 ± 19) lower than the 189 females (96 ± 9) with no previous knee injury ($p < .001$). 151 males reported previous knee injury and rated their KOOSQL (83 ± 20) lower than the 437 males (98 ± 6) with no previous knee injury ($p < .001$). Males with previous shoulder injury perceived their level of function (88 ± 17) to be higher than females (79 ± 20) with previous shoulder injury ($p < .001$). Similarly, males with previous knee injury rated their KOOSQL (83 ± 20) higher than females (76 ± 19) with previous knee injury ($p = .007$). **Conclusions:** Although all athletes were medically qualified to participate in their respective sport, those athletes with a previous injury had a perception of function which was less than optimal. History of shoulder and knee injury negatively impacts self-perceived function with female athletes consistently reporting lower scores compared to male athletes. This decreased level of perceived function is not typically captured in the athletic environment but may provide valuable information to facilitate intervention prior to the start of the competitive season. This information provides a relative baseline of function for clinicians to use as a guide for return to competition.

Squatting Mechanics Between ACL-Reconstructed Patients Who Pass And Fail Return-To-Sport Criteria

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Context: Patients with Anterior Cruciate Ligament (ACL) reconstruction undergo a long rehabilitation period and are at increased risk of developing knee osteoarthritis. These patients often have biomechanical asymmetries during movement which persist for years following return-to-sport (RTS). Additionally, RTS criteria often focus on performance tests alone and this may be insufficient. **Objective:** To examine single leg squat biomechanics in subjects with ACL reconstruction based on passing or failing RTS criteria. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-six volunteers with unilateral ACL reconstruction (34 Patellar Tendon, 20 Hamstring, 12 Allograft) (168.5 ± 7.1 cm, 68.3 ± 11.8 kg, 19.0 ± 1.7 yrs, IKDC: 84.3 ± 10.4 ; 7 Males, 59 Females, 34.5 ± 18.4 months from surgery). **Intervention(s):** All individuals completed biomechanical testing of the single leg squat. Five squats were performed with the hands on the hips during a single testing session. Subjects were instructed to squat as deep as comfortable on their reconstructed limb while maintaining balance. An electromagnetic tracking system interfaced with force plates was used to capture hip, knee, and trunk kinematics and kinetics. Variables were captured at peak knee flexion which corresponds to the lowest portion of the squat. Subjects also completed single (SHD) and triple (THD) hop for distance on each limb and a subjective knee function assessment scale (IKDC). Limb symmetry indices (LSI) were calculated for each hopping task relative to the healthy limb ($LSI = (\text{Reconstructed Limb}/\text{Healthy Limb})100$). **Main Outcome Measure(s):** Subjects were placed into the PASS group if they met certain criteria while all others

were placed in the FAIL group. Subjects were placed into the PASS group if they: 1) scored > 90% LSI on the SHD only, 2) scored > 90% LSI on the THD only, and finally 3) have an IKDC score > 85 and SHD and THD > 90% LSI. Single leg squat biomechanics were compared between groups using these three different grouping methods. Independent t-tests were performed on each biomechanical variable of interest using each grouping method with significance set a-priori at $P < .05$. **Results:** When hop performance alone was used, only 7 (method 1) and 9 (method 2) subjects failed RTS testing and no differences in SLS kinematics or kinetics were observed ($p > .05$) between groups. However, when patient-oriented outcome was included with hop testing (method 3), 29 subjects passed while 37 failed. Subjects who failed had deficits in internal knee extension moment at peak knee flexion (PASS: $-.97 \pm .69$ Nm/kgm, FAIL: $-.63 \pm .65$ Nm/kgm, $P = .048$) and tended to have more femoral adduction (PASS: $13.6 \pm 11.3^\circ$, FAIL: $18.1 \pm 8.6^\circ$, $P = .06$). **Conclusions:** Including patient-oriented outcomes, such as the IKDC, in combination with functional testing to determine RTS status is more discriminating than hop testing alone. Clinicians should use a battery of exams when determining readiness for RTS in patients with ACL reconstruction. Funding: UW Graduate School and the Sports Medicine Classic Fund.

Normative Values For Health-Related Quality Of Life In Healthy And Injured Baseball And Softball Players Using A Region-Specific Patient Self-Report Scale: The Functional Arm Scale For Throwers (FAST)

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Context: Patient-rated outcomes scales that are population as well as region-specific are important for evaluating health-related quality of life (HRQOL). The Functional Arm Scale for Throwers (FAST) is a region-specific, patient self-report scale designed to measure the HRQOL of baseball and softball players with upper extremity (UE) injury. Establishing normative values for the FAST is important for clinical interpretation. **Objective:** To determine normative FAST scores for throwers with and without current upper extremity (UE) injury for level of play, sport, and position. **Design:** Descriptive. **Setting:** Multi-center data collection. **Patients or Other Participants:** Five-hundred fifty-seven subjects (age: 18.8 ± 2.2 years, experience: 10.7 ± 3.9 years) consisting of high school (HS) ($n = 257$) and college ($n = 300$) baseball ($n = 409$) and softball ($n = 148$) players, including pitchers ($n = 240$) and position players ($n = 317$). **Intervention(s):** Subjects completed the FAST and a self-report UE injury history questionnaire to categorize injury status (UE injury, healthy), level of play (HS, college), sport (baseball, softball), and position (pitcher, position player), which were used to categorize normative data. **Main Outcome Measure(s):** The FAST contains 22-items across five subscales (throwing, pain, advancement, ADLs, psychological) to produce a total score (FAST-TS) and a separate 9-item pitching module (FAST-PM). The FAST-TS, subscales, and the FAST-PM are scored from 0–100, with higher scores

suggesting lower HRQOL. Summary data for the FAST-TS and FAST-PM were obtained across categories and are reported as mean + standard deviation. **Results:** Normative values for baseball players with UE injury ($n = 93$) and healthy ($n = 302$) were: FAST-TS (34.7 ± 17.6 ; 7.5 ± 10.8 , respectively) and FAST-PM (53.8 ± 34.8 ; 7.1 ± 14.8 , respectively). Normative values for softball players with UE injury ($n = 46$) and healthy ($n = 97$) were: FAST-TS (31.0 ± 20.3 ; 6.6 ± 8.8 , respectively) and FAST-PM (45.5 ± 37.8 ; 7.6 ± 11.9). Normative values for HS throwers with UE injury ($n = 106$) and healthy ($n = 219$) were: FAST-TS (35.7 ± 17.6 ; 8.0 ± 10.7 , respectively) and FAST-PM (58.7 ± 37.0 ; 8.2 ± 15.3 , respectively). Normative values for college throwers with UE injury ($n = 106$) and healthy ($n = 180$) were: FAST-TS (32.8 ± 18.8 ; 6.5 ± 10.0 , respectively) and FAST-PM (50.5 ± 34.4 ; 6.0 ± 12.7 , respectively). Normative values for pitchers with UE injury ($n = 62$) and healthy ($n = 172$) were: FAST-TS (37.9 ± 18.5 ; 7.7 ± 11.0 , respectively) and FAST-PM (52.8 ± 35.0 ; 7.2 ± 14.2 , respectively). Normative values for position players with UE injury ($n = 77$) and healthy ($n = 227$) were: FAST-TS (30.0 ± 18.0 ; 7.0 ± 10.0 , respectively). **Conclusions:** Baseball and softball players with UE injury self-report diminished HRQOL on FAST-TS and FAST-PM. Baseball and softball players with UE injury report average FAST-TS above 31.0 and average FAST-PM score above 50.5, whereas the healthy throwers tend to have average FAST-TS and FAST-PM scores below 10.0. Further research to establish measurement properties of the FAST is required to determine how these scores change with treatment. Establishing normative values enhances the interpretability of the FAST for clinicians working with baseball and softball throwers.

Normative Data For The Multi-Dimensional Fatigue Scale (MFS) In Adolescent Athletes

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Context: Fatigue is an important factor that may be related to an increased risk of injury, overtraining, and is a common symptom of concussion. The Multidimensional Fatigue Scale (MFS) is a dimension-specific patient-rated outcome measure that evaluates general (GF), sleep (SF), and cognitive (CF) fatigue and may be of use in assessing the patient perspective in adolescent athletes. There are no available data regarding normative values associated with the MFS in adolescent athletes, which impedes interpretation of scale scores pre- and post-injury. **Objective:** To determine normative values for the MFS in adolescent athletes by male and female sports. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of interscholastic adolescent athletes (males: $n = 3254$; females: $n = 890$) participating in football (males: $n = 2068$), wrestling (males: $n = 183$), cheer (females: $n = 83$), soccer (males: $n = 220$; females: $n = 235$), basketball (males: $n = 279$; females: $n = 188$), or baseball/softball (males: $n = 504$; females: $n = 384$) were included. **Intervention(s):** Participants were grouped according to male and female sports (ie, football, wrestling, cheer, soccer, basketball, and baseball/softball). Participants completed the MFS during one testing session at the start of their respective sport season. **Main Outcome Measure(s):** Dependent variables included the MFS GF, SF, and CF subscales. Descriptive statistics [means, standard deviation (SD), and range] were used to report normative total and subscale scores per sport and are reported as mean \pm SD, range. The MFS is scored on a scale of 0-100 with lower scores indicating a greater impact of fatigue on quality of

life. **Results:** Normative values for football were: GF = 86.2 ± 15.2 , 4.17-100; SF = 74.2 ± 18.0 , 0.0-100; CF = 84.4 ± 17.4 , 0.0-100. Normative values for wrestling were: GF = 85.3 ± 15.9 , 37.5-100.0; SF = 75.4 ± 18.3 , 25.0-100.0; CF = 84.0 ± 18.9 , 16.7-100.0. Normative values for cheer were: GF = 86.6 ± 15.5 , 29.2-100; SF = 73.0 ± 17.7 , 16.7-100.0; CF = 84.5 ± 17.6 , 29.2-100.0. Normative values for soccer were males: GF = 90.6 ± 12.0 , 45.8-100; SF = 80.8 ± 16.7 , 25.0-100; CF = 90.4 ± 13.3 , 33.3-100 and females: GF = 86.1 ± 16.2 , 0.0-100; SF = 75.4 ± 18.1 , 16.7-100; CF = 84.1 ± 18.3 , 0.0-100. Normative values for basketball were males: GF = 86.8 ± 15.3 , 16.7-100; SF = 74.6 ± 17.4 , 16.7-100; CF = 86.9 ± 16.8 , 12.5-100 and females: GF = 85.1 ± 15.8 , 20.8-100; SF = 74.0 ± 19.2 , 16.7-100; CF = 84.0 ± 17.3 , 12.5-100. Normative values for baseball/softball were males: GF = 88.2 ± 13.8 , 16.7-100; SF = 76.6 ± 17.3 , 29.2-100; CF = 86.7 ± 16.6 , 25.0-100 and females: GF = 86.5 ± 15.5 , 8.33-100; SF = 74.8 ± 17.7 , 4.17-100; CF = 83.9 ± 17.5 , 20.8-100. **Conclusions:** Our results provide the first report on normative data regarding the MFS in male and female adolescent athletes. These scores provide a reference value when reviewing athlete scores pre- and/or post-injury to determine whether scores are within expected ranges. In general, adolescent athletes, regardless of sport, scored in the highest quartile of MFS scores with the lowest scores reported for the sleep fatigue subscale. Increasingly, there is value in understanding the patient perspective as it relates to overall health. Because of the potential for fatigue to impact injury risk, present with over training, or emerge as a concussion symptom, efforts to evaluate fatigue over time may be beneficial in the healthcare of athletes. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Development Of A Patient-AT Trust Instrument

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Context: The patient clinician relationship plays a significant role in patient perception and involvement in treatment. Trust between the patient and clinician is at the core of this relationship and has been linked to increased adherence and better outcomes. We have previously qualitatively defined and identified the components of trust in the athletic training setting. Despite the positive influence of trust, there is no measure designed to quantify patient trust in athletic trainers. **Objective:** The purpose of this study was to develop a psychometrically sound patient-AT trust instrument for the athletic training setting. **Design:** Multiphase. **Setting:** A quiet room. **Patients or Other Participants:** A total of 150 Division I collegiate athletes ($n = 75$ per iteration) Age M \pm SD = 20.76 yrs. \pm 2.24) from a variety of sports (i.e., football, basketball, softball, diving, baseball, soccer, swimming, etc.) who had received services from an AT volunteered for the study. **Data Collection and Analysis:** Participants completed the instrument either through paper and pencil or Qualtrics. Items were created based on a blueprint produced by content experts. Acceptable items were retained while items that did not fit were reworded. Response options were evaluated using the Linacre's Heuristic Guidelines. Data were analyzed using the Rasch rating-scale model and model-data fit was evaluated using in-fit and outfit statistics (<0.5 and >1.5). Item and person separation and reliability were also evaluated. The Wright item-person map was visually examined. Item difficulty and participants' ability estimates were also calculated. Convergence with the Working Alliance Inventory and Patient-centeredness Survey was used to validate the instrument. **Results:** The optimization categorization indicated five response

options were appropriate based on the guidelines including proper ordering and each option most probable somewhere on theta. After two iterations, Rasch calibration yielded 25/28 items that fit the model. The Wright item-person map revealed that participant's levels were widely distributed ($M \pm SD = 0.00 \pm 0.47$ logits) and the items showed acceptable spread (0 ± 0.67 logits). Item difficulties ranged from -0.71 (easiest) to 1.46 (hardest). The easiest item on the instrument was related to building a relationship while the hardest item was related to the athletic trainer's ability to effectively communicate through writing. The separation index for the items was 2.40 with a reliability of 0.85 while the separation index for the persons (theta) was 3.08 with a reliability of 0.90. The Patient-AT Trust Instrument was significantly correlated with Working Alliance Inventory ($r = 0.93$; $p < .01$) and moderately correlated with the Patient Adherence Scale ($r = 0.64$; $p < .01$). **Conclusions:** The patient-AT Trust instrument is able to quantify trust between the patient and their athletic trainer. It also appears to be able to distinguish between levels of trust.

Test-Retest Reliability And Minimal Detectable Change Of The Disablement In The Physically Active Scale In Collegiate Soccer Athletes
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Context: The Disablement in the Physically Active (DPA) scale is a generic patient-reported outcome instrument (PRO) used in the clinical setting to assess health-related quality of life (HRQOL) in physically active patients. In order to determine clinically meaningful changes in health status when using the DPA in collegiate athletes with a history of lower extremity injury, the test-retest reliability and minimal detectable change (MDC) must be determined. **Objective:** To determine the test-retest reliability and the MDC of the DPA in collegiate soccer athletes with a history of lower extremity injury. **Design:** Reliability. **Setting:** Athletic facility. **Patients or Other Participants:** Fifteen Division I soccer athletes (7 males, 8 females, height: 176.3 ± 10.3 cms, mass: 69.5 ± 10.3 kgs, age: 19.7 ± 1.0 yrs) participated. Subjects were included if they were current members of the soccer team, cleared to participate in the 2013 spring season, had a history of lower extremity (knee and/or ankle) injury, and were free of knee and/or ankle injury when completing the DPA at the beginning of the study. **Intervention(s):** One week before the start of the spring season (TI) participants completed the DPA. One week later, on the first day of the spring soccer season (TII), the participants completed the DPA a second time. Data collection sessions occurred on the same day of the week and at approximately the same time of the day. **Main Outcome Measure(s):** The DPA is a 16-item generic PRO with scores ranging from 0-64. A Likert scale is used for each of the questions, with the scale ranging from 'no problem' to 'severe'. A higher score on the DPA represents

greater disablement. The dependent variables were the scores on the DPA, and the independent variable was time (TI and TII). Mean (\pm standard deviation) for the DPA at each of the time points was calculated. Test-retest reliability was determined using the intraclass correlation coefficient (2,1) and standard error of measurement (SEM). An ICC value ≥ 0.75 was considered acceptable for clinical implementation. MDC was calculated with a 95% level of confidence using the equation: $SEM1.96\sqrt{2}$. **Results:** Average scores on the DPA were $10.8 (\pm 9.9)$ for TI and $9.3 (\pm 10.1)$ for TII. The test-retest reliability was ICC2, 1 = 0.86 with a SEM of 3.8 points. The MDC for the DPA was 10.5 points. **Conclusions:** The DPA is a generic PRO instrument that can be utilized in the clinical setting to assess HRQOL in athletes with a history of lower extremity injury. The DPA demonstrated strong test-retest reliability for use in collegiate soccer athletes with a history of lower extremity injury. A change of ± 11 points is needed to identify a meaningful change when using the DPA in clinical practice.

Athletes' Perceptions Of The Motivational Climate In The Athletic Training Room: Goal Orientation Differences

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Context: In the rehabilitation setting, continued motivation and adherence is an important issue. The motivational climate within the rehabilitation context could potentially influence athletes' motivation, adherence, and ultimately, their ability to return to play. However, mastery and performance motivational climates have yet to be examined within the realm of rehabilitation. Additionally, differences in the athletes' own goal orientation could influence their interpretation of the rehabilitation climate.

Objective: The purpose of this study was to determine if athletes' goal orientation influences perceptions of the motivational climate in the rehabilitation setting. **Design:** A survey, with multiple assessment tools designed to assess athletes' perceptions of the motivational climate and individual goal orientation. **Setting:** Surveys were administered in either the athletic training room or individual athletic field/locker room. **Patients**

or Other Participants: A total of 200 male (n = 92) and female (n = 108) intercollegiate athletes participated. About 90% of participants reported having received treatment/rehabilitation services from their athletic trainer. **Intervention(s):** Previously validated measured assessed athletes task and ego goal orientations and perceptions of the motivational climate. All measures demonstrated adequate reliability with alphas ranging from .72-.92. **Main Outcome**

Measure(s): Athletes were first grouped based on task and ego goal orientation z-scores. A MANOVA was then conducted comparing the groups of athletes of varying task-ego orientations on their perceptions of mastery climate (cooperative learning, effort/improvement, important role) and performance climate (intra-team member rivalry, unequal recognition, punishment for

mistakes). **Results:** Significant differences emerged for perceptions of the motivational climate for individual goal orientation (Wilks' $\lambda = .57$, $F(15, 359.27) = 5.34$, $p < .0001$, $ES = 43\%$). Significant differences were found for each of the motivational climate subscales. Post-Hoc Tukey test revealed: (a) high task – low ego athletes had significantly higher perceptions of cooperative learning compared to low task – high ego athletes, (b) both high task groups had significantly higher effort/improvement perceptions than both low task groups, and (c) high task – low ego athletes had significantly higher perceptions of important role compared to all other groups of athletes. Additionally, goal orientation differences existed on performance motivational climate perceptions, (a) low task – high ego athletes had significantly higher perceptions of unequal recognition compared to all other groups, and (b) high task – low ego goal orientation athletes had significantly lower perceptions of punishment for mistakes compared to all other groups of athletes. **Conclusions:** Different types of the motivational climate seem to be present in the rehabilitation setting. Athletes' individual goal orientations also seem to influence the athletes' perception of the motivational climate.

Changes in Self-Reported Outcome Measures Following Platelet-Rich Plasma Injection for the Treatment of Medial Epicondylopathy

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Context: Overuse of the elbow and wrist can lead to tendinopathy of the common flexor tendon (medial epicondylopathy). Platelet-Rich Plasma (PRP) injection therapy has been proposed as a supplemental treatment to alleviate pain, improve function, and augment tendon healing in patients who do not receive pain relief or return of normal elbow function after conservative treatment (NSAIDs, rest, therapy including eccentric strengthening, iontophoresis, bracing, or cryotherapy). There is currently limited evidence to support the use of PRP injection therapy for medial epicondylopathy. **Objective:** To document changes in self-reported upper extremity pain, function, and Health Related Quality of Life (HRQOL) in patients treated with a single intratendinous PRP injection for medial epicondylopathy. **Design:** Case series, Level IV. **Setting:** Outpatient sports medicine clinic. **Patients or Other Participants:** Eleven consecutive patients (9 males, 2 females; age=50.9±12 years) with physical examination and imaging confirmed chronic medial epicondylopathy who were treated with a single intratendinous injection of PRP were studied. All participants had failed ≥3 months of conservative treatments. **Interventions:** All patients received a single intratendinous PRP injection at the origin of the common flexor tendon. Patients completed two region specific self-reported outcome measures, QuickDash (QD) and Patient Rated Elbow Evaluation (PREE), and a generic HRQOL measure, Short Form-12

v2.0 (SF-12) at pre-injection and specific intervals post-injection. The QD contains 11 items to measure physical function and symptoms in patients with upper limb musculoskeletal conditions. QD scores range from 0-100, with lower scores representing higher levels of function. The PREE contains 20 items to measure pain and disability on a 0-100 scale, with higher scores indicating greater pain and disability. The SF-12 contains 12 items and can produce a Physical Component Score (PCS) and a Mental Component Score (MCS). United States population MCS and PCS norm-based scores for the SF-12=50±10 with higher scores indicating greater HRQOL. **Main Outcome**

Measures: The primary outcome variables were the paired differences (Mean±SD) in the scores of the QD, PREE, PCS, MCS between pre-injection and post-injection assessed using the Wilcoxon Signed-Rank test. **Results:** Average post-injection follow up was 44.7±10.1 weeks. QD post-injection scores were significantly lower than pre-injection ($p = 0.037$; pre = 36.98 ± 20.6, post = 26.86 ± 23.4). PREE post-injection scores were significantly lower than pre-injection ($p = 0.037$; pre = 31.45 ± 16.86, post = 21.70 ± 22.79). There was no difference in the MCS scores ($p = 0.212$; pre = 53.84 ± 13.97, post = 57.77 ± 6.69) or in the PCS scores ($p = 0.212$; pre = 41.28 ± 7.42, post = 44.34 ± 8.85). **Conclusions:** In patients who failed conservative treatment for medial epicondylopathy, PRP injection therapy resulted in significantly improved upper extremity and elbow specific pain and function but did not result in overall HRQOL improvement. Intratendinous PRP injection therapy should be considered a viable treatment option for patients with medial epicondylopathy who do not respond to conservative treatment.

Free Communications, Poster Presentations: Validity of Clinical Tests

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

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Test-Retest Reliability And Concurrent Validity Of A Region-Specific Patient Self-Report Scale In Baseball And Softball Players: The Functional Arm Scale For Throwers (FAST)

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Context: Upper extremity (UE) pain and injuries in baseball and softball players result in diminished health-related quality of life (HRQOL). The Functional Arm Scale for Throwers (FAST) is an 22-item UE region-specific patient self-report scale designed for use with overhead throwers with a separate 9-item pitching module scored from 0 – 100, with higher scores representing lower HRQOL. The reliability and validity of the FAST must be established prior to recommending its use. **Objective:** To examine test-retest reliability and concurrent validity of the FAST in baseball and softball players. **Design:** Repeated measures and cross-sectional. **Setting:** Multiple patient clinics contributed data. **Patients or Other Participants:** Five-hundred fifty-seven subjects (18.8 ± 2.2 years of age, 10.7 ± 3.9 years experience) consisting of high school ($n=257$) and college ($n=300$) baseball ($n=409$) and softball ($n=148$) athletes. Among subjects, 240 were pitchers and 317 were position players; 142 were currently injured and 415 were not currently injured. **Intervention(s):** For the test-retest component, subjects completed the FAST during two separate testing sessions that were conducted between 3 and 7 days apart (average = 4.5 ± 2.4 days). Reliability was estimated using ICC (2,1) and SEM among those who reported no change in status. Concurrent validity was evaluated using correlational analyses (r) for subsets of data (ranging between $n=50$ and $n=104$), comparing the FAST to two validated, region-specific patient self-report scales. **Main Outcome Measure(s):** The FAST total score (FAST-TS), FAST

subscales (throwing, activities of daily living, psychological, advancement, pain), and pitching module (FAST-PM), were compared across two repeated measures (test-retest reliability) and to two reliable and valid UE region-specific patient self-report scales (concurrent validity): The Disabilities of the Arm, Shoulder, and Hand (DASH) total score (DASH-TS) and sport module (DASH-SM), and the Kerlan-Jobe Orthopedic Clinic (KJOC) scale. **Results:** The FAST-TS (ICC = 0.97; SEM = 3.8), FAST-PM (ICC = 0.98; SEM = 5.7), and FAST subscales (ICC = 0.91 to 0.97; SEM = 4.3 to 6.1) all demonstrated excellent test-retest reliability. The FAST-TS demonstrated high correlations with the DASH-TS ($n=104$, $r=.71$) and DASH-SM ($n=94$, $r=.58$) and the KJOC ($n=50$, $r=-.74$). The FAST-PM demonstrated moderate correlations with the DASH-TS ($n=104$, $r=.48$) and DASH-SM ($n=94$, $r=.49$) and the KJOC ($n=50$, $r=-.54$). Each of the FAST subscales demonstrated moderate to high correlations to the DASH-TS ($n=104$, $r=.48$ to $.79$) and DASH-SM ($n=94$, $r=.42$ to $.57$) and the KJOC ($n=50$, $r=-.50$ to $-.75$). All correlations were statistically significant, $p < 0.001$. **Conclusions:** The FAST UE region-specific patient self-report scale possesses excellent test-retest reliability and excellent concurrent validity when compared to the DASH-TS, DASH-SM, and the KJOC. These findings suggest that the FAST may be valuable for measuring patient-rated healthcare outcomes in throwers with UE injuries. Clinicians and researchers should consider using this patient-rated outcomes measure to evaluate the HRQOL of throwers with UE injuries.

Intra- And Intertester Reliability Of The Dr Goniometer iPhone/iPad App At The Knee Joint

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Context: Standard goniometry (SG) measurements have demonstrated inconsistent and sometimes unreliable results encouraging the use of alternative methods of consistently assessing range of motion (ROM). One such option is through the use of iPhone applications. **Objective:** To determine intra- and intertester reliability of knee flexion (KF) and extension (KE) active range of motion (AROM) using the iPhone/iPad paid application, Dr.Goniometer (CDM SrL, Cagliari, Italy) on an iPhone in healthy subjects. **Design:** Test-retest reliability study. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Thirty-nine healthy (males = 16, females = 23) college-aged participants, (age = 20.5 ± 1.1 years; height = 171.6 ± 8.5 cm; mass = 74.3 ± 16.7 kg) free of dominant side lower extremity injuries and surgery/pain for 6 months were analyzed by four testers. **Intervention(s):** Participants were supine for a single session measurement of KE and KF AROM by two independent raters (not blinded) using the subjects' dominant leg (used to kick a ball). To control measurement error, a PVC frame was placed at the pelvis to maintain a 90° hip joint angle. Measurements were counterbalanced to control effect bias. Subjects maximally flexed and extended the knee while maintaining a 90° hip joint angle to collect AROM. The app landmarks included: lateral epicondyle (axis), greater trochanter (stationary arm), and lateral malleolus (moveable arm). Once maximal joint movement was obtained a digital image using the app was recorded on a 16gb iPhone 4 (Apple, Cupertino, CA). ROM was calculated using images from one iPhone via the app by manipulating three markers so a crosshair was placed over the landmarks above. No visual markers were used to

identify the landmarks. To maintain proper positioning the app provided a dotted line connecting the individual reference points to ensure alignment. Four different testers (2-certified athletic trainers, 2-athletic training students) measured each image on three separate occasions, one week apart. **Main Outcome Measure(s):** KE and KF AROM. Intraclass correlation coefficients (ICC) determined intra- (ICC2,1) and inter-tester (ICC2, 3) reliability. Person Correlation Coefficients were calculated to determine the relationship between athletic training students and certified athletic trainers mean KE and KF ROM scores. Alpha level was set a priori at $p < 0.05$. **Results:** ICC measurements for intratester reliability values were high, ranging between 0.950-0.993 (95% confidence interval [CI]: .901, .996) for KE and 0.888-0.978 (95% CI: .799, .988) for KF. Intertester reliability values were also high, 0.994 (95% CI: .990, .997) for KE and 0.980 (95% CI: .963, .989) for KF. **Conclusions:** Results demonstrated that the app, Dr.Goniometer had both high intra- and intertester reliability when measuring AROM for knee extension and flexion. These results combined with a previous study suggest that the Dr.Goniometer iPhone/iPad app is a viable option for assessing knee AROM in healthy subjects. Further research is needed to validate the use of Dr.Goniometer in unhealthy subjects.

Intra-Rater And Inter-Rater Reliability Of The Posterior Talar Glide Test

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Context: The posterior talar glide test (PTGT) is used to assess arthrokinematic restrictions in posterior glide of the talus in patients with a history of ankle injury. The reliability of the PTGT is unknown making it unclear whether clinicians can rate performance consistently over time or if multiple clinicians produce similar results. **Objective:** To examine the intra-rater and inter-rater reliability of the PTGT. **Design:** Reliability. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-three physically active adults (7 males, 16 females, age = 22 ± 1.75 yrs, height = 170.62 ± 10.26 cm, mass = 71.95 ± 12.8 kg) volunteered to participate. All participants had no lower extremity injury within the previous six months or surgeries within the past year. Two Athletic Trainers (certified < 1 yr) with no prior PTGT experience served as the raters and underwent three hours of training with an experienced clinician. **Intervention(s):** All participants reported to the laboratory for two sessions separated by one week. During each session, each rater performed the PTGT on the left and right limb of each participant. To perform the PTGT, participants were seated with their hips and knees at 90° of flexion off the end of an examination table. Each rater positioned an inclinometer proximal to the lateral malleolus in the sagittal plane and placed both thumbs over the talar window and their fingers over the plantar aspect of the foot. The foot was placed into subtalar neutral while the rater gradually glided the talus posteriorly while maintaining the foot in a position parallel to the floor until a firm capsular end-feel was encountered. Once this restriction was identified, a third investigator documented the angle of tibial inclination. Following a practice trial, three trials of the PTGT were

performed on each limb and averaged for analysis. The order of rater and limb was counterbalanced. Raters were blinded to all PTGT results. **Main Outcome Measurement(s):** The independent variables were session and rater. The dependent variable was the average tibial inclination ($^\circ$). Intraclass correlation coefficients (ICC2,3) and standard error of measurement (SEM) were calculated to determine intra-rater and inter-rater reliability. Minimal Detectable Change (MDC) at the 95% confidence level was calculated to examine the responsiveness of the PTGT. **Results:** Intra-rater reliability for Rater 1 ranged from ICC2, 3 = 0.56 (SEM = 1.59° , MDC = 4.41°) to ICC2, 3 = 0.60 (SEM = 1.36° , MDC = 3.78°). Intra-rater reliability for Rater 2 ranged from ICC2, 3 = 0.31 (SEM = 1.64° , MDC = 4.54°) to ICC2, 3 = 0.53 (SEM = 1.69° , MDC = 4.67°). Inter-rater reliability for Session 1 ranged from ICC2, 3 = 0.46 (SEM = 1.31° , MDC = 3.63°) to ICC2, 3 = 0.81 (SEM = 1.13° , MDC = 3.12°). Inter-rater reliability for Session 2 ranged from ICC2, 3 = 0.77 (SEM = 1.08° , MDC = 3.00°) to ICC2, 3 = 0.78 (SEM = 1.08° , MDC = 3.00°). **Conclusions:** The PTGT demonstrated poor-to-moderate intra-rater reliability; as well as, poor-to-good inter-tester reliability when measured in healthy adults and performed by recently credentialed Athletic Trainers. The MDC values indicate that changes in the PTGT exceeding $\pm 5^\circ$ are clinically relevant. Overall, the PTGT demonstrates acceptable inter-rater reliability but unacceptable intra-rater reliability for use in clinical practice.

The Development And Assessment Of Core Strength Clinical Measures: The Reliability And Validity Of Medicine Ball Toss Tests

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Context: Core strengthening has become a significant focus in physical fitness, performance training, injury prevention, and rehabilitation as it may optimize athletic performance, reduce risk of injury, and facilitate return from injury. Reliable and valid clinical measures of core strength are necessary to determine the effectiveness of injury prevention, rehabilitation, and performance optimization programs. **Objective:** The purpose of this study was to determine the reliability and validity of three medicine ball toss tests (MBTs). **Design:** A descriptive study design was utilized to determine validity of MBTs compared to tests of isokinetic strength, and intersession test-retest reliability. **Setting:** All isokinetic strength variables were collected in a laboratory setting; medicine ball variables were collected in an athletic facility. **Patients or Other Participants:** A total of 20 healthy and physically active males and females (Age: 22.7 ± 7.8 years, Height: 164.8 ± 25.7 cm, Weight: 71.0 ± 12.3 kg) participated. Testing occurred in two sessions separated by a minimum of 24 hours. **Intervention(s):** During session one, isokinetic testing was performed followed by MBTs. Concentric-concentric isokinetic strength testing for torso flexion, extension, and bilateral rotation, was performed at 60 degrees per second for five repetitions. Subjects performed five MBTs in forwards, backward, and right/left rotation directions; the order was randomized using a Latin square design. Subjects performed only the MBTs in session two. The MBTs were developed to be field-friendly and minimize the contribution of the extremities. **Main Outcome Measure(s):** Average peak torque was assessed for isokinetic strength. Average

distance of the first three successful MBTs in each direction were utilized for analysis. Pearson correlations were calculated between MBTs in session one and the corresponding isokinetic strength measure to assess validity of the MBTs. Intraclass correlation coefficients (ICC) were calculated to determine the reliability of the MBTs between sessions.

Results: No significant correlations were observed between the forward, backward, and rotational MBTs and corresponding measures of isokinetic strength ($r = -0.047$, $p = 0.845$; $r = -0.074$, $p = 0.756$; $r = 0.051$, $p = 0.832$ (right); $r = 0.180$, $p = 0.447$ (left), respectively). Significant intraclass correlations were observed between session one and two MBTs (ICC = 0.835, CI: 0.600-0.934; ICC = 0.835, CI: 0.598-0.934; ICC = 0.870, CI: 0.660-0.949 (right); ICC = 0.909, CI: 0.742-0.966 (left); $p < 0.001$, respectively). **Conclusions:** These results illustrate that MBTs have excellent reliability but are not related to isokinetic strength measures as measured by average peak torque. This lack of relationship could be due to differences in muscles examined, muscle contraction type, and/or motion performed. Future research should focus on determining what these MBTs truly measure as well as finding a field-friendly measure that is valid against isokinetic strength testing, while also being reliable.

Validity And Reliability Of Clinical Tests For Humeral Torsion

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Context: Humeral torsion is the rotation about the humerus in overhead athletes that may contribute to shoulder injury. Humeral torsion is commonly assessed through computed tomography or ultrasound imaging (US), which can be costly and may not be accessible for clinicians. Currently, no valid or reliable clinical test exists to measure humeral torsion. The ability to implement clinical testing for humeral torsion may allow clinicians to identify athletes at risk for shoulder injury. **Objective:** To observe the reliability of three clinical tests and to assess the validity of each test to US. **Design:** Descriptive Laboratory Study. **Setting:** Research laboratory. **Patients or Other Participants:** Sixty shoulders from thirty healthy individuals with a history of overhead athletic participation (12 male, 18 female; sport: 11 volleyball, 6 tennis, 9 baseball, 4 softball; age: 20 ± 2 years; height: 174.24 ± 9.35 cm; mass: 70.53 ± 11.06 kg; body mass index: 23.13 ± 2.47 kg/m²; years in sport: 9 ± 4 years). **Intervention(s):** An average of three trials using the bicipital tuberosity palpation at 90 degrees (Palp90), the bicipital tuberosity palpation at 45 degrees (Palp45), horizontal adduction test (HADD), and US were observed bilaterally with the individual on a standard plinth by tester one using a digital inclinometer. Tester two then completed Palp90, Palp45 and HADD measurements. **Main Outcome Measure(s):** Interrater and intratester intraclass coefficients (ICC) and 95% confidence intervals (95%CI) were used to measure reliability for humeral torsion angles. Pearson's r correlation coefficients were used to identify relationships between clinical tests and US measures. **Results:** Mean humeral torsion angles ranged from 22° of external rotation (ER) to 8° of internal rotation (IR) from the vertical axis (tester 1: US: 2° ER

$\pm 15^\circ$; Palp90: 3° ER $\pm 10^\circ$; Palp45: 4° IR $\pm 9^\circ$; HHT 19° ER $\pm 8^\circ$, tester 2: Palp90: 6° IR $\pm 9^\circ$; 8° IR $\pm 8^\circ$; 22° ER $\pm 6^\circ$). Intratester reliability was excellent for US (ICC = 0.907, 95% CI: 0.862-0.940) and all clinical tests (tester 1: Palp90: [ICC = 0.857, 95% CI: 0.791-0.907]; Palp45: [ICC = 0.884, 95% CI: 0.827-0.925]; HADD: [ICC = 0.816, 95% CI: 0.735-0.878], tester 2: Palp90: [ICC = 0.847, 95% CI: 0.778-0.900]; Palp45: [ICC = 0.909, 95% CI: 0.864-0.941], HADD: [ICC = 0.769, 95% CI: 0.672-0.845]). Intertester reliability for each clinical test was poor (Palp90: [ICC = 0.256, 95% CI: 0.0-0.529]; Palp45: [ICC = 0.419, 95% CI: 0.057-0.646]; HADD: [ICC = 0.243, 95% CI: 0.0-0.537]). Significant Pearson's r correlation coefficients were observed for the Palp90 ($r = 0.326$, $p = 0.011$), but not for the Palp45 ($r = 0.171$, $p = 0.192$) or the HADD test ($r = -0.218$, $p = 0.095$). **Conclusions:** Although the clinical measurement techniques to assess humeral torsion were reliable within testers, comparisons between testers did not agree. Since these measures are based on clinical application, administration of each test could vary between testers. When using clinical tests for humeral torsion, additional strategies should be incorporated to limit variability between testers.

Intra-Rater And Inter-Rater Agreement Of The Intrinsic Foot Muscle Test

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Context: Intrinsic foot muscle weakness may be associated with overuse foot injuries, however, there are a lack of objective measurements that allow for assessment of intrinsic foot muscle function. The intrinsic foot muscle test (IFMT) is a test purported to clinically identify intrinsic foot muscle weakness. The reliability of the IFMT is unknown making it unclear whether a clinician can rate performance consistently over time or if multiple clinicians can produce similar results. **Objective:** To examine the intra-rater and inter-rater agreement of the IFMT within two novice raters. **Design:** Reliability. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-five healthy, physically active adults (16 females, 9 males, age: 22.4 ± 1.7 years, height: 170.8 ± 10.2 cm, mass: 73.5 ± 12.8 kg) volunteered to participate. All participants were free of lower extremity injury within the previous six months and foot or ankle surgeries within the past year. Two Athletic Trainers (certified < 1 yr) with no prior IFMT experience served as the novice raters, and underwent approximately three hours of training prior to data collection. **Intervention(s):** All participants completed two data collection sessions separated by one week. During each session, intrinsic foot muscle function was assessed bilaterally by each rater using the IFMT. The IFMT consisted of performing 30 seconds of single-limb stance while attempting to maintain the medial longitudinal arch without utilizing extrinsic foot muscles. Verbal instructions and a demonstration were given to each participant by Rater 1. For each limb all participants performed one practice

trial and one trial for data analysis, for a total of two trials at each data collection session. The IFMT was rated simultaneously by both raters during each trial. Both raters were blinded to the other rater's results. **Main Outcome Measure(s):** Each rater simultaneously assessed errors during the IFMT including: lifting toes off of the ground, curling toes, or changes in navicular height. Participants were scored as "poor" if errors were committed for a majority of the trial, "fair" if at least one error occurred for less than half of the trial, and "satisfactory" if no errors occurred during the trial. The independent variables were session and rater. The dependent variable was the IFMT score. Kappa coefficients (κ) were calculated to determine the intra-rater and inter-rater agreement of IFMT results. Coefficients ≥ 0.8 were considered acceptable for clinical implementation. **Results:** Intra-rater agreement for the left foot ($\kappa = -0.06-0.41$) and for the right foot ($\kappa = -0.03-0.12$) ranged from slight-to-fair. Inter-rater agreement ranged from fair-to-moderate for the left foot ($\kappa = 0.25-0.51$) and was moderate for the right foot ($\kappa = 0.55-0.60$). **Conclusions:** Intra- and inter-rater agreement for the IFMT demonstrated slight-to-moderate agreement suggesting the IFMT is not suitable for implementation within clinical practice at this time. Future research is needed to determine a more reliable method of measuring intrinsic foot muscle weakness to improve evaluation techniques and patient care.

A Comparison Of 2-Dimensional Measurements Of Knee Abduction In A Clinical Setting

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Context: The quantification of knee movement from 2-Dimensional video can be performed using multiple methods; a comparison of these methods utilizing data collected outside of a laboratory has not been performed. Frontal Plane Projection Angle (FPPA) has been used to identify knee abduction in 2-dimensional video by measuring the angle created by two lines established between the estimated joint centers of the ankle and knee and the knee and hip. Knee/ankle ratio has also been used to describe motion at the knee by measuring the distance between the knee and the ankle and calculating the ratio of these measurements. **Objective:** Establish the relationship between results of FPPA and knee/ankle ratio analysis from data collected by clinicians. **Design:** Cross sectional study. **Setting:** High school. **Patients or Other Participants:** Video of 60 DVJ landings were randomly selected from high school age athletes (age 15.6 ± 1.2 yrs., height $1.67 \pm .14$ m, weight 69.2 ± 14.1 kg.) **Intervention(s):** Data were collected as part of an ongoing study using a GoPro digital camera capturing at 60 hz, 1280x720 pixels, and set 186 cm away from the participant. The participant performed a drop vertical jump from a 30 cm box. The video was then transferred to VirtualDub and the frame in which peak knee flexion was achieved was isolated. This image was analyzed in ImageJ to calculate the FPPA and knee/ankle ratio for each. **Main Outcome Measure(s):** The FPPA was calculated from the estimated joint centers of the hip, knee ankle and the distance from the joint centers of the knee and ankle were calculated to determine the ratio of inter-knee distance to inter-ankle distance. Pearson correlations were

conducted and an a priori alpha of .05 was selected. **Results:** Right knee FPPA ($r^2 = .715$, $p < .001$, mean -14.9 , 95% CI -21.9 , -7.9) and left knee FPPA ($r^2 = .755$, $p < .001$, mean -15.8 , 95% CI -22.4 , -9.2) account for a large portion of the variability of the knee/ankle ratio (mean 1.14, 95%CI 1.08, 1.2). **Conclusions:** FPPA and knee/ankle ratio are comparable measures of knee abduction angle. FPPA measurements account for a large portion of the variability of knee/ankle ratio in both the right and left leg. Previous research in landing mechanisms has focused on asymmetry of knee motion when landing. The use of knee/ankle ratio does not allow for analysis of knee abduction asymmetry. Previous research reports the knee/ankle ratio accounted for a higher variance of the results from 3-dimensional motion analysis than FPPA. The high correlation indicates the FPPA measurement method is comparable to the knee/ankle ratio and can be used to obtain the knee motion asymmetry as well as abduction angles.

Three-Minute All-Out Test As A Diagnostic Challenge For Exercise-Induced Dyspnea: A Pilot Study

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Context: Exercise testing for exercise-induced dyspnea (EID) often fails to exacerbate symptoms in trained athletes. A valid and reliable high-intensity exercise challenge appropriate for a clinical setting would benefit athletic healthcare providers evaluating EID. A challenge that could discriminate among common diagnoses could expedite appropriate interventions. **Objective:** The objective of this study was to evaluate the efficacy of the three-minute all-out cycle ergometer test (3MT) in ambient air as a diagnostic challenge for EID. Our hypotheses were: 1) the 3MT exacerbates respiratory conditions, including exercise-induced bronchoconstriction (EIB) and exercise-induced laryngeal obstruction (EILO); and 2) 3MT will demonstrate agreement with the mannitol challenge (MCT) relative to EIB. **Design:** Cross-sectional. **Setting:** Athletic Training Laboratory. **Patients or Other Participants:** Twenty intercollegiate and club sport participants volunteered for this study. All participants reported prior episodes of EID. Four participants failed to complete all testing; data are reported on 4 males and 12 females (19.9 years + 1.15). **Intervention(s):** Each participant performed resting spirometry to provide baseline flow-volume loops (FVL), MCT to assess EIB, and 3MT as an exercise challenge for EIB and EILO. The 3MT was conducted 2-7 days after MCT; FEV1 was utilized to identify EIB and FVLs were utilized to identify EILO. The 3MT is reliable for estimating critical power and has high ventilatory demands, but has not been investigated as an exercise challenge for EIB or EILO. Results of each test were recorded as positive or negative. A positive finding for EIB was a 15% fall (from baseline) in FEV1 during MCT and/or a >10% fall after 3MT. An

expiratory-inspiratory flow ratio at 50% of vital capacity (FEF50/FIF50) >1.30 was considered positive for EILO. This measure (FEF50/FIF50) demonstrates 87% sensitivity for extra-thoracic obstruction.

Main Outcome Measure(s): Diagnoses based on change in FEV1 in response to mannitol and exercise challenges, and on FEF50/FIF50 in response to 3MT. Sensitivity, specificity, likelihood ratios and diagnostic odds ratios were calculated using a 2x2 table. **Results:** All participants demonstrated EID during and after the 3MT. Five participants (31%) were EIB positive per MCT; three of these were confirmed through 3MT. Eleven participants (68.7%) were EIB negative on both measures. Eleven participants (68.7%) were EILO positive; 4 participants had concomitant EIB/EILO. The sensitivity and specificity of 3MT compared to MTC in identifying EIB were 0.58 (95% CI .241, .860) and 0.96 (95% CI .698, .995), respectively. The 3MT demonstrated a positive likelihood ratio of 14 (95% CI .85, 229) and a negative likelihood ratio of 0.43 (95% CI .17, 1.13). The 3MT had diagnostic accuracy of 83%. **Conclusions:** The 3MT provides a sufficient challenge to elicit EID in trained athletes and exacerbates EILO. With this small sample, 3MT appears to lack sensitivity as a standalone test for EIB.

Time To Return-To-Play Following ACL Reconstruction In Southeastern Conference Women's Soccer Players

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Context: Anterior cruciate ligament (ACL) injury rates have been reported for a variety of sports at different levels. Return-to-play (RTP) rates and time lines following ACL injury have been reported less frequently and vary largely by sport and level. **Objective:** Our purpose was to describe time to RTP characteristics for NCAA Division I women's soccer players in the Southeastern Conference (SEC). **Design:** Retrospective epidemiology study. **Setting:** Survey. **Patients or Other Participants:** Athletic trainers and sports medicine physicians at the 14 SEC schools participating in Women's Soccer in 2012. **Intervention(s):** A study packet was e-mailed to athletic trainers and physicians identified on athletic department websites, in the SEC Physicians Directory, or via word of mouth as working with women's soccer. Study forms requested details regarding ACL injuries within the last 8 years. **Main Outcome Measure(s):** Details regarding ACL injuries collected included: age at time of injury, history of previous ACL injury (yes/no), RTP (yes/no), eligibility completion (yes/no), year in school at injury (Year 1-2-3-4-5), depth chart position (starter, utilized, or utilized-rarely), scholarship (yes/no), time-to-clearance for practice (months), time-to-clearance for games (months), and participation in an injury prevention program (continuous, pre-season/offseason, or never). Median (range) was calculated for continuous variables and percentages or counts were calculated for ordinal and categorical variables. Non-parametric Mann-Whitney U or Kruskal-Wallis tests ($p < 0.05$) were employed to determine

differences in time-to-clearance for games by history of previous ACL injury, depth chart position, and scholarship status. **Results:** A total of 80 ACL injuries (19.3 years (17-22)) were reported, 79 underwent ACL reconstruction with 55 reported as primary reconstructions. RTP status was reported for 78 athletes, of whom 84.6% returned; however only 73.4% completed eligibility. The number of ACL injuries reported decreased as year in school increased (Year 1 = 31, Year 2 = 20, Year 3 = 19, Year 4 = 9, Year 5 = 1). Injuries were reported on 40 starters, 20 players considered utilized, and 20 players rarely-utilized. ACL injuries were reported to 69 scholarship and 11 non-scholarship athletes. For all athletes, time-to-clearance for practice was 5.5 months (3.8-12.7) and for games was 6.1 months (3.9-33.2). Between primary and revision ACLs there were no differences for RTP (87.3% vs. 77.3%, $p = 0.499$), completion of eligibility (71.4% vs. 77.3%, $p = 0.643$), or time-to-clearance for games (6.8 vs. 5.9 months, $p = 0.724$). No differences were observed for time-to-clearance for games based on depth chart position (starter = 5.9 months (3.9-19.9), utilized = 6.0 months (5.4-33.2), rarely-utilized = 7.0 months (4.9-12.7) ($p = 0.716$)) or scholarship status (scholarship = 5.9 months (3.9-33.2), non-scholarship = 7.9 months (5.5-10.4) ($p = 0.304$)). Regarding knee injury prevention protocols, 30% were continuously involved, 23.8% participated in preseason/offseason programs, and 46.3% did not participate in a program. **Conclusions:** When reviewing outcomes following ACL reconstruction it may be important to examine both return-to-play and eligibility completion rates. Among high-level soccer players, time-to-clearance for games following ACL reconstruction was not significantly influenced by depth chart position, scholarship status, or history of previous ACL injury.

Free Communications, Poster Presentations: Musculoskeletal Case Studies

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14054SC

Acetabular Fracture In Middle School Football Player

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Background: A 14 year old male football player fell onto a flexed knee while being tackled. He stated that he heard a pop as he landed and had an immediate onset of pain in his left hip. The athlete was removed from play, placed on crutches, and started taking ibuprofen. He has had no previous injuries or surgeries to that area. **Differential Diagnosis:** Hip muscle strain, acetabular fracture, femur fracture, slipped capital femoral epiphysis, labral tear, hip dysplasia, septic arthritis. **Treatment:** The athlete was examined the following day at the sports medicine clinic. He had neither ecchymosis nor edema around the left hip area. Upon palpitation, his pain was generalized around the left groin region with no other tenderness at any other location. He was able to actively move throughout the range of motion of his hip, albeit with pain. The same pain was reproduced with passive range of motion of the left hip and any weight bearing on his left leg. He had full strength with all motion of the hip. The contralateral hip exam was unremarkable. No abnormalities of the ipsilateral knee or back were appreciated. The athlete was neurovascularly intact to all four extremities. Hip and pelvis radiographs did not reveal any abnormalities of pelvis and femur. A MRI was ordered the same day to rule out an occult fracture. The MRI revealed a non-displaced posterior wall acetabular fracture, anterior superior labral fraying, a joint effusion, and strains of the of the gluteus minimus and obturator externus muscles. After consultation from a pediatric orthopaedic surgeon, a nonoperative treatment plan was initiated. The athlete was made nonweightbearing until his follow up with the pediatric orthopaedic surgeon. 5 weeks later, the athlete

returned with no pain upon palpitation and throughout the range of motion of his left hip. Followup radiographs redemonstrated the nondisplaced posterior acetabular fracture. He was allowed to return to weight bearing status, begin physical therapy, start nonimpact aerobic activities in 1 week, and progress to a treadmill in 2 weeks. 4 weeks later, the athlete returned without any complications from his treatment plan. A final radiograph was taken to show further healing of his fracture. 9 weeks post-injury, the athlete was released to full activities and asked to follow up in 3 months to ensure no other complications. **Uniqueness:** Acetabular fractures are more often seen in high energy trauma injuries such as motor vehicle accidents. However, even with the general population, acetabular fractures have an incidence of only 3 per 100,000 people. These types of fractures are even more rare in athletic events, but still remain a possibility due to falls and collisions in sports. **Conclusions:** As seen with this middle school football player, a routine play can result in an uncommon injury. This particular athlete sustained a nondisplaced acetabular fracture during a contact sport. This case demonstrates that pain upon physical examination with inconclusive radiographs may warrant further imaging. Pertinent physical examination findings included pain with log roll and passive and active range of motion.

14057SC

Zaricznyj Fracture: A Traumatic ACL Avulsion Injury In An Adult Female Skier

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Background: A 23 year old female skier with a chief complaint of right sided knee pain. Injury occurred attempting to stop while skiing in slushy snow. Mechanism of injury described as falling forward, knee extension and external rotation without release of ski binding. She immediately experienced pain and was unable to bear weight. Patient did not hear or feel a pop within the knee. Physical examination revealed moderate effusion and tenderness over the distal and proximal attachments of the MCL. Ligamentous testing revealed moderate laxity with Anterior Drawer and Anterior-Medial Drawer, positive clunk during Pivot Shift, anterior translation with Lachman's and moderate laxity of the MCL under valgus stress. **Differential Diagnoses:** Tibial spine avulsion fracture, tibial plateau fracture, Segond fracture, meniscus injury, MCL sprain, ACL sprain. **Treatment:** Anterior-Posterior and lateral radiographic images of the right knee were obtained and revealed a depressed fracture of the medial tibial plateau, a fracture fragment in the joint space near the medial tibial spine and a lateral tibial spine avulsion fracture. A CT scan showed a Zaricznyj Type IV classification comminuted intra-articular fracture involving the central tibial plateau and tibial spines. MRI revealed a medial and lateral tibial spine fracture near the ACL footprint with intact ACL, a moderate MCL sprain and a posterior horn medial meniscus tear. Immediate surgical intervention was performed to reduce the tibial spine fractures, repair the meniscus and reconstruct the MCL. Following surgery, she was braced in a post-op hinged knee immobilizer locked at 0-0 and 30% weight bearing for 5 weeks. In rehabilitation she was allowed 0-90 degrees of passive ROM and emphasis was

placed on patella mobility. At 5 weeks a second surgery was performed to remove a proximal anchor from her MCL reconstruction. She was placed in a hinged brace for 5 weeks and could progress to 50% weight bearing and full ROM in therapy. At 7 weeks she began full weight bearing while wearing her brace and started closed kinetic chain exercises. Four months status post, she had an improvement in ROM with 140 degrees of flexion and 0 degrees of extension. At the patients 6 month follow up she had significant gains in strength and was fitted with a functional knee brace. **Uniqueness:** Tibial spine fractures are relatively rare with the incidence rate estimated at 3 per 100,000. Adolescents account for the greatest number of tibial spine fractures with adults making up only 40% of the total affected population. Research describes the majority of tibial spine fracture cases as Types I, II, and III classification with no known cases reported in the literature detailing Type IV or comminuted fractures. In addition, when approaching rehabilitation for an ACL avulsion fracture, ossification of the fracture site should be established before advancing the rehabilitation protocol. **Conclusions:** Tibial spine avulsion fractures are an increasing injury seen in sports medicine. In such an injury, direct trauma, usually by a hyper-extension and rotation mechanism, causes an avulsion fracture occurring at the tibial eminence while the ACL is spared. It is important that they are diagnosed promptly in addition to recognizing that they are many times associated with subsequent injury such as the ones seen in this case. A tibial spine avulsion fracture adds to the differential diagnoses for athletic trainers as it may present with many of the same signs and symptoms as a traditional ACL pathology. Various treatments options exist and generally the results are good if anatomical reduction is obtained. In addition, early rehabilitation is crucial as it encourages a faster recovery and prevents the development of secondary complications.

Spontaneous Femur Fracture In A Female Track Athlete: A Case Report

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Background: An 18-year-old female track athlete was rounding a corner during indoor track practice and was cut off by a teammate. She attempted to slow down to avoid contact; however, she stepped on her teammate's foot and fell to the ground. The athlete was unable to move therefore a teammate ran to get the AT. During initial evaluation the patient reported her left knee went to the right and the rest of her leg stayed straight, she heard a pop, and felt like something was not attached. Further evaluation revealed she was unable to move her leg, had extreme muscle guarding, and palpation revealed extreme tenderness at the mid-shaft of the femur. EMS was called and the patient was transported to the hospital. Past medical history was significant for left knee and hip pain, and left knee bursitis in high school. The patient reported irregular menstrual cycles on her pre-participation physical examination. **Differential Diagnosis:** Femur fracture, tibial avulsion fracture, quadriceps strain, or patella tendon rupture/dislocation. **Treatment:** X-rays revealed a transverse mid-shaft femur fracture. The patient was placed on slight traction and underwent surgery the following day. During surgery a 380mm titanium rod was placed in the femur with two screws to hold the rod in place. Due to the patient's height, weight, age, and injury, the physicians wanted to examine blood samples to analyze for vitamin/mineral deficiencies. The results showed low levels of Vitamin D, Vitamin C, and Iron. As a result she was prescribed Vitamin D3, Vitamin C, and a Therapeutic Multivitamin at her

follow-up appointment after hospital discharge. Following surgery the patient was on bed rest for four days and performed supervised in-patient therapy which consisted of 25% partial weight bearing, seated quadriceps contractions, abduction/adduction exercises, and straight leg raises. Approximately one-month post-operatively the patient was 50% weight bearing while using crutches. Rehabilitation goals were to increase ROM, improve strength and balance. Two-months post-operatively the patient was full weight bearing and was instructed to continue quadriceps and hip strengthening exercises. In addition, rehabilitation focused on improving gait and balance. Approximately two and a half months post-operatively the patient met with a nutritionist and was instructed to track her daily food intake and continue her Vitamin D3, Vitamin C, and Therapeutic Multivitamin supplements. Three-months post-operatively she was cleared by the surgeon to begin a running progression and strengthening program under the care of the ATs. The patient experienced an increase in pain while running therefore running was discontinued until further muscle strength was gained. Nine-months post-operatively the patient was cleared for participation and began training with the team with no complications. **Uniqueness:** In an athletic population femur fractures are rare, and non-contact femur fractures are even rarer. Female athlete triad is comprised of three components: eating disorder, amenorrhea, and osteoporosis and components of this disorder have been linked to predispose individuals to fractures. Following her injury it was determined this patient was predisposed to her femoral fracture as a result of her poor nutritional habits, irregular menstrual cycles, and vitamin/mineral deficiencies as found on her blood test results. **Conclusions:** The patient presented with all of the components of female athlete triad which predisposed her for a non-contact femoral fracture. The patient underwent surgery and completed a successful rehabilitation as well as focused lifestyle changes to improve her nutritional

health. Through patient education and subsequent lifestyle changes she was able to return to pre-injury activity levels and participate in competitive track. Her nutritional health continues to be monitored by the ATs to prevent future injury.

Pilon Fracture In A Collegiate Lacrosse Player: A Case Study
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Background: A 19 year old Division I collegiate male lacrosse player was injured acutely during a recreational basketball game. He reported being hit from the left while jumping for a rebound and inverting his right ankle upon landing. His primary complaint was immediate sharp pain in the right ankle and the inability to bear weight. The skin was intact however soft tissue swelling was present. **Differential**

Diagnosis: Lateral ankle sprain, syndesmosis sprain, ankle subluxation, distal tibia fracture, distal fibula fracture and Maisonneuve fracture. **Treatment:** The patient was immediately referred to the emergency department. Upon assessment, soft tissue swelling and a minor deformity on the lateral aspect of the right ankle were noted. Plain film radiographs revealed fractures of the distal tibia and fibula. The patient was initially placed non weight bearing in a short leg cast with medial and lateral openings to allow for swelling. The patient was also prescribed the anticoagulant Lovenox (Enoxaparin Sodium) prophylactically for deep venous thrombosis. Computerized tomography (CT) scan performed 72 hours later demonstrated a comminuted vertical oblique (pilon) fracture of the distal tibia diaphysis with intra-articular extension and a minimally distracted fracture at the junction of the tibia plafond and inner vertical line of the medial malleolus. A minimally comminuted fracture of the distal fibular shaft with lateral apex angulation was also noted. The fractures were managed with surgical intervention ten days following trauma, consisting of an open reduction and internal fixation (ORIF) using an anterolateral approach with a separate medial approach to reduce the fracture of the medial malleolus. The medial malleolus was fixated with a cortical screw, while an anterolateral plate with six locking screws were used to fixate

the pilon fracture. The fibula was reduced but no fixation was required. The patient was initially placed non weight bearing in a Cam Walker boot, progressing to partial weight bearing and ultimately full weight bearing at eight weeks post-surgery. Removal of the boot was allowed for rehabilitation and, at ten weeks, use of the boot was discontinued. The patient continued conservative rehabilitation consisting of range of motion and strengthening, progressing to running and functional activity. At twenty-two weeks post-surgery, the patient was cleared for full participation. He returned for full activity and completed the lacrosse season without incident. **Uniqueness:** Pilon fractures represent less than 1% of all lower extremity fractures and represent only 5 to 10% of all tibia fractures. This injury occurs primarily in males between the ages of 25 and 50. Because of the energy required to cause this type of fracture, 25% to 50% of patients have additional injuries that require treatment. Our patient had associated malleolus and fibular fractures. The fibula is typically not fractured if the mechanism of injury is considered low-energy, like playing basketball. **Conclusions:** Pilon is a French word for pestle, an instrument used for crushing or pounding. In many pilon fractures, the bones of the ankle joint are crushed due to the high-energy impact causing the injury. The ORIF using an anterolateral and medial approach was successfully in treating our patient's injury. Approximately six months after the initial injury, the athlete returned to lacrosse without recurrence and only minimal symptoms. This time frame is typical for patients who participate in high-impact activities like lacrosse. In some cases, the plates and screws irritate the skin or cause discomfort. Our patient began to experience some discomfort due to a prominent medial screw. He is contemplating having it removed prior to the next lacrosse season.

Femoral Shaft Stress Fracture In A Collegiate Lacrosse Player

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Background: A 21 year-old female lacrosse attacker complained of left groin and hip pain, but denied acute trauma. She was evaluated late in the fall season and found to have pain over the adductor and lateral pubic tubercle. After conservative measures failed, an injection at the adductor origin was performed. Three months later she again complained of pain in the hip area. Further questioning revealed that pain now extended into the left thigh and knee area. The examination revealed full knee and hip active range of motion, stable joints, but pain with internal rotation of the hip. She reported no neurologic symptoms. Complicating her presentation was a history of a surgically repaired distal femur fracture with hardware subsequently removed.

Differential Diagnosis: Athletic pubalgia, pubic symphysisitis, hip labral tear, stress fracture, thigh contusion and/or myositis ossificans, hip or knee synovitis, tumor. **Treatment:** The athlete was initially treated with rest, 400 mg ibuprofen qid, cryotherapy, electrical muscle stimulation but had to subsequently be referred to the team physician for further evaluation. Initial x-rays showed a cortical irregularity in the proximal femur. A bone-scan was ordered and a femoral shaft stress fracture was confirmed. The athlete was then withheld from athletic activity, and instructed to be non-weight bearing for 3 weeks. She was permitted to perform upper body strength training and swimming for cardiovascular conditioning. Following three weeks of non-weight bearing, the athlete was advanced to partial weightbearing with crutches for two weeks, encouraged to continue her aquatic therapy and begin riding a stationary bike. Follow-up x-ray at six weeks revealed a resolved femoral stress fracture. The athlete was permitted to begin a return to play regimen over the next two weeks. Athlete then returned to full activity and was able to participate in the latter part of the competitive lacrosse season without

further incident. **Uniqueness:** According to the literature, femoral stress fractures account for only 7-10 percent of all stress fracture-type injuries with the majority of these occurring in the femoral neck. It is believed that about only 3.5 percent of the stress fractures to the femur actually occur in the femoral shaft. Stress fractures in the mid to proximal femoral shaft have also been called "thigh splints" as the mechanism of injury is similar to injury to the lower leg. Most authors recommend conservative treatment with continuous rest and non-weight bearing for three to six weeks and then an additional 2-4 weeks of a graduated return to activity. **Conclusions:** This case demonstrates the necessity of prompt recognition and treatment of an unusual stress fracture-type injury in the femoral shaft. Femoral stress fracture should be in the differential diagnosis of athletes who present with insidious hip, thigh or knee pain especially when the hip or knee examination is found to be unremarkable. This case also supports the non-operative management and care of femoral shaft stress fractures. Rest and activity modification along with a progressive return to play is recommended. The athlete at this time is asymptomatic and has returned to all athletic and daily living activities.

First Rib Stress Fracture In High School Baseball Player: Case Report

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Background: A fifteen year-old right-handed high school athlete complained of right neck and shoulder pain. He is a multi-sport athlete that plays both baseball and basketball, and first reported pain during off-season baseball practice. He noted pain in the scapular and trapezius regions which had worsened during throwing and hitting for a couple of weeks despite rest. He stated he made adjustments with his catching and throwing mechanics in an attempt to relieve the pain. He also reported sharp pain with over-head lifting, but was pain free at rest. Evaluation revealed full range of motion of his neck, but he was point tender over the trapezius muscle and in the superomedial scapular region. He had pain with resisted shoulder elevation and abduction above 90 degrees, but full strength without pain with resisted elbow flexion and extension, as well as wrist flexion and extension. Apprehension, jobe relocation, and jerk tests were negative. Scapular motion with forward elevation of his shoulder was normal. Neurovascular exam of right upper extremity presented as normal. **Differential Diagnosis:** Soft tissue contusion, acromionclavicular sprain. **Treatment:** Plain radiographs showed no evidence of acute fracture or dislocation using four views. Magnetic Resonance Imaging (MRI) without contrast was ordered and indicated extensive edema surrounding posterolateral, lateral, and anterior aspects of the right first rib, additionally a contour abnormality was observed on the anterior aspect of the first rib. Final diagnosis based on MRI was right first rib stress fracture. The treating physician placed the patient into a sling for comfort, for three weeks, and recommended naproxen twice-a-day. Throwing was forbidden for eight weeks. Patient

reported being pain free in both the neck and down the arm beginning 3 weeks post-diagnosis. At evaluation 5 weeks post-diagnosis the patient denied numbness or tingling. Neck and shoulder range of motion and strength were full without any pain. However, discomfort could be elicited with deep palpation of the upper trapezius on the right side. At this time point the stress fracture was considered to be healing, and the patient was cleared to start a shoulder-strengthening program, emphasizing the rotator cuff and scapular stabilization. The patient was also released for gradual resumption of basketball activity with initiation of a winter baseball-throwing program to occur 12 weeks post initial diagnosis. **Uniqueness:** First rib stress fractures have been reported to occur in the dominant arm of throwing athletes due to stress-induced fatigue secondary to repetitive muscle contractions. As athlete specialization increases at younger ages, overuse injuries have become increasingly common. The presented stress fracture may have been a result of back-to-back spring and summer baseball seasons followed by fall training. Atraumatic complete first rib fractures have been reported among throwing athletes, with speculation that these fractures may be secondary to an untreated stress fracture. Additionally, previous research has demonstrated that resumption of throwing between six and eight weeks does not allow for adequate healing despite callus presentation. In the presented case early diagnosis and gradual return to activity, especially throwing activity, were key to appropriate management. **Conclusions:** Although, first rib stress fractures are rare, clinicians should include them in their upper extremity differential diagnosis, particularly with overhead athletes involved in extended training. Typical clinical presentation includes insidious onset of dull aching pain in the posterior shoulder, scapula, or clavicle. A thorough evaluation and appropriate imaging, can lead to a timely diagnosis of first rib stress fractures and decrease the likelihood of further complications.

Multiple Mandibular Fractures In A Division II Basketball Player:

Case Report

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Background: The patient is an 18 year old, female, Division II basketball player. The patient fell while attempting a rebound. She landed prone and player from the opposing team tripped and fell on the patient's back which forced the patient's mandible to hit the gym floor. Patient was able to walk to the bench with her hand supporting her mandible and complained of bilateral temporomandibular joint (TMJ) pain. There was a mandibular laceration, which required sutures. Patient did not experience crepitus or cracking. Patient had a visual deformity, malocclusion and a positive tongue blade test. **Differential Diagnosis:** LeFort fractures, single versus multiple fractures, TMJ dysfunction, concussion, nasal fracture, cervical spine injury. **Treatment:** Patient was immediately referred to the emergency department where she underwent X-rays and a CT scan. Through further examination, the mandibular laceration required eight nylon stitches and no intraoral lacerations or bleeding; she also had a luxated tooth. Cranial nerves II-XII intact bilaterally. CT scan showed three fractures: 1) medially displaced left subcondylar fracture (condyle still in fossa), 2) minimally displaced symphysis and 3) right subcondylar fractures. Patient had an open reduction internal fixation (ORIF) with inferior border plate via intraoral approach three days after injury followed by six weeks of intermaxillary fixation (IMF). The patient was offered immediate surgery but declined and waited three days because she was anxious. Patient was put on a liquid diet and prescribed Penicillin VK and Percocet elixir. Patient required immediate second surgery 2 weeks post-op due to surgical site infection, potentially caused by micromovement or inadequate nutrition. Patient lost a significant amount

of weight between first and second surgery. The patient will eventually require another surgery and orthodontics due to misalignment during healing. This is not causing her any pain or dysfunction currently. Patient wishes to wait until after her basketball career is over to have the third surgery, which will be three years after initial injury. **Uniqueness:** Mandible fractures represent maxillofacial fractures by 25% and mandibular body fractures (MBF) are 11% to 36% of all mandible fractures. The most common mechanism of mandibular fractures includes violence. The patient was injured during sports participation. This case is unique because the patient had more than one fracture; the fracture in the lower mandible was 95% of the way through. Furthermore, the patient had problems healing which will require a total of three surgeries and orthodontics. **Conclusions:** The mechanisms and complications of this case report are significant to the Athletic Training profession. It is important to monitor a patient with mandibular fractures in order to detect and prevent the risk of infections. The clinician should be aware and monitor the patient's dietary intake. Patient with mandibular fractures may encounter physiological, psychological, social, and physical problems.

14087SC

Mandible Pain In A High School Athlete

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Background: This case discusses pain in a high school athlete's jaw. The athlete is an 18 year old Caucasian male, participating in football. The athlete stands 67.5", weighs 168 pounds and plays linebacker/running back. He has no significant medical history. The athlete presented to the Certified Athlete Trainer complaining of pain in his jaw and difficulty speaking. **Differential Diagnosis:** Mandible contusion, fractured tooth, tempomandibular joint sprain, tempomandibular joint dislocation. **Treatment:** During defensive drills the athlete tackled an opposing athlete. As he made the tackle, the crown of the opposing athlete's helmet made contact with the involved athlete's chin strap. The impact forced the athlete's jaw to be moved in a supierolateral motion. Upon inspection, the athlete's mandible was misaligned with his maxilla. During palpation it was noted that his left tempomandibular joint was dislocated medially. Per standing orders from the supervising physician, the AT decided on a course of reduction on site. With the consent of the athlete the AT donned gloves and inserted her thumbs into the athlete's mouth to palpate the joint. At that time the AT applied longitudinal traction with lateral force to the mandible. As the force was applied the mandible began to translate inferior and laterally eventually returning to the correct anatomical position. The athlete stated that his teeth felt correctly aligned but that he had obvious pain in his TMJ. The athlete was seen by his family dentist. Radiographic films obtained were negative. The athlete was instructed to eat soft foods for approximately 48 hours and told he could return to athletics as tolerated. The AT restricted the athlete to

noncontact activities for two days and athlete returned to full contact for the game that Friday. **Uniqueness:** Mandibular dislocations are rarely seen in the emergency department and even more rare on the athletic field. Lowery et al (2004) states only 37 dislocations were seen in a seven year period in an ED setting with more than 100,000 visits. **Conclusions:** While dental injuries are rarely seen Certified Athletic Trainers must be properly prepared to evaluate and treat them as they occur. A well written and practiced set of standing orders from the supervising physician enables AT's to perform procedures that create positive medical outcomes as well as positive economic outcomes by reducing visits to the ED.

14035MC

Complete Pectoralis Major Tendon Rupture In A Collegiate Wrestler: A Case Report

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Background: A 21-year-old collegiate middle-weight wrestler suffered an injury during the third match of the day at an open tournament. The injury occurred while the patient had his hands locked around the opponent's leg with his left arm fully internally rotated. The opponent then hiked his leg back, and the patient felt and heard a pop in his shoulder causing immediate sharp pain. The patient was unable to continue wrestling, and an injury time out was called. Upon physical examination, the patient described severe pain generalized to his left shoulder. The patient was unable to actively lift his arm in any plane. Palpation revealed severe point tenderness at the biceptal groove, biceps muscle, and pectoral tendons and muscles. Manual muscle testing of deltoids, biceps, and pectoralis major were all 1/5. The patient complained of tingling in his fingers, but sensation and neurovascular screens were within normal limits. The patient was injury defaulted, iced, and referred to the team physician the following day. **Differential Diagnosis:** Biceps tendon tear or avulsion, glenohumeral subluxation, pectoral tendon injury. **Treatment:** The team physician evaluated the patient 1-day post injury. The evaluation revealed similar findings as the AT's evaluation at the time of injury; however the patient noted a reduction in pain. An MRI was ordered and the report stated there was an isolated, complete detachment of the pectoralis major's sternal and clavicular head's common tendon from the humeral attachment. In addition, it was noted there was a 2-3 cm retraction of the torn tendon ends with associated soft tissue edema. No fluid collection or mass was found. It was determined that surgery was required to re-attach the tendon and surgical anchoring of the tendon was performed 10-days following injury. Following surgery the patient started a 3-phase rehabilitation/

functional return to participation (RTP) program designed by the AT and derived from the best available research evidence and the AT's clinical expertise. The first phase began immediately following surgery and lasted for 6-weeks. The goals of Phase-I were to protect the anchors, decrease pain and inflammation, and retain elbow, wrist, and hand strength and motion. The second phase (6-12 weeks) focused on initial strengthening and regaining shoulder ROM. Isometric strengthening of the shoulder was performed and progressed to isotonic exercises. Pectoralis major isotonic exercises were avoided until 12-weeks. The goals of Phase-II were to gain and maintain full ROM, promote soft tissue healing, and gradually increase muscle strength and endurance. The third phase (12-24 weeks) focused on advanced strengthening and return to activity. The goals of Phase-III were to increase flexibility, increase muscle strength, power and endurance, and gradually introduce sport specific activity and RTP. At 20-weeks the patient began a functional return progression consisting of shadow drilling and drilling on a dummy. At 22-weeks the patient began wrestling with smaller partners and slowly progressed up in partner size. At 26-weeks post-surgery, the patient began live wrestling, unrestricted, with athletes in his weight class. **Uniqueness:** Pectoralis major tendon avulsions are rare in athletics. Injury specific rehabilitation protocols and RTP protocols are scarce in the literature. The rehabilitation and RTP protocols were designed from the best available evidence and by the AT's clinical expertise and sport specific knowledge. The end result was a successful return to participation for the patient. **Conclusions:** This case involves the surgical reconstruction of the pectoralis major tendons following rupture off of the humeral head in a collegiate wrestler. Using the evidence-based practice model, the AT was able to derive a rehabilitation protocol and RTP protocol that allowed for the patient to return successfully to wrestling without any complications.

AC Joint Pain In A Male Division I Competitive Cheerleader

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Background: A 22-year-old, male, competitive cheerleader reported complaining of pain directly over his right acromioclavicular (AC) joint and lateral glenohumeral (GH) joint after feeling a pop while bench pressing. He had no previous history of right shoulder injury. Upon examination he had full active range of motion (AROM) with pain during resistive GH flexion, abduction, and horizontal adduction. There was an obvious step-off deformity and piano key sign of the AC joint along with pain during palpation. In addition, there was no point tenderness over the rotator cuff or GH joint, only a constant, dull ache with no paresthesia reported. All shoulder labral pathology testing was negative without notable crepitus. AC compression, Cross Body Flexion, and AC Traction tests were positive for pain but not for subluxation or laxity in the joint. Neer's, Speed's, Empty Can, Yeagerson's and Apley's Scratch tests were all positive for pain and lack of ability to resist pressure. **Differential Diagnosis:** AC joint sprain, AC joint subluxation, clavicular osteolysis, subacromial impingement, rotator cuff pathology, labral pathology, bicipital tendinosis, biceps tendon strain or subluxation. **Treatment:** Following initial improvements in the first 72 hours, the patient began a rotator cuff and scapular stabilization program. After 4 weeks of rehabilitation with no noticeable improvement the patient was referred to an orthopedic surgeon. The physician found full, but painful, AROM and 4/5 MMT for shoulder abduction and flexion; with positive tests for subacromial impingement and AC joint pathology. An x-ray followed by an MRI Arthrogram were ordered. The x-ray displayed degenerative changes and the patient was diagnosed with clavicular osteolysis while the MRI Arthrogram showed inferior and posterior labral tears.

The patient underwent an arthroscopic labral repair with subacromial decompression and a 1cm clavicle resection. The patient is progressing well and expected to return to activity approximately six months post surgery. **Uniqueness:** AC joint injuries represent nearly half of all athletic shoulder injuries. Clavicular osteolysis, also known as "weight lifters shoulder," is generally seen in individuals who participate in heavy overhead lifting. The rate of occurrence for this type of injury is unknown due to the suspicion that many occurrences go unreported. This is hypothesized to be due to the hardworking, "push through pain," mentality of the athletes it generally affects. Long-term cessation of activity (6+ weeks) has been shown to reduce pain levels. However, continuation of activity allows the osteolysis to continue to degenerate the clavicle and in order to return to a high level of athletic participation, surgical intervention is necessary. The degeneration rate varies based on the individual and level of sustained athletic participation. **Conclusions:** What presented as an AC joint sprain was a clavicular osteolysis with multiple asymptomatic labral tears, and required surgical intervention. As commonplace and routine as some injuries seem to be and present to Athletic Trainers we must always consider the uncommon possibilities. When initial treatments and rehabilitation do not progress as they should, we must take a step back to reevaluate what other possibilities there may be and when to seek further assistance. Due to the commonalities between overhead weightlifting and the daily activity of competitive male cheerleading, AC joint symptoms should be closely monitored in this population. The timeliness of his treatment and physician referral may have kept this injury from becoming significantly more serious. Further studies on clavicular osteolysis and the degeneration rate will allow medical staffs to better care for athletes with injuries such as this.

OATS Procedure: Management Of An Unstable Osteochondral Lesion In A Surfer

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Background: A young, active 22 year old male surfer presented with right knee pain in August, 2011. The athlete described acute insidious onset after awaking from sleep, with no other mechanism of injury. The athlete complained of deep anterior knee pain with aerobic and impact activities. The athlete is a healthy male with no prior medical history or surgeries. Physical examination revealed mild effusion and range of motion of 2 degrees of hyperextension and 120 degrees of flexion. Tenderness to palpation under the patella and crepitus during active range of motion were noted. McMurray's, anterior drawer, posterior drawer, Lachman's, varus, and valgus special tests were negative.

Differential Diagnosis: Chondromalacia of patella, chondral defect, osteochondral lesion, meniscus tear, bursitis, tendinosis.

Treatment: Magnetic resonance imaging (MRI) was obtained in 2012 revealing an unstable patellar osteochondral lesion. Conservative treatment for approximately one year included a patella stabilizing brace in conjunction with physical therapy emphasizing a lower extremity closed-chain kinetics strengthening program. Anti-inflammatories were taken as needed. After failed conservative treatment, a second MRI was performed in 2013 which revealed mild change compared to the previous MRI. A patellar osteochondral lesion was re-confirmed. The patient underwent a right knee arthroscopy, extensive debridement, synovectomy, patellar chondroplasty and open suprapatellar osteochondral autograft transfer (OATS). The early rehabilitation process consisted of non weightbearing for 6 weeks and locked in a post-operative knee hinge brace. 0-90 degrees range

of motion (ROM) was implemented for 4 weeks then was increased as tolerated by pain. Significant effusion after surgery required multiple aspirations, and one steroid injection about 6 weeks post surgery. **Uniqueness:** Osteochondral lesions were first identified more than a century ago; however, no definitive causes have been identified. The athlete denies having any mechanism of injury or any prior injuries to the affected knee. An OATS involves transferring healthy cartilage from a non weightbearing area of the knee to a damaged area of cartilage. The OATS procedure utilizes large plugs of healthy cartilage to replace the site of the osteochondral lesion. **Conclusions:** The patient had a full recovery and no major complications or complaints. He returned to surfing and athletic activities. It is important that ATC's recognize osteochondral lesions as possible insidious pain generators in the knee, and early detection is paramount to prevent further damage. It is important for ATC's to understand different treatments for osteochondral lesions since the proper course of action can prevent arthritis and preserve natural cartilage, thus improving quality of life as the patient ages. Delay in treatment can cause the lesion to become more severe and decrease the chance for a successful outcome. MRI and CT scans are the gold standard for diagnosing osteochondral lesions. It is common for these patients to complain of pain with weightbearing activities, swelling, instability, occasional catching, and tenderness. Conservative treatment may consist of pain management, including anti-inflammatories, activity modification, bracing, and increasing flexibility and strength. If the osteochondral lesion is unstable or if conservative treatment fails to provide relief an operative solution should be offered.

Osteochondral Talar Defects In An NCAA Division 1 Women's Soccer Player

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Background: In Fall 2010, a 21-year-old female division one soccer defender suffered a sprained ankle that later resulted in a contusion to the dome of the talus. The athlete was tackled from behind in Fall 2012, causing pain and soreness in her left ankle especially when standing for long periods of time. She had full AROM, normal end feels with PROM, and full strength with all manual muscle tests. Anterior Drawer was positive for laxity. **Differential Diagnosis:** Differential diagnoses included return of the previous talar dome contusion, osteochondral defects of the talar dome, inversion ankle sprain to the ATF and CF ligaments, Achilles tendon strain, and bone spur of the left ankle. **Treatment:** A 2011 physician evaluation found "nothing wrong" with the athlete's left ankle. Following a return of symptoms she was seen by a specialist. The specialist diagnosed her with osteochondral defects of the talus based on MRI findings. She was placed in a boot for approximately 8 weeks, and a return to play progression saw her play pain free during the 2011 season. After a return of symptoms in Fall 2012, the attending physician recommended two surgical intervention options. The first was DeNovo cartilage implantation, and the second was a debridement procedure that would stimulate cartilage growth. The debridement procedure was chosen and performed on 1/22/2013. A physician directed return to play progression was followed for the 2013 season. This included an 8 week period of non-weight bearing activity, followed by 25% weight bearing on 3/15/13, 50% on 3/25/13, and 4/8 she was cleared to progress into full weight bearing and into a shoe. She completed a functional progression throughout the summer and was able to start practice at the beginning of the fall season with the team. She was

listed as tolerated for the beginning of the first game and by week three was able to play two games per weekend if necessary. Throughout this process she was limited in her number of practices per week and placed on crutches and in a walking boot when not at practice or games in order to optimize healing of the ankle. Despite limitations her pain and soreness began to linger and spread down into her foot. She was referred to her physician for additional evaluation and testing on the ankle. Another MRI revealed increased cartilage growth over the debridement area, but also indicated multiple stress reactions and stress fractures in the ankle and foot. The athlete was placed in a walking boot with no crutches by her physician and held out for the remainder of the season.

Uniqueness: This case is unique because there does not seem to be a high incidence of talar debridement and return to play in collegiate soccer players. Also it is interesting the talar debridement site showed cartilage growth and healing on the follow up MRI, but the new pain, which had been similar to the original injury, was caused by a different injury all together.

Conclusions: A 21 year old division 1 women's soccer player with a history of talar dome contusion and multiple ankle sprains developed osteochondral defects. Though precautions were taken to limit exposure to the area and a functional progression to play was followed as directed by the physician, the athlete still developed stress reactions and stress fractures even though healing and cartilage growth was noted at the debridement site. This case can aid in the treatment and rehabilitation of similar pathology.

Severe Injury Of The Left Foot In A Collegiate Basketball Player: A Case Report

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Background: A 21-year-old (height: 203.2 cm; weight: 102.1 kg), male Division-II basketball forward/center presented to the athletic training room with left posterior ankle pain and no prior history of ankle injuries. The athlete stated that he was back pedaling over a wet spot on the court when he fell and felt a pop in his left Achilles tendon, and had torn the back of his ankle brace. Upon examination the next morning in the athletic training room, significant swelling and point tenderness over the insertion of the Achilles tendon were noted. All ligamentous ankle tests and fracture test were negative, including Thompson. Strength with plantarflexion was 4+/5 and he claimed with his "shoe tied tight", he had no pain with ambulation. Rehabilitation began 4 days after initial injury with goals of decreasing swelling, and regaining strength and ROM for return to play. Rehabilitation continued for 10 days and the athlete was cleared for full participation. One month following initial injury, the athlete slipped in practice again and complained of pain along his left medial longitudinal arch. Swelling returned around both medial and lateral malleoli and the physician ordered an MRI. **Differential Diagnosis:** Plantaris strain, partial tear of the Achilles tendon, spring ligament sprain, plantar fasciitis, tear of the medial plantar fascia. **Treatment:** MRI revealed edema within the talus suggesting contusion or micro fractures. The anterior syndesmotric ligament appeared thickened, suggesting partial thickness tear. The anterior talofibular (ATF) ligament had no discrete intact fibers and the calcaneofibular (CF) ligament was not well visualized compatible with a full thickness tear. Deltoid ligament diagnosed with grade 2 sprain. The spring ligament appeared thickened, suggesting a sprain. Fluid

surrounding the posterior tibial tendon suggested mild tenosynovitis. The athlete was cleared to play as tolerated and Voltaren (diclofenac sodium) was prescribed for pain and inflammation (topical gel and oral). Surgery was suggested but athlete declined. A rehabilitation program involving sports specific motions was implemented. Exercises include: hip twists and high knees on BOSU ball and knee squats while balancing on a foam roller, in conjunction with lateral hops, knee squats, isometric knee squats with a ball lift, resistive lunges, calf raises, resistive 4-way theraband, and side to side jumps on a flat surface. The athlete continued to compete fully, but occasionally experienced pain. **Uniqueness:** The athlete's initial injury presented in the posterior region of his ankle and his second episode presented with pain over the medial longitudinal arch. Neither mechanism, nor symptoms were consistent with the torn ATF, CF, syndesmotric sprain, micro fractures, or deltoid sprain; yet the athlete does not recall previous injury to that ankle. **Conclusions:** The athlete does not remember any event of trauma to his ankle that would explain the ligamentous injuries. The only traumatic event he recalled were two instances of slip and fall at practice. His pain presented posteriorly and over the medial longitudinal arch, while the ligaments that were torn were medial and anterior. Despite the results of diagnostic imaging, all manual ligamentous tests were negative. He was able to fully participate and refused surgery. This case study exemplifies that not all injuries present with mechanisms of injury or signs and symptoms consistent with diagnostic testing.

14053SC

Knee Injury In A High School Football Player

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Background: An 18 year old football player has pain following an anterior-lateral blow to the right knee and was unable to ambulate off the field. He complains of diffuse pain throughout, no obvious deformity, pain is a 9/10, and is neurovascularly intact distally. Range of motion is limited secondary to pain. He is able to fire his quad. Athlete is stable to varus and valgus at 0 degrees. Sideline exam reveals laxity to valgus stress at 30 degrees, no varus laxity. Athlete guards on further special testing but exhibits some laxity with posterior drawer and apparent negative Lachman's. He is not permitted to return to play and is immobilized and treated with ice. **Differential Diagnosis:** MCL rupture, PCL rupture, medial meniscus tear, ACL rupture. **Treatment:** The athlete was placed on crutches and banded for compression. He was instructed to rest, ice and elevate the knee and follow-up with the primary care sports medicine physician in two days. He was given the usual precautions for emergent care if vascular symptoms developed or pain was uncontrollable. He was evaluated 2 days post injury in the sports medicine clinic. Exam showed mild effusion, no ecchymosis or gross deformity. He had full ROM, pain with terminal extension. Pain localized to the medial aspect of the knee. Special tests remained unchanged with the exception of a grossly positive poster drawer test and positive posterior sag test. Xrays were negative. An MRI was ordered to assess the PCL and MCL. The athlete was to continue ice, compression and crutches but was also placed in a brace locked at 30 degrees. Ten days post injury exam is unchanged. MRI reveals femoral sided MCL injury and mid-substance PCL rupture. The athlete was consulted to the orthopaedic surgeon. Surgery

was scheduled for 2 weeks time to attempt MCL scarring; the athlete was consented for potential MCL repair if necessary and PCL reconstruction. He was given a muscle stimulator with garment to use prior to surgery to prevent quadriceps atrophy. Twenty-one days post injury the athlete underwent PCL reconstruction with Achilles allograft and MCL repair. The athlete was admitted for 23 hrs following surgery for pain control and observation. He was placed in a post op brace locked at 30 degrees and non-weight bearing for 2 weeks, CPM 8 hrs daily and muscle stim device 4 hrs daily. He was allowed to use the TENS component of the device for pain control. He was scheduled for routine follow-up 5 days post op. He returned for suture removal 12 days post op. At that time he was permitted to toe touch weight bear in the locked brace. He was to begin physical therapy per PCL protocol and return to clinic in 3 weeks. He will continue to be checked in clinic and will follow the PCL protocol with MCL precautions with a goal of returning to baseball in late spring. **Uniqueness:** Combined MCL and PCL tears are not as common as other ligament combination injuries in athletes. Because of the multi-ligament injury the femoral sided MCL rupture was repaired to increase the long term stability of the knee. The athlete was also placed in an at home muscle stimulator device pre and post operatively to aid in the prevention of quad muscle atrophy as a weak VMO has been shown to be a predictor of re-injury in post operative knees. **Conclusions:** It is important for an athletic trainer to recognize multi-ligament knee injuries and make sure the athlete receives proper treatment. New advances in surgical techniques and devices for pre and post operative care can improve athlete outcomes.

14011FC

Bostrom Procedure And Removal Of Accessory Ossicle For The Right Ankle: A Case Analysis

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Background: This report details the treatment of an 18year-old female track athlete suffering from acute right ankle pain. The athlete stated that she "rolled her ankle and felt a pop" while completing her warm-up routine on the hurdles. The athlete conservatively self-treated until she reinjured the ankle during a competitive track meet. The physical evaluation revealed soft tissue edema about the lateral malleolus and sharp point tender pain on lateral aspect of ankle that was not decreasing. Anterior drawer and talar tilt tests were (+) for pain and laxity but had solid endpoints. Athlete also presented with an antalgic gait with shortened stride length on affected side. Athlete referred to team physician for evaluation. **Differential Diagnosis:** Lateral Ankle Sprain, Avulsion Fracture, Ankle Arthralgia, Subtalar Ligament Lesion. **Treatment:** Evaluation by physician under fluoroscopy revealed increased anterior excursion with anterior drawer test as compared bilaterally indicating moderate instability of anterior talofibular ligament (ATFL). X-Rays also revealed a painful accessory ossicle just distal to lateral malleolus. An MRI was scheduled and reviewed by physician. It was decided to proceed with a Brostrom Procedure and removal of the accessory ossicle. This procedure requires an incision just anterior to the distal fibula. The ATFL was transected and a small piece was removed. The foot was then everted while the talus was pushed slightly posterior in the ankle joint while the ATFL was tightened. The extensor retinaculum was also sewn into the repair. The incision was lengthened to the tip of the fibula. The ossicle was located and removed. Athlete was casted for six weeks non-weight bearing. After the cast was removed, the athlete's rehabilitation plan consisted of partial weight bearing,

ankle range of motion, closed kinetic chain lower extremity strengthening, biking, and proprioception activities. After completion of activities she received interferential electrical stimulation with cryotherapy. After full weight bearing, progressed to sport specific activities. Ten weeks post cast removal, released to full track and field activities with ankle brace.

Uniqueness: Lateral ankle sprains are a common injury treated by certified athletic trainers most often resolved through conservative management and participation modification. However, there may be some underlying pre-existing conditions that contribute to the slow resolution of the ailment. Even with conservative treatment strategies including prophylactic taping and bracing, the painful accessory ossicle along with the forward shift of the talus was limiting sport participation. The use of surgical intervention was a beneficial treatment option due to the biomechanical abnormalities creating an increase in ankle instability and pain. The Brostrom procedure allowed the athlete a full recovery and return to full participation without complications. **Conclusions:** This case highlights the successful surgical and rehabilitation treatment of an athlete with an acute ankle sprain with an underlying condition that may be commonly overlooked. Even though ankle sprains are common in sport, a detailed evaluation by the certified athletic trainer and proper referral to the physician is necessary.

Case Report Of A Traumatic Knee Injury In A Middle School Football Athlete

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Background: A 13 year old adolescent male was participating in a middle school football game when he was tackled from the right in his upper torso and simultaneously hit in the left lower leg which was planted on the ground. The athlete had no previous history of injury or illness. Upon on-field evaluation by the athletic trainer, the athlete was in a supine position with his left leg in an externally rotated position in extreme distress. The athlete was easily calmed down, and obvious deformity of his leg was noted. The injury was closed in nature with his femur protruding medially and the lower half of his leg displaced laterally. **Differential Diagnosis:** Distal femur fracture, complete knee dislocation, or proximal tibial fracture of the left leg. **Treatment:** Emergency medical services (EMS) were called to transport the athlete. The athlete's left leg was immediately stabilized with a semi-rigid splint from ankle to mid-thigh. No attempt was made by the athletic trainer to reduce the injury. The athlete had strong distal pulses with normal dermatome and myotome reactions throughout on-field care. Once EMS arrived he was lifted via a scoop stretcher and transported to the local pediatric emergency room. In the emergency room during the initial exam a resident physician believed the injury to be a complete knee dislocation, and expressed frustration that the knee was not restored to normal alignment on the field. However, following the initial evaluation radiographs revealed a displaced type II Salter Harris fracture of the distal femur. The distal condyles of his femur had completely slipped and rotated laterally. The athlete was immediately taken into surgery where a closed reduction was performed. Following the reduction, fixation was achieved using 2 percutaneous pins

placed in an X-like fashion from the distal femur obliquely across the physeal plate to maintain bony integrity. Post-fixation radiographs revealed a very successful reduction, and the athlete was kept overnight to monitor his vitals and neurovascular integrity. Post reduction plan of care consisted of 6 weeks in a long-leg cast in 25° of knee flexion, followed by removal of percutaneous pins. The athlete is at high risk for a growth arrest in his left femur from this injury. However, based on follow-up radiographs premature full closure of the growth plate is not anticipated. His growth will continue to be closely monitored to ensure normal growth is achieved. **Uniqueness:** In a skeletally mature athlete the same injury mechanism may have resulted in a total knee dislocation. However, because of the athlete's age a growth plate fracture had to be included in the differential diagnosis. Therefore, given that the athlete was neurovascularly intact and displayed no signs of shock, the limb was splinted as it lay, and no attempt was made to restore normal anatomical alignment. Salter-Harris type II fractures involve the growth plate and the metaphysis, sparing the epiphysis with or without displacement. In this case, the athlete had a complete physeal plate fracture along with complete displacement of the femoral condyles. Had successful reduction not been achieved, surgical closure of the contralateral distal femoral growth plate may have been indicated to prevent a substantial leg length discrepancy. **Conclusions:** In conclusion, athletic trainers need to be aware of injuries that adolescent athletes can sustain and how to appropriately manage the injury on-field. In this case appropriate on-field management may have reduced the risk for a permanent, substantial leg length discrepancy.

14072UC

Non-Contact Hip Dislocation In Male High School Football Player

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Background: During a football game, a sixteen-year-old male high school football player with no known medical conditions predisposing him to a hip injury, was running along the sideline at full speed when he decelerated to cut across the field and fell to the ground. When the athlete planted his right foot to cut across the field, his ankle was inverted, knee was fully extended and hip was internally rotated and slightly flexed. The athlete limped off the field without assistance for further evaluation. During the sideline evaluation by the athletic trainer and physician assistant, the athlete stated he heard a pop, and complained of tenderness to palpation over the lateral hip. He also reported pain and a popping sensation in the hip with passive hip internal and external rotation. **Differential Diagnosis:** Hip dislocation or subluxation, acetabular labral tear, hip joint ligament sprain, tensor fascia latae strain. **Treatment:** The athlete was not immediately sent to the hospital but was instructed to see a physician the next morning. On the sideline, he was treated with ice and sensory transcutaneous electrical stimulation and went home that night on crutches. The next morning, the athlete reported to the physician that he was experiencing deep pain in his groin region. The physician noted increased laxity of the coxofemoral joint and pain with passive hip internal and external rotation. Based on these findings, the physician scheduled a CT scan for the athlete three days post injury to determine if the femur was displaced within the acetabulum. Upon reading the results of the CT scan, the physician determined the presence of a small non-displaced acetabular fracture and the head of the femur was displaced posterior to the acetabulum

with enough separation warranting a manual reduction of the hip. The physician immediately called the athlete back into the office, and under anesthesia performed a closed reduction of his hip. An MRI was performed four days post injury to assess the integrity of the arteries surrounding the femoral head. The MRI was unremarkable. **Uniqueness:** Sport-related hip dislocations are rare, accounting for only 2-5% of all hip dislocations. In addition to this, it is very uncommon for a hip dislocation to occur based on a non-contact mechanism of injury. **Conclusions:** This case presents a unique scenario of a non-contact sport-related hip dislocation in a high school male football player. Although the appropriate steps were taken to manage this injury based on the initial evaluative findings, advanced imaging was required in order to identify the presence of a hip dislocation. Due to the traumatic complications commonly associated with hip dislocations (i.e. avascular necrosis), clinicians should be aware of the potential for non-contact sport-related hip dislocations to occur without the presentation of severe functional limitations.

14085MC

Atraumatic Spontaneous Sternoclavicular Subluxation:

A Case Series

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Background: Three Division III athletes from volleyball, baseball and lacrosse reported with pain and clicking over the chest. The first athlete was a 21 year-old, male, infield baseball player. Onset began 12 weeks after a labral repair in the contralateral shoulder. The second athlete was a 21 year-old, female, volleyball player (outside hitter). Onset began two years prior with no previous traumatic injury or damage to the contra or ipsilateral shoulder. The third athlete was a 19 year-old, male, offensive, lacrosse player. Onset began at the start of his collegiate career. Previous history included several AC joint injuries to both shoulders several (~7) years prior. All denied a particular mechanism or time of onset. Upon evaluation, an observable shift of the sternoclavicular joint with active shoulder ROM including shoulder flexion, abduction, and scapular retraction was evident. The shift in each case was in the anterior direction. Each reported the clicking emanated from their non-dominant shoulder. All complained of no pain, just a mild discomfort when the clavicle subluxed and relocated with movements. Palpation over the SC joint did not recreate pain or subluxation. Mobilization of the proximal end of the clavicle in superior and inferior directions demonstrated some laxity of the sternoclavicular joint ligaments. All described the subluxing event as reoccurring without change in severity or frequency over time. All were currently participating in their sport at the time of the evaluation. **Differential Diagnosis:** SC joint sprain, SC joint subluxation, SC joint instability. **Treatment:** In the case of a SC joint sprain or ligamentous laxity conservative treatment is advocated. For each case, shoulder strengthening exercises and scapular stabilization exercises were implemented three times per week before practice. All continued to participate in their sport

while completing rehabilitation. Exercise for scapular stabilization included scapular punches, inferior glide, low and high rows with therabands, and scapular squeezes. Each exercise was completed as two sets of ten, then progressed to three sets of ten. Exercises for shoulder strengthening included rotator cuff theraband exercises including internal and external rotation, rhythmic stabilization progressing from perturbations at 90 degrees of shoulder flexion, to wall ball exercises, and PNF patterns. All avoided movements that caused SC joint subluxation. Each saw a decrease in the overall magnitude of the subluxation but none experienced a complete resolution of symptoms. **Uniqueness:** A review of literature supports that atraumatic spontaneous sternoclavicular subluxations are rare. It was particularly interesting to have the same mechanism in three different sports. Each presented with the pathology in their non-dominant, non-throwing or hitting arm. Instability of the joint due to ligamentous laxity is most common in individuals <20 years old. All three cases were in this general age range. Two of the three athletes reported no history of traumatic injury to the pathologic shoulder. Present research suggests that conservative treatment is the best approach for management of the pathology and each case responded positively to this treatment. **Conclusions:** Spontaneous sternoclavicular subluxation can occur secondary to trauma or in rare cases due to atraumatic ligamentous laxity. Age is a key factor with atraumatic onsets, as ligamentous laxity is greatest at younger ages. In these cases current recommendation is conservative management. The pathology however seems to be self-limiting with pain and discomfort which was variable dependent on the case. Management should therefore include a comprehensive plan of treatment including pain management, shoulder and scapular stabilization and strengthening, and avoidance of movements that create the

subluxation. It is important to note that athletic participation can be completed as tolerated.

Free Communications, Poster Presentations: Vascular Case Studies

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14017MC

Effort Induced Subclavian Vein Thrombosis In A High School Basketball Player

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Background: Eighteen year-old, male basketball player reported to his athletic trainer complaining of sharp pain in his right shoulder and down into his arm and hand. Swelling and cyanosis in his right shoulder extending to his hand was noted. The patient had no predisposing conditions or remarkable medical history. Two days prior to diagnosis, the patient recalls shortness of breath while walking up inclines and minor aches in his right arm throughout the day. He did not share his symptoms or seek medical attention. The subject was immediately referred to a physician. **Differential Diagnosis:** Thoracic outlet syndrome, subclavian vein thrombosis. **Treatment:** A regular study radiograph and a weighted study radiograph revealed no significant findings in the right upper extremity. A Basic Metabolic Panel test revealed no significant findings. A Prothrombin Time test and Partial Thromboplastin Time test were positive for increased coagulation. A thrombosis of the right subclavian vein was diagnosed through a duplex venous ultrasound. The ultrasound of the right subclavian vein showed low-level internal echoes and absence of blood flow, indicating the presence of a thrombosis. The patient received an injection of Heparin and was placed on Coumadin therapy for 6 weeks. The following day, the patient received a catheter directed thrombolysis and a balloon angioplasty. The treatment only partially dissolved the thrombosis; therefore, one month later a venous thoracic outlet decompression

was performed. The patient underwent a resection of the right first rib along with an anterior scalenectomy and a subclavian balloon angioplasty. Coumadin therapy was terminated and the patient was placed in a sling for one week. The subject maintained cardiovascular fitness by use of a stationary bicycle 30 minutes daily, 5 times per week at submaximal pace. The patient was cleared to begin normal activities of daily living, non-contact exercises, and rehabilitative exercises to regain strength, flexibility, and range of motion just 26 days following the rib resection. These exercises included pendulums, wall slides, and 4-way wall walking. He progressed from non-contact exercises to sport specific exercises and was cleared to return to play 44 days after the thoracic outlet decompression. **Uniqueness:** A healthy high school athlete with no predisposing conditions presented with a thrombosis in the right subclavian vein. A review of the literature finds that only 1-2% of deep vein thrombosis occur in the upper extremity. Primary upper extremity deep vein thromboses, occurring with a presentation of exertion in combination with an anatomical structure which increases pressure on the subclavian vein, account for 20% of all upper extremity deep vein thromboses. Seventy-six days after the initial diagnosis and 44 days after the thoracic outlet decompression, the patient was pain-free, able to return to his basketball season with full range of motion, and did not present with compromised performance. The return to play is faster than others noted in the literature, which range from 4-6 months. **Conclusions:** An effort induced subclavian vein thrombosis is a rare pathology which presented in a high school basketball player and resolved 44 days after a partial rib section, anterior scalenectomy, and subclavian balloon angioplasty. The subject of this case avoided additional complications and possible fatality due to a prompt referral. Athletic trainers and other health care professionals should be educated on the signs and symptoms

of a subclavian vein thrombosis and understand that this pathology can be atraumatic in etiology, and can affect young, healthy individuals.

14015MC

Upper Extremity Deep Vain Thrombosis In A Healthy High School Division I Baseball And Football Recruit

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Background: The athlete is a 17 year old healthy male who participated in yearlong baseball as a catcher/pitcher both at the high school level and with a traveling team, in addition to participating as a linebacker in football. He had just returned earlier in the week to football after spending the summer traveling the country playing baseball and reported to the ATC complaining of numbness on the lateral side of his right arm and stated that he noticed his arm appeared pale. The athlete did not recall a mechanism of injury; however he did state that his arm had felt tight while throwing the previous evening. On evaluation the athlete presented with 3rd degree edema of his upper arm, 1st degree edema of the forearm, which increased during the evaluation to 2nd degree. Minimal edema was present in the hand but this increased during the course of the evaluation. When compared bilaterally the right upper extremity presented with a slightly paler appearance. Range of motion (ROM) testing revealed a decrease in elbow flexion due to edema. Sensation and strength tests were within normal limits except for decreased sensation noted over the lateral aspect of the shoulder. A radial pulse could not be detected; however, capillary refill in the hand and fingers was normal. **Differential Diagnosis:** Thoracic outlet syndrome, Muscle strain/tendonitis, Upper extremity deep vein thrombosis (UEDVT). **Treatment:** Based on the initial evaluation findings the athlete was referred to the emergency room to rule out UEDVT. Physician's evaluation revealed regular heart rate/rhythm, delayed capillary refill on effected side, 2+ radial pulse bilaterally, edema in right upper extremity up to the level of the shoulder, full strength of the upper extremity, and no deformities or tenderness. Diagnostic Ultrasound was

ordered and revealed a thrombus within the right subclavian vein in which no blood flow was identified as well as a superficial thrombus within the right basilica vein. The athlete was diagnosed with subclavian vein deep venous thrombosis and thoracic outlet obstruction syndrome and immediately prescribed heparin and transferred for thrombus intervention. The following day he underwent an angioplasty, remained in ICU for two days, and continued using anticoagulation (Xarelto) medication until he returned three weeks later for a scheduled 1st rib resection. The athlete was then released from the hospital four days post-surgery and remained on Xarelto. At this time he was prescribed to begin active and passive ROM exercises. Two weeks post rib resection a venogram was ordered which revealed stenosis and another angiogram was performed. The athlete was released for non-contact activity, including football practice, progressive resistance exercises with bands, and hitting baseballs in a controlled environment. He remained on Xarelto for a further 2 weeks. Five weeks post 1st rib resection the athlete received physician release and clearance for full contact and played in his first football game. The athlete continued working on ROM and strengthening exercises for scapular, shoulder, and forearm muscles. At 11 weeks post diagnosis the athlete played without complications in a baseball invitational stating he felt at about 90%. **Uniqueness:** UEDVT occurs infrequently, especially in healthy athletes. There have been case reports of UEDVT with 1st rib resection; however, paucity exists regarding treatment and rehabilitation plans for this pathology. The athlete in this case successfully returned to football 8 weeks and baseball 11 weeks post diagnosis. **Conclusions:** A 17 year old healthy male athlete presents with subclavian vein deep venous thrombosis and thoracic outlet obstruction syndrome. This case provides a base for treatment and rehabilitation of UEDVT. Further, it highlights the importance for more literature regarding treatment and rehabilitation plans for athletes who develop UEDVT.

14019MC

Division I Male Soccer Player With Bicuspid Aortic Valve

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Background: Twenty-one year old male Division I senior soccer player. Player was diagnosed with bicuspid aortic valve (BAV) with aortic regurgitation but no aortic stenosis at age 14 and has received yearly echocardiograms with no change. His sister also has a bicuspid aortic valve. Patient takes Norvasc 2.5mg/day to maintain his blood pressure. Patient discussed the eventual necessity of the Ross procedure with cardiac surgeon to replace aortic valve to decrease regurgitation. He was told any signs to watch for were shortness of breath and chest tightness; patient expressed during pre-participation physicals that he had never experienced any of these symptoms. He was to return to the cardiologist if he experienced any symptoms. During the preseason fitness test, his performance was significantly less than expected from both him and the coaches. He reported chest tightness and shortness of breath, which resolved after resting five minutes. His heartbeat was not irregular. **Differential Diagnosis:** Aortic regurgitation due to his bicuspid aortic valve, heat exhaustion, dehydration. **Treatment:** The patient was referred to his cardiologist, and echocardiogram revealed moderate dilation of his aortic valve. From his symptoms, he was not cleared to return to high intensity activities such as soccer. A stress echocardiogram revealed that atrial systolic function was preserved during exertion, but noted left ventricle dilation. The patient chose to seek a second opinion from a team of specialized physicians. The team ordered a 2D echocardiogram, which revealed a functional BAV with moderate leakage, and classified the results as class 1 using the New York Heart Association guidelines. The team of physicians stated he was cleared for activity since there was no irregular heartbeat and no risk of stenosis

leading to a cardiac emergency. They suggested the episode that occurred during preseason fitness testing was more likely a result of heat exhaustion or dehydration than aortic regurgitation. His return to play was discussed with both parents, who expressed they were comfortable allowing their son to return to full activity. Patient began a return to running program as well as progressive introduction back into practice. He remains restricted in the weight room to less than 50lbs in order to reduce the impact of weight lifting on his blood pressure. Patient claimed this year as a redshirt year since he missed more than half the season with further evaluation. **Uniqueness:** BAV occurs in less than 2% of the population. This case becomes more unique because it occurred in a young highly active athlete as opposed to an older individual. **Conclusions:** This case involved a 21-year old male diagnosed with BAV, who was previously asymptomatic before the fitness test. Due to the reported symptoms, he was referred to his cardiologist and not cleared for activity. After receiving a second opinion from a group of cardiologists who reviewed his case and his echocardiogram, he was cleared to return to participation. This reveals the importance of reviewing pre-participation physicals for pre-existing conditions as well as receiving updates before the beginning of each season. It also shows the importance of receiving specialized second opinions in cases this uncommon. His second opinion was from a team of physicians that specialize in congenital conditions, as opposed to a general cardiologist.

Cardiac Embolism In An 18-Year-Old Collegiate Softball Player

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Background: An 18-year-old, freshman, Hispanic, female, Division I softball player presented with no significant medical history, no known allergies, and an unremarkable pre-participation physical exam. Her only documented medication was the oral contraceptive Beyaz, which she began in July 2012. After team conditioning on September 15, 2012, she was taken to the athletic training room complaining of fatigue and showing signs and symptoms of deconditioning, including strong but elevated heart rate, elevated blood pressure and mild wheezing. After five minutes of monitoring and oral fluids, her symptoms resolved and she was able to return to individual practice later that morning. A week later, on September 22, 2012, she experienced shortness of breath while sedentary. She was immediately taken to the emergency room (ER) for evaluation. **Differential Diagnosis:** asthma, allergies, pneumonia, pulmonary embolism, cardiac arrhythmia. **Treatment:** A chest x-ray and CT in the ER revealed an embolus in her right lung and an echocardiogram revealed an unidentified mass in her right ventricle. The patient was immediately placed on intravenous heparin, discontinued the use of her oral contraceptive, and was transported via air ambulance on September 28, 2012 to Houston, Texas for further cardiac imaging and a consultation with a cardiac specialist. A cardiac MRI revealed a large thrombus in the apex of the right ventricle. Further lab testing determined her clotting occurred due to an underlying autoimmune disorder: Antiphospholipid Antibody Syndrome (APS), triggered by her oral contraceptive use. Upon discharge on October 5, 2012, she was instructed to discontinue all physical activity and prescribed 5mg warfarin daily with weekly appointments to monitor her international normalized ratio (INR) level. A repeat cardiac MRI and chest CT

in December 2012 showed the absence of the cardiac embolism and a decrease in size of the pulmonary embolus. The patient was cleared to begin moderate running and resistance exercise as tolerated and still withheld from contact activity. In February 2013, she experienced insidious lower leg edema. Doppler imaging and chest CT in the ER confirmed the absence of a deep vein thrombosis and no new pulmonary embolus. In March 2013, her hematologist determined the edema was caused by kidney dysfunction and referred her to a nephrologist. After evaluation in April 2013, the nephrologist suspected lupus nephritis, which was confirmed by a kidney biopsy in May 2013. She was prescribed extensive medications for the treatment of lupus nephritis and was medically disqualified from her sport, as her anti-coagulation therapy will continue indefinitely. **Uniqueness:** APS is a rare autoimmune disease affecting 1-5% of the US population. It is more prevalent in women, especially those of African-American or Hispanic descent, between the ages of 20 and 50. Approximately half of all APS patients have another autoimmune disease. APS is often detected after other health problems arise, including deep vein thrombosis, stroke and migraine headaches, none of which affected this patient. She had no risk factors for APS, which include having an autoimmune disease, having a serious infection, or having a family member with APS. **Conclusions:** The patient remains on warfarin indefinitely due to her history of clotting in multiple organs. She has had no other significant medical complications since her diagnosis and remains active in non-contact exercise. Patients taking oral contraceptives should be monitored for increased health risks associated with their use, especially when the medication is first prescribed. Since APS can cause several non-specific symptoms, physicians may not initially test for this disorder. Undiagnosed APS may lead to kidney failure, pulmonary hypertension, chronic venous insufficiency, stroke, and recurrent miscarriage.

Popliteal Artery Entrapment Syndrome Associated With Compartment Syndrome In A Collegiate Basketball Player

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Background: An 18 year old female collegiate basketball player complained of heaviness and pain bilaterally in the lower extremities after playing basketball for approximately five minutes. The symptoms resolved within minutes of discontinuing activity, only to return once she resumed play. Her past history consisted of bilateral exercise-induced compartment syndrome (EICS) of the deep and superficial posterior compartments. The EICS was diagnosed with compartment pressure tests and ultimately treated with single incision fasciotomies approximately eighteen months prior. Upon returning to competitive training, the patient was limited over the next six months as she experienced peroneal and achilles tendonitis and suffered a grade 3 left ankle sprain and a grade 1 right ankle sprain. When the patient finally returned to full competitive training approximately one year after fasciotomy, she once again began to experience symptoms of EICS. She had been managing this with rest and conservative treatment, however at the time of the current complaint she was unable to fully participate in basketball practice. With continued exertion the pain would progress bilaterally from the lower legs to the thighs and was accompanied by paresthesia and significant lower extremity weakness, limiting her ability to jump. Upon assessment in a rested state, the patient did not report any pain or tenderness. She was found to have bilateral tightness in the gastrocnemius-soleus complex with pes cavus and slight internal tibial torsion. Nothing else was remarkable as knee and ankle ranges of motion were normal. **Differential Diagnosis:** Periostitis, medial tibial stress syndrome, EICS, tibia stress fracture, lumbar radiculopathy, lower leg

myopathy, neuropathy, neurogenic claudication, vascular claudication and cystic adventitious disease. **Treatment:** Plain film radiographs and bone scans were negative for bony abnormalities, while magnetic resonance imaging (MRI) of the lower extremity and lumbar spine were negative for soft tissue injury and neural claudication. Electromyography was negative for neuropathy and myopathy and compartment pressure tests were negative. The patient was prescribed Neurontin for the pain and received acupuncture with no relief. Upon follow-up, computed tomography of the distal aorta and lower extremities was negative for stenosis. However, a second MRI with a fast imaging employing steady-state acquisition (FIESTA) technique revealed a functional popliteal entrapment syndrome (PES) with compression of the popliteal artery and vein (Type V) during plantar flexion. Assessment of the popliteal fossa showed a broad based insertion of the medial gastrocnemius causing lateral displacement of the artery and vein. Another more aggressive compartment pressure test revealed compartment syndrome bilaterally in all four compartments. The patient underwent bilateral functional popliteal entrapment releases and bilateral fasciotomies of all four compartments. Rehabilitation, including range of motion and strengthening exercises began following a period of immobilization after surgery. The patient progressed to running and functional activities and now participates fully in basketball activities with only minor discomfort. **Uniqueness:** PES is characterized by an irregular relationship between popliteal vessels and the musculotendinous structures causing a functional occlusion. Our patient suffered from Type V, which involves the artery and vein and occurs in only 7.6% of PES cases. This rare condition typically occurs in young otherwise healthy males. Young athletic women typically present with arterial entrapment alone. The EICS is not typically associated with PES and presented a significant complication to both

the diagnosis and the recovery from this condition. **Conclusions:** PES is a rare but potentially limb-threatening condition affecting predominantly young male adults. This syndrome is difficult to diagnose, presenting a significant challenge to the clinician. Awareness of this condition is a prerequisite for correct and prompt diagnosis. In symptomatic cases of PES, early surgical intervention is the treatment of choice and is important for positive outcomes.

14049SC

Diagnosis Of Subarachnoid Hemorrhage In A 35-Year-Old Male High School Soccer Coach: A Clinical Case Report
Loy CP: Rutgers Preparatory School, Somerset, NJ

Background: A 35-year-old male high school soccer coach slipped and hit his head during practice. He complained of a severe headache that pulsated towards his occipital bone. The patient had no past medical history of head injury and was not on medications. On exam, there were no visible lacerations or deformity over the injury site, cervical spine was non-tender. The right pupil was dilated and the right eye was deviated inferior and lateral. The headache was a sudden onset after he stated that there was a popping feeling in his head. During the evaluation the patient suddenly began to complain of nausea and photophobia. **Differential Diagnosis:** concussion, subarachnoid hematoma, epidural hematoma, subdural hematoma skull fracture. **Treatment:** Based on rapidly worsening status and conduction, the decision was made to immediately refer. An urgent noncontrast Computed Tomography (CT) scan was performed immediately, followed by a lumbar puncture and a Cerebral Angiogram. Patient was diagnosed with a subarachnoid hematoma (SAH). An underlying aneurism was confirmed. The intracranial aneurism was located at the middle cerebral artery bifurcation near the Circle of Willis. Neurosurgical clipping was performed by placing a small titanium clip across the neck of the aneurism stopping blood flow. Ten days following SAH, the patient remained in the neuroscience ICU, where staff watched closely for signs of bleeding, vasospasm, hydrocephalus, and other complications. Magnetic Resonance Imaging (MRI) of the brain showed normal post-op images. The patient returned home two weeks after surgery, and to coaching after 14 weeks. **Uniqueness:** Over 30,000 episodes of SAH occur annually in America.

Risk increases with age and is more common in women of African decent. 10% of patients will die before they reach the hospital, 40% will die in the hospital within one month of the hemorrhage. SAH comprises half of spontaneous atraumatic intracranial hemorrhages, usually as the result of aneurismal, leakage, or rupture. **Conclusions:** SAH is a sudden bleeding between the arachnoid membrane and the pia mater surrounding the brain. SAH is a life-threatening condition and patients must be stabilized and referred immediately. Patients usually present with the sudden onset of 'the worst headache of my life'. SAH is associated with high morbidity and mortality. The importance of early recognition and treatment is equal to the importance of early diagnosis. Diagnosis of SAH requires a thorough history and a very high index of suspicion. Once considered, an accurate diagnosis requires an understanding of the role of diagnostic CT, lumbar puncture, magnetic resonance imaging and cerebral angiography. Athletic Trainers must be able to recognize cardinal features and symptoms immediately. Having the ability to quickly stabilize and deduce potentially life-threatening conditions allows Athletic Trainers to provide optimal care. This case stresses the importance in utilizing an evidence-based approach to establish differential diagnosis when treating medial pathologies.

14021MC

Postural Orthostatic Tachycardia Syndrome In A Division III Swimmer
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Background: A 20 year old female division III collegiate swimmer had insidious complaints of fatigue, exercise induced dyspnea, lightheadedness, headaches, weakness, and vertigo. No previous history of shortness of breath or asthma. No family history of any heart or lung condition. The athlete told the athletic trainers she hadn't changed her diet or sleeping schedule. Athlete was referred for further testing. Blood work was negative. Echocardiogram showed no abnormalities. **Differential Diagnosis:** anxiety, fatigue, depression, Postural Orthostatic Tachycardia Syndrome (POTS), heart pathology. **Treatment:** The athlete was diagnosed with POTS through a table-tilt test. The athlete was strapped onto a table and her blood pressure and heart rate were monitored as the table tilted upwards at increasing angles. The test is complete after 40 minutes, or if the patient faints. Following diagnosis, the team doctor told the athlete to not participate in competitive swimming for a minimum of two weeks after being prescribed selective-serotonin reuptake inhibitors (SSRI), to allow the new drugs start working. The purpose of the SSRI was to increase nerve communication, and control hypotension and syncope. After two weeks off from swimming, the athlete returned to sport. The athlete takes Medilytes before and after practice to balance electrolyte levels. She was instructed to salt her food for every meal. The athlete previously had been taking Florinef (fludrocortisone) at the onset of her symptoms, but is now taking it daily with her SSRIs. Due to Florinef's effects on increasing sodium levels, it is typically the first line of treatment for POTS. She has to consume a minimum

of 64 ounces of water before practice, and drinks Gatorade during practice. The athlete has been advised to get out of the pool as soon as she has an onset of symptoms and to immediately lie down, consume water, and take electrolytes. Since the athlete has been taking the SSRIs and Florinef daily, she has only had one bout of POTS symptoms, two days after she got a flu shot. The team doctor has correlated the flu shot with the reoccurrence of symptoms. The athlete has been medically cleared by the team doctor and her own family doctor to continue competitively swimming. **Uniqueness:** Changes from supine position to standing causes an abnormal increase in heart rate in patients suffering from POTS. There are no accurate epidemiological studies on patients with POTS, or the prevalence of POTS among collegiate athletes, but it is known to occur most commonly in females. Treatment for POTS involves limiting change in position due to the increase in heart rate. This is difficult in swimming as it involves constant position changes resulting in an alteration and increase in heart rate from normal to increased throughout a two hour practice. Competitive swimming is typically contraindicated in people suffering from POTS. The uniqueness of the case is that swimming is a difficult sport to manage with a patient with POTS because of the change in environment. Typically syncope is a common symptom of POTS, but the diagnosing doctor believes since the athlete has been swimming since a young age, her body has adapted to the constant change in position, limiting her fainting. **Conclusions:** POTS is characterized by symptoms of headache, fatigue, weakness, anxiety, dizziness, and shortness of breath. The athlete will continue taking SSRIs, Florinef, and electrolytes daily as well as an increased intake of sodium and water.

Lower Leg Hemihypertrophy Secondary To A Venous Malformation In A High School Multi-Sport Athlete: A Case Report

Leavitt JL, Westerman G, Berry DC, Brooks EK: Saginaw Valley State University, University Center, MI

Background: This case report documents the treatment and outcome of right lower-leg hemihypertrophy secondary to a venous malformation (VM) in a multi-sport (football, basketball, baseball) male 16-year-old (height=170.1 cm, weight=70.3 kg) high school athlete. He remembers beginning to show signs of right lower-leg asymmetry around age twelve. As he aged, he began experiencing painful muscle cramping and twitching, but no signs of discoloration (commonly seen with VM). At fifteen, his signs and symptoms began negatively affecting his athletic performance and activities of daily living. Initially referred to an athletic trainer, he was treated for a muscle strain with no resolution of the symptoms. Unable to control the hypertrophy, the athlete was evaluated by his primary care physician and then a neuroradiologist. Magnetic resonance imaging, computed tomography, and ultrasound testing demonstrated a VM centered within the upper medial aspect of the right calf resulting in the lower-leg hemihypertrophy. His remaining medical history was unremarkable. The neuroradiologist recommended sclerotherapy, which is indicated when VM cause pain and functional or aesthetic problems. **Differential Diagnosis:** Muscle hypertrophy, strain, tumor, deep venous thrombus, venous aneurysm, inadequate/insufficient lymphatic flow/drainage. **Treatment:** With increasing hypertrophy and pain levels the athlete elected for the sclerotherapy procedure over three sessions; with eight-to-twelve weeks between sessions.

Pre-surgical circumference measurements were recorded at the calves (R = 29.6 cm; L = 37.4 cm) and thighs (R = 52 cm; L = 51.4 cm). The sclerotherapy was performed under general anesthesia with IV placement within the right foot. Percutaneous puncture of the VM was centered within the upper medial aspect of the right calf under fluoroscopic and ultrasound guidance. An infusion of 25cc of alcohol mixed with contrast occurred under fluoroscopy to cause apoptosis (cell death) of the endothelial cells lining the veins, thus preventing future growth of the VM and pooling and dilatation of the veins. Following each procedure the neuroradiologist noted significant decreases in the athlete's pain and cramping. There was minimal decrease in the lower-leg's hypertrophy. The athlete wore a custom compression stocking during all activity. In addition the athletic trainer performed lymphatic massage (3x wk, 20 minutes) to further decrease pain and swelling. The athlete was cleared for full participation two weeks following the sclerotherapy. **Uniqueness:** Venous malformations are singular and solitary isolated vascular anomalies in either superficial or deep veins that are abnormally formed and dilated at birth. The most common of all vascular anomalies, VM are not well documented in athletic training. Patients may present clinically as early as age 2; however, presentation may be delayed until later in life as the body develops. Many patients do not realize a problem exists until hypertrophy and edema significantly increase; resulting in chronic, intense pain. In this case, relief from these symptoms occurred with sclerotherapy. **Conclusions:** Venous malformations, as presented in this case, are rare and require further medical attention to manage the pain, edema, and hypertrophy. Special attention should be given to athletes

with chronic muscle cramping, pain, and edema so that a proper referral can be made when conservative care for a musculoskeletal injury is unresolved. Athletic trainers should be made aware of the clinical features of VM to ensure that athletes are not under or undiagnosed. Early signs can be hard to detect and often would not be part of a clinician's differential diagnosis for muscle cramping, pain, and hypertrophy. Early diagnosis and management can decrease the severity of the condition, reduce risk of injury and improve quality of life if early recognition/intervention is provided. A pre-participation physical could initially be used to recognize a VM.

Idiopathic Thrombocytopenic Purpura In A Female High School Swimmer

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Background: Our subject is a 14-year-old female high school swimmer. In early January of 2009, she noticed several idiopathic ecchymotic areas on her body. She frequently experienced headaches and occasionally suffered epistaxis. The subject took a CBC as part of a routine medical check up. This test took place on February 13, 2009. The subject's platelet count was abnormally low at 13 K/cmm (normal range = 150-450 K/cmm), however, other CBC indices were normal. Her signs and symptoms matched those of several acute diseases, and so she was referred to a pediatric specialty hospital for a more complete medical evaluation on February 14, 2009. Upon admission to the pediatric hospital, a new CBC test was performed: platelets- 7 K/cmm, white count- 7.9 with ANC of 4000, hematocrit- 39. **Differential Diagnosis:** idiopathic thrombocytopenic purpura, disseminated intravascular coagulation (DIC), acute leukemia, drug-induced thrombocytopenia, hypersplenism, systemic lupus erythematosus (SLE), human immunodeficiency virus (HIV). **Treatment:** By the process of elimination, a diagnosis of idiopathic thrombocytopenic purpura (ITP). Leukemia was ruled out with a normal white count. ITP presents itself in otherwise healthy subjects who have cases of thrombocytopenia. Subjects with ITP only show signs of bleeding correlated with their low platelet count. To elevate her platelet count, the pediatric hospital gave the subject intravenous immunoglobulin therapy (IVIG). Two days later (2/16/09), the IVIG treatment had elevated her platelet count to 41 K/cmm. The subject spent a total of three days in the hospital. Our subject's platelet labs results in the first five weeks following the diagnosis were: 2/25/09- 3 K/cmm (another IVIG treatment administered at

this point); 3/02/09-122 K/cmm; 3/05/09-181 K/cmm; 3/09/09-126 K/cmm; 3/10/09-123 K/cmm; 3/16/09-26 K/cmm; 3/18/09-17 K/cmm. At this point, she received a treatment of IV WinRho (human antiserum) to raise her platelet count. The WinRho was given in hope of fewer side effects than the IVIG (significant headache and nausea). However, she did not respond well to the WinRho with shaking, fever, and nausea. She did not receive subsequent WinRho or IVIG treatment because of the side effects. **Uniqueness:** Her physicians were hopeful that she had the acute version of ITP. 90% of patients who are diagnosed with ITP will recover within six months. However, since she still had symptoms after six months, she is now considered a chronic sufferer of ITP and will likely have life-long effects of the condition. This condition is more likely to be diagnosed in females (female-to-male ratio is 2.6:1). More than 72% of patients older than 10 years of age are female. **Conclusions:** She has not received any additional IVIG treatments since 2009. The platelet level has bounced up and down until finally maintaining an "acceptable" level of 30-50 K/cmm by reducing stress and fatigue in her lifestyle. Our subject no longer participates in sporting activities. Because of the risk of hemorrhage during childbirth, her physicians recommended she not have children. Hormone therapy helps to regulate her menstrual cycle that has lasted up to 32 days. She also suffers from occasional depression, which she can correlate to times when her platelet counts are lower. She also notices moderately frequent bleeding when brushing and flossing her teeth. Unfortunately for our subject, a simple procedure such as a tooth extraction requires a blood transfusion and a night of hospitalization. Although ITP is a relatively rare condition, athletic trainers need to consider it among the differential diagnoses in those who bruise and bleed easily.

14064UC

Atraumatic Swelling And Discoloration Of The Upper Extremity In A Male Collegiate Baseball Player

Klaine CM, Niemann AM, Charles-Liscombe RS, Sipes B: College of Mount St. Joseph, Cincinnati, OH

Background: A right-handed 21 y/o male collegiate baseball player presented to the athletic trainer with complaints of sudden discoloration and swelling of his right upper extremity (UE) during a team conditioning session. Patient reported performing bicep curls when noting skin color changes. Earlier training during the session included bench press. Patient reported no previous injury to the UE. Physical examination revealed visible tetany of the entire limb spanning from the axilla to the wrist. Range of motion examination revealed normal hand and finger motion and limited elbow and wrist motion. Neurological exam revealed no significant findings. Due to the extreme nature of the swelling and discoloration, exacerbation tests for thoracic outlet syndrome (Allen, Adson, Roos, military brace tests) were not performed. **Differential Diagnosis:** Acute compartment syndrome, lymphedema, Vascular-type Thoracic Outlet Syndrome, Deep Vein Thrombosis (DVT), Paget-Schroetter's Syndrome (PSS). **Treatment:** The patient was referred immediately to the emergency department due to acute onset of symptoms and potential vascular compromised. An UE venous duplex ultrasound and venogram confirmed a 12 cm DVT in the right subclavian vein. Radiographs of the chest revealed a plateau shape of the 1st and 2nd ribs compressing the subclavian vein near the clavicle. Vascular and radiographic evidence confirmed the diagnosis of PSS, a primary exertional upper extremity deep vein thrombosis (UEDVT). Anticoagulant Enoxaparin 80 mg/8 mL every 12 hrs IV was administered in hospital for 5 days and oral coumadin therapy at 2.5-7.5mg daily was prescribed for 6 months. In preparation for a 1st rib resection at week 11, the patient indicated that

his mother suffers from hyperhomocysteinemia, a genetic condition further increasing the likelihood of thrombosis. Following rib resection, he was released into a sling for 10 days and resumed anticoagulant therapy until week 24. During follow up, it was discussed that a left rib resection may be warranted due to the plateau shape of the 1st and 2nd rib and potential risk for thrombosis. At 5 months post rib resection, the patient has gradually returned to play and conditioning without complication or medications and continues to be monitored for symptoms in both limbs. **Uniqueness:** Primary UEDVT occurs 3 in every 100,000 patients in the general population and accounts for approximately 10% of all DVTs. Of these UEDVT, PSS accounts for 10%-20%. Repetitive overhead upper extremity motion involved in baseball throwing combined with overhead resistance training and an anteriorly rotated pectoral girdle likely exacerbated the impingement from the ribs on the subclavian vein. PSS can easily be misdiagnosed as vascular thoracic outlet syndrome as they share similar symptoms, notably complaints of vascular compromise (cold, paresthesia, pain) to the upper extremity. UEDVT has a potential for considerable morbidity because pulmonary embolism is present in up to a third of patients with UEDVT and other complications, such as persistent pain and swelling, superior vena cava syndrome, and problems with vascular access, can be disabling. **Conclusions:** Athletic trainers should be suspicious of acute onset of swelling and discoloration of the UE in the absence of trauma. The combination of an anteriorly rotated pectoral girdle and repetitive overhead shoulder motion can predispose patients to vascular compromise in the UE, especially in those with anatomic alterations of the ribs and thorax. Emergent management includes initiating thrombolytic therapy and monitoring to minimize the likelihood of further complications. Surgical excision and rehabilitation are warranted in those with rib compression of the subclavian vein.

14077UC

Bilateral Subclavian Artery Impingement In A High School Swimmer

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Background: A 16 year old Caucasian male swimmer with a history of intermittent chest and shoulder pain, exertional syncope, exercised induced asthma, costochondritis and spondylolisthesis began complaining of non-specific right shoulder, forearm and hand pain during swimming activities. The patient also complained of paresthesia, coldness, ischemic pain and claudication in the medial aspect of his forearm and fourth and fifth digits with swimming. Physical examination revealed point tenderness over the coracoid, no signs of ecchymosis or edema and no atrophy about the right shoulder. The examination also revealed good strength, normal shoulder and cervical range of motion and normal color, temperature and sensation in his right hand. A diminished right biceps reflex was noted along with positive Allen's and Elevated Arm Stress tests. **Differential Diagnosis:** Peripheral nerve entrapment, cervical disc disease, arterial, venous, or neurogenic thoracic outlet syndrome (TOS), shoulder pathology, vasospastic disorder. **Treatment:** Right shoulder and cervical radiographs, right shoulder magnetic resonance imaging arthrogram and upper extremity electromyography and nerve conduction studies were unremarkable. The patient was referred to a vascular surgeon where Doppler ultrasonography with pulse volume recordings (PVR) and provocative positioning showed absent PVR waveforms and decreased Doppler signal in the right upper extremity with abduction and external rotation. His left arm also displayed decreased PVR waveforms with provocative positioning. Arch aortography with selective bilateral runoff and provocative testing displayed right subclavian artery stenosis and mild post-stenotic dilatation and occlusive stenosis with abduction and

external rotation at the level of the thoracic outlet. High grade near occlusion stenosis was also found in the left subclavian artery at the level of the thoracic outlet with abduction and external rotation. No thrombus or embolization of the subclavian artery or distal vascular bed was observed. The patient was diagnosed with bilateral, right greater than left arterial thoracic outlet syndrome (ATOS) and placed on immediate anticoagulant therapy to prevent thrombus formation and embolization. The patient decided to wait until the left upper extremity became symptomatic and underwent a right first rib resection, brachial plexus neuroplasty and total scalenectomy. Physical therapy consisted of range of motion exercise and general shoulder and scapular strengthening.

Uniqueness: ATOS accounts for less than 1% of all cases of TOS, an already relatively uncommon condition. Furthermore, TOS is more common in females than males and rarely affects those under the age of twenty. Unlike neurogenic and venous TOS, ATOS seldom occurs in the absence of a cervical rib. This was not present in our patient for whom the exact cause is uncertain. Finally, ATOS is rarely diagnosed early in its course before aneurysm and embolization have occurred. **Conclusions:** ATOS is a rare condition, which if unrecognized can result in potentially limb threatening ischemia. Diagnosis of ATOS can be made through an in depth history, physical examination and Doppler studies, and can be confirmed with arteriography. Patients with ATOS often complain of primarily hand symptoms, including ischemia and claudication along with pain, paresthesia, coldness, pallor, erythema and cyanosis, which are often exacerbated with activity. Physical findings are usually those suggesting arterial occlusion including loss of pulse at rest or in a provocative position, color changes and ischemia in the distal portion of the digits. Although many provocative tests have been proposed for TOS, they are nonspecific and commonly result in false positives. In this case a first rib resection, brachial plexus neuroplasty, and total scalenectomy were successful in

ATOS. The patient was able to return to all activities 6 weeks following surgery and has had no recurrence of symptoms. He is now a collegiate swimmer without incident, and his left upper extremity has yet to become symptomatic.

Arrhythmogenic Right Ventricular Cardiomyopathy/ Dysplasia In A Division II Collegiate Baseball Player: A Case Report

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Background: A 24-year-old, previously healthy National Collegiate Athletic Association Division II male baseball player was genetically tested for the presence of Arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D). ARVC/D is a condition that is characterized by the heart tissue dying and being replaced with fatty scar tissue. Patient was tested due to an extended family history, which included his mother, grandmother, and possibly uncle. The genetic testing included a cotton swab test which identified if the patient carried the gene mutation that had the possible ARVC/D trait. Other testing for this disorder included an echocardiogram, stress test, MRI with contrast, and standard blood tests. These tests specifically looked at the structure of the heart, the blood flow in and out of the heart, and any arrhythmias that may be present.

Differential Diagnosis: Arrhythmia, enlarged heart, heart murmur, heart palpitations, angina, long QT syndrome, Wolffe-Parkinson-White syndrome. **Treatment:** The patient was placed on a beta blocker, Metoprolol Succinate after diagnosis. Along with oral medication, the patient had a single chamber Implantable Cardioverter Defibrillator (ICD) implanted. The patient was shocked three times during physical activity due to the set limits of the ICD within two months. Initially the patient's low level was set at 40 beats per minute (bpm) and the high level was set at 200 bpm. The first episode occurred while the patient was jumping rope for 20 seconds. The patient's heart rate jumped to 210 bpm and he was shocked. After this episode the patient's high limit was changed to 210 bpm. The next episode occurred while the patient was doing snatch jumps, the patient's heart rate increased to 213 bpm and he was shocked on the sixth repetition. After this episode the patient's high limit

was reset to 220 bpm. The patient experienced one final episode while running 200 meter sprints at a 34 second pace. The patient's heart rate jumped to 231bpm on the fourth on and he was again shocked. The patient's high level was not changed after the episode and has remained the same since it occurred. The patient's collegiate play would have been suspended if his eligibility had not been completed at the end of the season. Patient was not given any exercise limitations but it was recommended by the doctor to self-limit intensity and frequency of exercise. Since getting the ICD implanted and high level regulated the patient monitors his heart rate and tries to keep it under 170 bpm at all times in order to prevent possible fibrillation and the potential of being shocked. **Uniqueness:** There is a lack of documented research and literature in the presence and diagnosis of ARVC/D in the collegiate aged population. This case also shows uniqueness through the challenges that the patient fought through throughout the beginning stages of the disorder. The patient endured many lifestyle modifications, reaction to the implanted ICD, and medication regimens. The patient was able to participate in physical activity, including a half marathon less than one year after diagnosis. **Conclusions:** Arrhythmogenic right ventricular cardiomyopathy/dysplasia is not a common diagnosis among collegiate aged athletes; because of this, athletic trainers may not be familiar with this condition. However, they should familiarize themselves with this condition as well as its diagnosis, and treatment. It is important to ask specific questions during pre-participation exams about previous heart conditions and family history in order to determine if a heart disorder, such as ARVC/D, could be present in an athlete.

Free Communications, Poster Presentations: Neurologic Case Studies

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14055SC

Unresolved Plantar Fasciitis: A Case Study On Baxter's Nerve Impingement

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Background: Plantar fasciitis is a common cause of foot pain in collegiate basketball athletes; however, its etiology can be difficult to discern, making appropriate intervention problematic. The purpose of this report is to present the case of a 22 year-old, Division III collegiate women's basketball athlete who failed multiple methods of conservative treatment for plantar fasciitis, and ultimately was diagnosed with Baxter's Nerve Impingement. The athlete presented with pain in the plantar aspect of her left foot that was more persistent in the morning and at the beginning of practice. The athlete had pes planus and a history of bilateral chondromalacia patella. She was point tender along the plantar aspect of her left foot and had palpable crepitus along her plantar fascia. **Differential Diagnosis:** The differential diagnosis for this specific case includes plantar fasciitis, stress fracture, flexor digitorum strain, tarsal tunnel syndrome, Baxter's nerve impingement, and sesmoiditis. **Treatment:** During the basketball season the athlete completed rehabilitative treatment five to six days a week with her athletic trainer. Therapeutic interventions consisted of ultrasound, myofascial massage, stretching, strengthening, night splints, orthotics, heel cups, plantar fascia tape for all activity, and ice massage or ice pack. When this six week course of conservative management did not alleviate symptoms, an MRI was requisitioned by the team physician to rule out stress fracture or other abnormalities. After a negative MRI report, the athlete underwent a cortisone injection, which also failed to alleviate symptoms. The athlete finished her senior season without time loss; however, the pain did not resolve. She was then referred to four different physicians over the next year. We attempted a course of low to no impact over the five months following the end of her season; in which she was in a walking

boot for a total of 17 weeks and had not performed any weight bearing activity. During this time period she underwent an EEG and had a series of three more cortisone injections. She was eventually referred to a plantar fasciitis specialist who diagnosed her with Baxter's Nerve Entrapment upon clinical evaluation. The surgeon performed a plantar fascial release and resected the first branch of the Lateral Plantar Nerve, which is known as Baxter's Nerve. The athlete then spent the next three weeks in a walking cast and six more weeks in a walking boot. She started rehabilitation where she began with swimming, non-weight bearing range of motion, joint mobilizations, and strengthening of her foot and calf muscles, slowly progressing to functional activities. She was able to return to full, pain free activity four months after surgery. **Uniqueness:** Although this case seemed to be a typical case of plantar fasciitis, it ultimately was diagnosed as Baxter's Nerve Impingement. It is a fairly common cause of heel pain, but is frequently misdiagnosed. During this athlete's surgery, the surgeon found Baxter's Nerve to be trapped in a maze of varicose veins causing the nerve to be significantly damaged and generating pain in the area of the plantar fascia. **Conclusions:** When faced with a particularly difficult case of plantar fasciitis and when all conservative treatments have failed, there may be other options. In the case of this female basketball athlete, Baxter's Nerve Impingement was causing the pain and dysfunction in her foot. The surgery was highly successful with return to full pain free activity and no recurrent symptoms. Athletic trainers should consider neurological dysfunctions in cases of failed plantar fasciitis rehabilitation.

14032MC

Peripheral Paresthesia In A Collegiate Football Player

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Background: A 22-year-old, male, Division I defensive lineman presented with bilaterally equal upper and lower extremity peripheral paresthesia during an off-season weight training session. The athlete was performing submaximal back squats, with his cervical spine positioned in slight extension, when he began experiencing idiopathic numbness and tingling in his upper and lower extremities. Within seconds of cessation, the symptoms resolved, but returned once lifting resumed. As a result of the reoccurring symptoms, he was removed from all weight lifting activity. Initial evaluation revealed bilaterally equal upper and lower extremity dermatomes and myotomes. Symptoms were not reproducible by any special test or motion. The athlete had a previous history of a left brachial plexus traction injury occurring 4 months prior with symptoms completely resolving two weeks post injury. He had no previous history of cervical spine pathology prior to the initial brachial plexopathy. **Differential Diagnosis:** Spinal cord contusion, spinal cord tumor, demyelinating disease, transverse myelitis, cervical spondylosis, cervical stenosis, cervical myelopathy. **Treatment:** Physician evaluation revealed that he had full range of motion with no focal motor or sensory deficit. He was able to reproduce the peripheral paresthesia with cervical rotation and lateral flexion to the left. Diagnostic imaging consisted of MRIs on his cervical spine and brain, a CT scan of his cervical spine, and bilateral EMG/NCV testing of his upper extremity. The CT scan showed left foraminal narrowing and spinal canal narrowing, but a Torg-Pavlov ratio above 0.7, at the C3-C4 level. The most significant finding from the cervical MRI was evidence of myelopathy involving the spinal cord at the C3-C4 level. The MRI of his brain revealed no evidence supporting demyelinating disease and NCV testing

revealed normal latency, amplitude, and nerve conduction velocities. Additionally, EMG testing showed no evidence of denervation, reinnervation, abnormal motor recruitment, or morphology. As a result of the C3-C4 cervical myelopathy, the athlete was medically disqualified from participation in collegiate football.

Uniqueness: Approximately 11,000 cervical spine injuries due to American football present to emergency rooms in the United States annually. Congenital cervical spinal stenosis is common among adult athletes with the prevalence reported to be between 7.6 and 29 cases per 100 football players. The rapid and insidious onset of this athlete's symptoms and absence of previously related cervical spine pathology contribute to the uniqueness of the case. He had participated in collegiate football and weight training for 4 years prior to this injury without a previous history of neuropathy. Since cervical spinal stenosis can lead to cervical myelopathy, it is unusual to have this type of injury with a Torg-Pavlov ratio within normal limits.

Conclusions: Cervical spinal stenosis and myelopathy are very serious conditions in any level of competitive sports. Trauma, in conjunction with a congenitally narrowed cervical canal, predisposes football players to life threatening conditions. This athlete incurred no life altering pathology as a result of his injury. However, since his condition posed potential life threatening risk, he was medically disqualified from participation in collegiate football. Despite his medical disqualification, he is fully functional with all ADLs, cleared to participate in all recreational sports, and cleared to fully return to weight training. Based on his EMG/NCV results, there was no evidence of long-term neurologic damage from his injury. Athletic trainers must consider all possible differential diagnoses when evaluating cervical spine injuries and make proper physician referrals when warranted. Diagnostic imaging should be utilized in ruling out cervical stenosis and myelopathy in athletes experiencing similar symptoms.

Ulnar Nerve Injury In A Collegiate Football Quarterback

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Background: We present the case of a collegiate football quarterback who suffered an ulnar nerve injury to his throwing arm. A healthy, twenty-two year old, male quarterback was tackled to the ground when another player stepped on the posterior medial aspect of his right elbow. The athlete was initially examined on the field and complained of a sharp pain from his elbow to his hand and an inability to move the hand. There was an open wound on the posterior distal triceps. He had a Tinel's sign at the ulnar groove of his right elbow. On the sideline, the athlete was still unable to flex or extend his 4th and 5th digits. He had a similar nerve injury a few weeks prior that resolved within minutes. At the time of the current injury, he was unable to grip a ball and could not throw without increasing symptoms. Serial sensory and motor examinations were performed throughout the rest of the game, but symptoms did not resolve and the athlete did not return to play. **Differential Diagnosis:** Ulnar nerve contusion, ulnar nerve entrapment, ulnar neuropathy, UCL sprain, triceps contusion, distal humerus fracture. **Treatment:** After the game, the athlete was placed in a sling to help relieve tension on the ulnar nerve and prescribed Naproxen Sodium (550mg). He was seen by the team Orthopedist the next day with the following findings: point tenderness and localized swelling proximal to and around the cubital tunnel, diminished sensation in the distribution of the ulnar nerve as measured by decreased sharp/dull recognition, diminished motor function measured by the inability to extend the 4th and 5th digits, and a Tinel's sign that radiated both proximally, as well as down the length of the forearm. The athlete was placed in a bivalved cast with approximately 20 degrees of elbow flexion to immobilize while sleeping. A diagnostic ultrasound examination of the right

elbow revealed a focal nerve contusion of the ulnar nerve as well as a partial thickness tear of the triceps medial head muscle. Low level laser therapy, pulsed ultrasound, microcurrent and cryotherapy were administered throughout the athletes' recovery with the goals of decreasing inflammation and nerve irritation. A peripheral nerve specialist and a second orthopedic surgeon were consulted as well. After discussions with the specialists and the athlete, it was determined that his throwing should be eliminated as it irritated the nerve. After 2 weeks of treatment he returned to play as a running back with a custom posterior medial elbow pad to help reduce the risk of sustaining a direct blow to the same area. As symptoms continued to resolve he competed in the final three games of his senior season without further trauma. **Uniqueness:** Blunt trauma to the ulnar nerve is relatively common, but the symptoms are typically short lived and do not result in any functional limitations. This case presents the unique situation in which the loss of motor control affected the athlete's ability to properly throw the ball, while leaving the athlete otherwise completely functional. The decision for conservative treatment was based on the clinical exam findings and interpretations of imaging by the physicians as well as the athlete's preference. **Conclusions:** Recovery from nerve injuries can be a lengthy process, and while this athlete was able to return to playing in a game after 3 weeks, his position had to be modified so he could compete.

Dual Thoracic Outlet Syndrome Surgeries And Ulnar Neuropathy In A Female Collegiate Softball Athlete

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Background: In August 2012 a 20-year-old female intercollegiate softball athlete reported gradual onset of right shoulder pain exacerbated by motion and throwing beginning four years ago in April, 2008. In October 2008, she experienced intermittent right hand numbness of the index and middle fingers and diminished grip strength. Nerve conduction velocity testing at the time resulted in a diagnosis of mild-moderate sensorimotor Median neuropathy. Within the following months she reported medial elbow pain with continued numbness and tingling into her hand and was referred to a neurologist. Thoracic outlet syndrome (TOS) was diagnosed and in January 2009, a right supraclavicular thoracic outlet decompression and pectoralis minor tenotomy was performed. In July 2010 the athlete experienced right elbow pain and hand paresthesia. She was diagnosed with mild demyelinating ulnar neuropathy. Conservative treatment at the time included corticosteroids, anti-inflammatory drugs, and neural stretching. A month later she began her collegiate softball career and experienced no relief with conservative treatment. An ulnar nerve decompression and subcutaneous transposition was performed due to failed non-operative treatment. In September 2011, she had a second TOS surgery to remove obstructive scar tissue around brachial plexus nerve roots. Following the surgery, she withdrew from all overhead softball activity. In August 2012, she returned to collegiate softball at another institution as a designated hitter, restricted from any fielding and throwing. Basic shoulder strengthening and stretching was performed 3 times/week to assist with pain free daily activity. A month into training,

during a hitting session, she reported to the athletic training room with nerve pain and numbness along the length of her arm into her 3rd, 4th and 5th digits. Her right hand was cold to the touch, had a noticeable amount of edema and was cyanotic. Activity was immediately stopped and she was referred to the team physician.

Differential Diagnosis: Exacerbation of thoracic outlet syndrome; compression/occlusion of the subclavian vein or artery.

Treatment: The team physician referred her to a vascular surgeon who determined the current signs and symptoms were a result of excess scar tissue and inflammation in the shoulder aggravating the TOS. All activity was stopped for 7-10 days and medication was prescribed for pain and inflammation (Lortab 7.5-500mg, Medrol Pak 4mg, Neurontin 300 mg). Two days later, the athlete self-admitted to the emergency department for pain, nausea and inability to sleep and eat since the initial re-injury. She was released after two doses of narcotic pain relievers. After pain and discomfort only mildly decreased over the following few days, it was recommended by the team physician that the athlete be medically disqualified. Following her release rehabilitation was performed to return to pain free daily activity. **Uniqueness:** Dominant shoulder pain is common in overhead throwing athletes, however neurologic TOS is uncommon. Surgical intervention for TOS is recommended with caution because it can result in complications such as pain, brachial plexus or nerve injuries, and blood vessel damage requiring amputation.

Conclusions: TOS is a serious condition that can result in decreased performance and inability to participate in overhead or physical activity. It is recommended that conservative management and modification of behaviors be the first course of action to take when dealing with a TOS case. Conservative treatment typically includes avoiding provocative activities and arm positions coupled with an individualized rehabilitation program that helps to restore normal muscle balance, flexibility

and strength. In most cases, conservative management is successful, however in this specific case surgical interventions were needed to decrease or prevent symptoms, but were not successful to allow continued participation.

Retinal Detachment Resulting From Indirect Trauma In A Collegiate Pole Vaulter

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Background: A 20-year-old female Pole Vaulter reported to the athletic trainer, complaining of a shadow in the vision of her right eye with 3 weeks of progressively worsening symptoms. She denied any acute distress, or history of acute trauma to the head, face or neck. The athlete reported having symptoms beginning January 7th, after a pole vault competition, that continued to January 28th, when she first reported to the ATC. She was referred immediately to the ophthalmologist. **Differential Diagnosis:** Floaters, retinal tears, retinal detachment. **Treatment:** On January 29th, the ophthalmologist dilated her eyes with tropicamide 1% and phenylephrine 2.5% to obtain images of the retina. The fundus exam of the vitreous, optic nerve, cup-to-disc ratio, macula, retinal vessels and periphery collectively showed damage to the right retina compared to the left. Smaller tears were found in both eyes and a more significant tear was found in the middle of the retina of the right eye, described as a 9 o'clock to 12:30 detachment with a retinal tear at 12 o'clock. The ophthalmologist also conducted an external examination of the lids and lashes, and slit lamp examination of conjunctiva, cornea, iris, anterior chamber, and lens. These findings were normal. Surgery was recommended and on January 30th she underwent right eye Scleral Buckling Retinal Repair. On February 6th she received a prophylactic procedure in order to prevent traumatic tears to the left eye. She was not to wear contacts or participate in physical activity for the first 3 weeks following the procedures, with no visual activity for the 1st week, including reading, writing, and watching television.

When she progressed to pole vaulting after 3 weeks she began wearing goggles and gradually transitioned into contacts after another 3 weeks. The visual acuity in her right eye decreased from -5.75 to -7.75, as evaluated by the optometrist on February 20th. Beginning in August, she reported occasional headaches, which she attributed to computer use. She also reported seeing occasional flashes in her right eye when exposed to bright sunlight. **Uniqueness:** Though pole vault involves skilled falling from 4 meters in the air, it is a repetitive action that can be traumatic. Of retinal detachments in individuals aged 17-19 years, 61.5% occurred with ocular trauma, and 23.1% occur secondary to high myopia without any trauma. In this case, the athlete had moderate to high myopia (-3.00 to -5.00 dioptres; -6.00 dioptres or more, respectively), which predisposed the retina to detachment without a single episode of acute trauma. **Conclusions:** Referral was made to a specialist who diagnosed the athlete with retinal detachment and referred her for a surgical procedure. With a history of high myopia and desire to continue sport/activity, the involved retina was repaired and the other was treated prophylactically. While retinal detachments in sports are often thought to be related to direct trauma, this case was not, and illustrates how myopia and falls in pole vaulting can contribute to the injury. Rapid referral and surgical intervention helped the athlete to retain vision and return to sport.

Shoulder Dysfunction In An Intercollegiate Butterflyer

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Background: A 21 year-old male butterflyer with no significant history presented to the athletic trainer with idiopathic left shoulder tightness, upper trapezius spasm, and difficulty sleeping. Symptoms began two weeks prior and significantly limited his athletic participation. Examination revealed tenderness with palpable trigger points superomedial to the scapula and shoulder abduction and external rotation weakness (3/5). **Differential Diagnosis:** thoracic outlet syndrome, scapular dyskinesis, cervical neuropathy, rotator cuff pathology, labral pathology, subacromial impingement, brachial plexopathy, quadrilateral space syndrome, and suprascapular neuropathy. **Treatment:** The patient was treated with heat, electrotherapy, stretching, kinesiotape, and was referred to the team orthopedist. The physician identified a tight left trapezius and paresthesia into the left upper extremity in the C5-6 distribution with associated abduction and external rotation weakness. The patient was diagnosed with a C5-6 neuropathy and was prescribed heat, manual therapy, skeletal muscle relaxants, and NSAIDs for one week. The patient was cleared for participation with restrictions including limiting the number of strokes during swimming. Status post three weeks, the patient reported a decrease in symptoms; however, he experienced pain while competing. Follow up examination revealed a decrease in trapezius spasms with normal dermatome distribution, left scapular dyskinesis, infraspinatus and supraspinatus weakness, and a positive Roos test. The patient was disqualified from participation and was placed on a rehabilitation program consisting of heat, manual therapy, and therapeutic exercise emphasizing improving glenohumeral and scapular neuromuscular control and stabilization. Status post four weeks, the

patient presented with left upper extremity paresthesia with right cervical rotation, limited active external rotation, and shoulder fatigue while completing the therapeutic exercise program. Status post ten weeks, the patient did not report any upper extremity symptoms with ADLs or during rehabilitation; however, he continued to demonstrate supraspinatus and infraspinatus weakness and fatigue during rehabilitation. The patient was cleared for activity and his return did not elicit difficulty with swimming. Status post 12 weeks, the patient continued to report improvement, but still felt that his arm felt “awkward” during swimming. The patient followed up with the team orthopedist who elicited continued supraspinatus and infraspinatus weakness. The physician recommended adding cervical strengthening to the rehabilitation program. Status post 16 weeks, at the conclusion of the season, the patient reported a paresthesia reoccurrence. Examination by the athletic trainer identified supraspinatus and infraspinatus atrophy. Electrotherapy was reintroduced into the rehabilitation program and the patient was referred back to the team orthopedist, who ordered an MRI. The MRI indicated a normal cervical spine and identified nonspecific supraspinatus and infraspinatus muscular edema which was thought to be a sequelae of a brachial neuropathy without evidence of a cyst. The orthopedist definitively diagnosed the patient with suprascapular neuropathy based on the MRI and evident supraspinatus and infraspinatus atrophy and prescribed an additional four months of rehabilitation. Status post nine months, following off season rehabilitation, the patient was cleared for unrestricted swimming during pre-participation screenings.

Uniqueness: Suprascapular neuropathy is unusual with an incidence rate of less than 0.4% of all shoulder injuries.

Conclusions: Suprascapular neuropathy should be considered with patients presenting with shoulder dysfunction given the similar clinical presentation as other common pathologies. Suprascapular

neuropathy can occur as a result of macrotrauma, compression by a lesion, or in this case traction at the suprascapular or spinoglenoid notch secondary to repetitive stress from extreme shoulder girdle motions found in repetitive overhead activities such as swimming. The insidious onset, paresthesia, atrophy, weakness, and the exclusion of other conditions assisted the medical staff in diagnosing and treating this unique condition. Affected areas can last for months and responds favorably to conservative management encompassing activity modification, medication, physical agents, manual therapy, and therapeutic exercise.

Free Communications, Poster Presentations: General Medical Conditions: Case Studies

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14066UC

Myoadenylate Deaminase Deficiency In A Collegiate Soccer Player

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Background: A 19-year-old (height: 161.29cm; 64.86kg), African-American male collegiate soccer player suffered from sporadic bouts of severe muscle cramping, headaches and malaise brought on after periods of extreme exertion. The patient was tested for sickle cell trait and Fabry's disease, both of which came back negative. An electrocardiogram screening revealed an irregular heartbeat that was determined to be normal for an athlete of his status. Unable to discern the cause of the debilitating episodes, the patient was referred to a rheumatologist who performed a muscle biopsy and identified slightly lower levels of the metabolic enzyme myoadenylate deaminase. Although levels of myoadenylate deaminase were only mildly reduced, it was believed that with extreme exertion, levels would be further depleted. The patient was diagnosed with myoadenylate deaminase deficiency. **Differential Diagnosis:** flu, dehydration, sickle cell trait, and cardiomyopathy **Treatment:** Initially, the athlete was advised to begin a daily regimen of creatine phosphate supplements. Although creatine phosphate supplementation is permitted by the National Collegiate Athletic Association (NCAA), the NCAA does not allow colleges and universities to supply this product to their students when using school funds. As a result, the athlete discontinued taking creatine phosphate and was instead counseled to take 250mg of L-carnitine as well as 200mg of Co-enzyme Q10 daily for his condition. The athlete was also instructed to undergo cold water immersion for at least 10 minutes following all practices and games. Currently, the patient is fully cleared to participate in his sport; however, due to the nature of the sport of soccer and the intensity at which it is played, failure to take the recommended nutritional supplements naturally still results in the

manifestation of symptoms both during and after activity. **Uniqueness:** People suffering from myoadenylate deaminase deficiency are not able to create sufficient amounts of the enzyme AMP Deaminase. AMP Deaminase is part of the metabolic process that converts sugar, fat, and protein into cellular energy. In cells, the deficiency reduces the energy that would be available to the cell. In muscles, excess amounts of adenosine accumulate and signal muscle fibers to feel fatigued. The deficiency also causes muscles to fatigue more rapidly and remain fatigued for longer periods of time. In the brain, excess adenosine decreases alertness and causes sleepiness. Although myoadenylate deaminase deficiency is one of the most commonly inherited muscle disorders in Caucasians, affecting 1 in 50 to 1 in 100 people, the prevalence is significantly lower in African-Americans, affecting an estimated 1 in 40,000 people. The effects of this condition are especially worrisome for the physically active individual because of the potential to diminish exercise capacity and cardiorespiratory responses, as well as to reduce power output and alter blood flow response during some types of activity. **Conclusions:** Due to the infrequency of this condition, particularly amongst African-American individuals, recognition can be challenging. It is important for athletic trainers to learn more about conditions such as myoadenylate deaminase because it can severely affect an athlete's ability to perform. Although myoadenylate deaminase can be a debilitating condition, dietary supplementation with common nutraceutical products such as creatine phosphate or L-carnitine can help offset the effects of this metabolic disorder.

14071UC

Skin Lesions In A Collegiate Softball Player

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Background: A 20 year-old female softball player with no significant history presented to the Athletic Trainer during the fall season with idiopathic erythematous skin lesions over her anterior lower legs that had been present for three weeks. Initial examination revealed no other abnormalities. Immediate treatment consisted of emollient application and referral to the university health center. **Differential Diagnosis:** Dermatitis, MRSA, eczema, psoriasis, and psoriatic arthritis. **Treatment:** The physician preliminarily diagnosed the patient with dermatitis. She was prescribed a corticosteroid clobetasol, instructed to ice the lesions to reduce pain, and report back to the Athletic Trainer for monitoring. After consultation with the patient, the Athletic Trainer referred her to an infectious disease specialist. Status post two weeks, while waiting for the appointment, the patient reported back to the Athletic Trainer after experiencing flu-like symptoms. Follow-up physical examination revealed the lesions had spread systemically, were purulent, and extremely painful with palpation. Status post four weeks, the infectious disease specialist diagnosed the patient with MRSA and prescribed the antibiotic minocycline for four months. The patient reported back to the Athletic Trainer for continued monitoring. Status post four months, the MRSA resolved; however, the skin lesions appeared intermittently over 80% of her body, with flare-ups occurring during times of stress. Additionally, the patient reported experiencing new symptoms including systemic arthralgia, stiffness, and edema at rest and during exertion. Status post six months, still complaining of pain, the patient was referred to a community-based primary care physician. She was definitively diagnosed with psoriatic arthritis based on the history and physical examination and was referred to a dermatologist who confirmed the diagnosis and

prescribed a retinoid tazarotene, vitamin D derivative calcipotriene, and a second round of clobetasol for three weeks. The Athletic Trainer continued to monitor the skin lesions and determined that the topical medications were unsuccessful. The patient was referred back to the dermatologist and underwent ultraviolet A radiation therapy four times a week for four months. The radiation therapy effectively treated the lesions, but the pain persisted. Following radiation treatment, the dermatologist prescribed an immunosuppressant cyclosporine and ordered monthly blood tests to monitor kidney function. Cyclosporine was effective in managing the condition; however, the patient experienced significant side effects including hyperemesis and fatigue. The patient was switched to a different immunosuppressant adalimumab, a weekly subcutaneous injection, which was effective in treating the lesions and arthralgia with manageable side effects. She continues to receive adalimumab and participate in intercollegiate softball. **Uniqueness:** A healthy young adult female with no personal or family history developed psoratic arthritis secondary to a lower leg streptococcal infection and psoriasis. Psoriasis is most commonly seen on the anterior knees and posterior elbows and characteristically begins during childhood. Psoratic arthritis is a unique condition with a prevalence of 0.04% in the United States, with a peak age of onset of 30 to 55 years. Also, psoratic arthritis patients classically present with asymmetric oligoarthritis, while this patient presented with polyarthritis. **Conclusions:** Psoriasis is a skin condition that is difficult to manage and can flair-up throughout life. Psoratic arthritis is an inflammatory condition associated with psoriasis which affects an estimated 5% of people with psoriasis. The etiologies of psoriasis and psoratic arthritis in this case are unknown; however, the streptococcal infection is believed to have triggered the lesions and arthritis and prolonged a definitive diagnosis and management. Individuals with psoratic arthritis can develop disabling chronic arthritis. As such, it is important not to overlook subjective symptoms which

may assist Athletic Trainers in making the correct referrals and providing the emotional support needed to deal with the psychological and physical aspects of managing the condition.

Complex Regional Pain Syndrome In An Adolescent Athlete

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Background: A fifteen-year-old Caucasian male high school basketball and cross-country athlete complained of anterior right leg pain and ecchymosis that extended from the posterior mid-thigh to the mid-calf area. His past history consisted of an avulsion fracture of his left anterior superior iliac spine and a superior and inferior pubic rami stress fracture diagnosed six months prior. Ten days prior to the current complaint, the patient sustained an injury to the right knee while running track. He stated that he made a sharp turn on a gravel path and twisted his knee. He felt a pop and had immediate pain and general instability. Following the initial assessment, a medial collateral ligament sprain and possible bone contusion were suspected. At that time there was no ecchymosis, gross deformity or edema and no sensory complaints. The patient was placed non weight bearing in a knee immobilizer and referred to an orthopedic physician. The patient presented to the physician with an antalgic gait, mild effusion and flexion range of motion limited to 90 degrees. Magnetic resonance imaging revealed only a bone contusion in the area of the medial femoral condyle. The patient was advised to continue wearing the brace and follow up with physical therapy. Upon current assessment, the patient's active range of motion was limited to thirty degrees of flexion however passive range of motion was full. Nothing else was remarkable other than his complaint of pain and ecchymosis. **Differential Diagnosis:** Medial collateral ligament sprain, bone contusion, rheumatoid arthritis, complex regional pain syndrome, reflex sympathetic dystrophy, peripheral neuropathies and nerve entrapment syndromes. **Treatment:** After immobilization and conservative treatment failed to relieve symptoms, the patient was referred a physiatrist to rule out Complex Regional Pain

Syndrome (CRPS). The patient initially presented to the physiatrist with severe bruising and slight discoloration of the right leg. The patient stated that the pain had worsened since the original knee injury and expanded to the entire right leg region. The pain was greater with walking and general weight bearing and was even elicited by changes in weather and light touch. Further examination revealed strong peripheral pulses with slight blue discoloration and bruising over the anterior and lateral aspect of the knee. Slight hyperesthesia was noted on the lateral aspect only. Reflexes could not be elicited secondary to pain. His discomfort was only minimally relieved with analgesic medication. At this point it was decided that a right lumbar sympathetic block with fluoroscopy would be performed at L3 to confirm the diagnosis of Type I CRPS and provide relief. Complete relief was obtained after the initial injection for three days. Following a second injection exactly one week later, the patient reported complete pain relief, normal color and return of functional movement. He returned to physical therapy and was cleared for full activity within a few weeks. **Uniqueness:** The pathophysiology of CRPS remains unclear. It has been suggested that it may include both sympathetic and non-sympathetic pathways, and both central and peripheral neuronal pathways. It is much more common in women and the average age of affected individuals is about 40 years. Recurrence rates appear higher in adolescents than in adults however our patient has not had a recurrence. **Conclusions:** CRPS is often misdiagnosed because this condition is poorly understood. The prognosis is generally much better when the condition is identified and treated as early as possible, ideally within three months of identifying the first symptoms. Aggressive treatment can prevented more permanent and more difficult-to-treat neurodegenerative changes often associated with chronic CRPS symptomology.

Complex Regional Pain Syndrome Type II In A Collegiate Softball Athlete

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Background: An 18year-old, female, collegiate softball athlete complained of pain in her right elbow, August 30, 2012. The athlete heard and felt a pop in the right elbow during a bear crawl exercise, and aggravated later that day when she was lifted by her arms during a ropes course activity. On August 31, she came to the athletic training room complaining of continued pain since the second incident on the 30th. Initial evaluation revealed active elbow range of motion limited to 95° flexion and 20° extension due to pain. Active and passive pronation, wrist extension, elbow flexion and extension all elicited pain. Resisted range of motion, manual muscle tests, and special test were not performed due to pain. Swelling was visible surrounding the lateral epicondyle and muscle belly of wrist extensor mass. The lateral aspect of the elbow was tender to palpation within a two-inch radius of the radial head. No complaint of numbness or tingling. Capillary refill was slow compared bilaterally but present. **Differential Diagnosis:** Proximal fracture of the radius, annular ligament tear, and/or extensor tendon strain. **Treatment:** Immediate treatment included ice and compression wraps, and the athlete was referred to a physician on September 4th. X-rays were unremarkable, and a diagnosis of extensor tendon strain with possible annular ligament involvement was made on September 5th. Over the next three weeks the athlete was instructed to maintain the injured arm in a sling with a wrist brace cocked in extension at all times, but was advised to use the arm as tolerated. The elbow and forearm were iced daily to decrease inflammation and pain. On September 8th the athlete noticed increased swelling and intermittent paresthesia in digits 2-4, which progressed

to constant paresthesia of increased intensity during pronation and wrist extension by September 10th. At this time, the physician ordered a Contrast-MRI of the elbow. The MRI was negative, and treatment continued as previously described in hopes that rest would reduce the symptoms. Although paresthesia persisted, on September 18th, the athletic trainer observed changes in skin coloration and temperature on her right arm and hand. Although an October 2nd nerve conduction velocity test revealed no abnormalities, the athlete was diagnosed with complex regional pain syndrome (CRPS) type II on October 10th. It was not until a therapy session in the spring of 2013 that it was observed her right ulnar nerve was subluxing from the cubital tunnel, leading to an ulnar nerve translocation surgery on May 9, 2013. **Uniqueness:** CRPS is a chronic disease process associated with dysregulation of the central or autonomic nervous systems. CRPS Type II is the most severe form of CRPS, and is a diagnosis restricted to CRPS associated with evidence of obvious nerve lesions. In the case presented here, diagnosis of CRPS type II was made with neither a known mechanism for nerve damage, nor a diagnosis of a nerve lesion. It was well after the rare diagnosis of CRPS II that the innocuous and relatively common diagnosis of subluxing ulnar nerve was made. **Conclusions:** Complex regional pain syndrome type II is very rare in a young, healthy, athletic population. However, a diagnosis of a subluxing ulnar nerve is relatively common in young, healthy athletes. A review of the literature revealed that nerve conduction velocity tests may be of little value for a mildly subluxing ulnar nerve, even though the nerve may be mechanically damaged. It is important for the athletic trainer to remember that any repetitive trauma to a nerve, with or without overt symptoms, may result in a dysregulation of the autonomic nervous system, and potentially CRPS if left untreated.

Pancreatic Transection In A High School Soccer Player

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Background: The patient is a 17 year-old soccer player who was kneed in the stomach as she was jumping to head the soccer ball during a game. She was in a position of trunk extension when she was struck. The patient immediately felt as if she had the “wind knocked out of her” and as if she could not “catch her breath”. She complained of a constant, stabbing pain under her left costal margin. The patient was removed from the game and was not allowed to return to competition. While walking to her vehicle after the game, she complained of pain radiating to her lower abdomen. At the time of injury, the patient reported a pain quotient of 6/10 and following the game, she reported an increased pain quotient of 9/10. Because the patient was without orthostatic symptoms when observed by two physicians on the sidelines, she was not immediately referred for follow-up care. Instead, she returned home after the game and attempted to sleep. Over the next several hours, the patient experienced a further increase in pain, developed nausea and began vomiting. At this time, the patient was referred to the emergency department where CT scans of the abdomen and pelvis were performed. **Differential Diagnosis:** Abdominal pain after left upper quadrant trauma could result in splenic fracture, internal organ damage, solar plexus injury, injury to the costal margins, or muscular trauma. **Treatment:** The CT scan demonstrated a pancreatic transection with hematoma formation. The patient underwent emergency surgery to remove her pancreas. A splenectomy was also required due to the close association of the splenic artery with the pancreas. However, sufficient pancreatic tissue was preserved so

that the patient does not suffer from diabetes as a result of the injury and surgical intervention. **Uniqueness:** The pancreas is the tenth most commonly injured internal organ, accounting for fewer than 10% of all injuries related to blunt force abdominal trauma. Due to its anatomical location, pancreatic injury, in the absence of other internal organ damage occurs in fewer than 5% of all cases. Unlike splenic injuries, little data exists to support the presence of pre-existing primary or secondary disease of the pancreas resulting in higher injury rates. Post-injury development of pancreatitis and diabetes mellitus is fairly common following trauma and/or surgery. **Conclusions:** Pancreatic transections, although rare, can occur in athletics and prompt recognition and treatment are critical for positive patient outcomes. When the trunk is extended, the pancreas is susceptible to injury by being compressed against the spine. Patients with delayed diagnosis and treatment following an acute traumatic event suffer a much higher rate of morbidity and mortality. Pancreatic transection is an important part of the athletic trainers’ differential diagnosis following blunt force abdominal trauma.

Medicine

ICC Exhibit Hall I; Thursday, June 26, 10:00AM-5:00PM; Friday, June 27, 10:00AM-5:00PM; Saturday, June 28, 10:00AM-1:00PM

Authors present June 26: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

14073UC

Symptomatic Os Acromiale In A Collegiate Women's Tennis Player

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Background: A 19-year-old female NCAA Division I collegiate tennis player presented with right shoulder pain following a competition in the spring of her sophomore season. She initially complained of a snapping sensation and pain over the posterior aspect of her shoulder, which was diagnosed and treated as rotator cuff tendonopathy. Clinical evaluations yielded positive findings for Hawkins-Kennedy, Empty can, and Obrien's tests. **Differential Diagnosis:** Rotator cuff strain, rotator cuff impingement, labral pathology. **Treatment:** The shoulder pain did not subside with rest over the summer, and the athlete was referred to a team orthopedist for further evaluation prior to her fall season. X-rays revealed an unfused acromial apophysis at the meso-acromion, also referred to as os acromiale. Following diagnosis, the athlete completed six weeks of rehabilitation with an emphasis on rotator cuff strengthening and scapular stabilization with restricted participation in overhead activities. Two weeks into rehabilitation, the athlete began to complain of numbness and tingling in her right fourth and fifth digits, as well as swelling of the dorsal surface of her hand and heaviness in her involved shoulder. She was referred to the team orthopedist and was diagnosed with secondary Thoracic Outlet Syndrome. In order to relieve her symptoms, first rib and scapular joint mobilizations were incorporated into the rehabilitation regimen. The athlete completed four more weeks of rehabilitation without recurrence of neurological symptoms and gradually increased her practice time from 35 to 120 minutes. Anti-inflammatory medications were consistently taken and a cortisone injection was administered to help relieve pain and inflammation. Despite all intervention attempts, the athlete did not have any reduction in pain and began to show psychological distress toward

the situation. She was once again referred to the team orthopedist who ordered a MRI of the right shoulder without contrast. MRI results confirmed the presence of the os acromiale, but no other remarkable findings were reported. The athlete was cleared for full participation by the team orthopedist and competed in a tournament the following weekend without incident. During participation, the athlete was advised to wear a Sully brace for support in conjunction with a modified acromioclavicular McConnell taping. She also began individual consultations with the team sport psychologist to decrease anxiety as recommended by her athletic trainer. The athlete was able to successfully complete the remainder of her fall tennis season. Conservative rehabilitation and treatment will continue unless symptoms worsen. **Uniqueness:** Os acromiale is a rare condition occurring in approximately 8% of the population with most cases being asymptomatic and in black males. A majority of cases require surgical intervention by acromioplasty or open reduction and internal fixation. In this case, conservative management will proceed pending sufficient pain control and her return to a competitive level. It is also unique that there was no associated rotator cuff pathology found on the MRI, which is usually present with os acromiale. The isolated episode of secondary Thoracic Outlet Syndrome also differentiates this case from others. Such associated conditions have yet to be reported in the literature. **Conclusions:** A collegiate women's tennis player who presented with possible rotator cuff pathology was found to have os acromiale of the right shoulder. The condition was treated non-surgically with topical anti-inflammatory medications, rotator cuff strengthening and scapular stabilization, as well as prophylactic taping and bracing. Pending the reoccurrence of secondary Thoracic Outlet Syndrome or an increase in pain, the athlete will participate fully for her junior spring season.

14029MC

Congenital Variation In The Distal Ulna And Subsequent Extensor Carpi Ulnaris Subluxation In A Female Tennis Athlete

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Background: A 20-year-old female collegiate tennis player presented with left wrist pain. She reported pain is greatest during backhands and with forearm rotation during any tennis activity. Athlete reports a history of falling on outstretched arm out of a car in January of 2012, along with on and off wrist symptoms since that incident. Reports previous x-rays, which revealed no bony damage and was treated conservatively as a wrist sprain following the initial mechanism. Physical examination revealed localized pain over the dorsal lateral aspect of wrist with wrist extension, ulnar deviation along with supination and pronation. Athlete was tender to palpation over the lateral wrist joint, ECU tendon and the triangular fibrocartilage complex. The athlete was referred to the team physician for further evaluation. **Differential Diagnosis:** wrist extensor tendinopathy, wrist extensor sprain, triangular fibrocartilage complex tear/injury, and possible ulnar stress fracture. **Treatment:** Physician examined the athlete and ordered an X-ray, which was negative for fracture. Athlete received an injection in her lateral wrist for TFCC pain and had pain relief for 2 months until her symptoms began re-occurring. At this time the athlete realized that during active supination her forearm tendon was snapping, which was at the site of the extensor carpi ulnaris (ECU) tendon which appeared to be subluxing. Athlete was referred to a hand surgeon who ordered an MRI that revealed a longitudinal tear of the ECU and a shallow ulnar groove. The hand surgeon recommended surgery to deepen groove and stabilize the ECU in order to continue tennis. The athlete agreed and underwent surgery and was immobilized in a long arm removable splint with the elbow flexed to 90° and neutral forearm rotation for 4 weeks. This type of

splinting was necessary to allow adequate bone healing and remodeling. Following 2 weeks of complete immobilization periodic brace removal was allowed to initiate active elbow flexion and extension only to minimize stiffness. At 4 weeks post-operatively, assisted passive range of motion of static flexion, extension, supination and pronation was started to regain full motion. Each position was held for five minutes for three repetitions each direction twice daily. Manual overpressure in pronation and supination near end ranges was started on 4.5 weeks post-operatively. Five weeks post-op the athlete was allowed to initiate hitting and progress back into practicing wearing a long-arm hinged elbow brace that restricted forearm rotation. Simultaneously, the athlete began completing isotonic strengthening exercises and using a gyroscope device called a "Powerball". As the athlete regained supination and pronation, she was progressed to a more functional short-arm wrist brace. At 3 months post-op, the athlete began hitting 2 handed backhands. The athlete has been cleared for full participation and gradually progressed back into hitting full court backhands and participating in matches. **Uniqueness:** The congenital variation of the shallow groove was a surprise to the hand surgeon that she did not present with symptoms earlier without the traumatic event. The surgeon warned the athlete prior to surgery, that this operation might have been career ending, however in this case the athlete has returned to sport with no issues and is performing better than she was prior to surgery. **Conclusion:** Even in the event of a traumatic event, congenital variance can be a cause of pain. Post-operative compliance and teamwork of physician, patient, and athletic trainer can result in better than expected outcome. The static sustained stretches allowed athlete to regain range of motion while protecting the repaired tendon and bone. The athlete has now returned to full competition with no wrist pain and is looking to play on the professional tennis circuit.

Accessory Soleus In A Collegiate Women's Lacrosse Player

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Background: On January 20, 2011, an 18 year old freshman Caucasian female collegiate lacrosse player reported to the athletic training room complaining of bilateral lower leg pain which was believed to be due to new footwear and an increase in conditioning. Tenderness to palpation noted along the belly of the gastrocnemius/soleus. No tenderness along the tibia. The left leg was more painful than the right. Observation revealed bilateral swelling, which was greater in the left. ROM revealed decreased active and passive left ankle dorsiflexion by 20 degrees.

Differential Diagnosis: Tendonitis of the lower extremity, chronic posterior compartment syndrome, tarsal tunnel syndrome.

Treatment: Initial treatment for this lower extremity pain and swelling included complete rest, cryotherapy and the use of compression socks. Over the course of the next 2 ½ months conservative management included: NSAIDs, transition to walking boot, Kinesio tape, achilles taping, heel lifts, activity modification, superficial hot and cold modalities, and therapeutic exercise to stretch and strengthen the anterior and posterior lower leg, ankle and foot musculature. Rest and conservative treatment resulted in symptom and ROM improvement, but not resolution. In April 2011, the athlete was referred for an MRI by the team physician. It revealed an accessory distal attachment of the soleus in left lower leg. Specifically, the accessory soleus originated from the deep fascia of the soleus muscle and had a separate insertion, anteromedial to the Achilles tendon. The athlete continued to train as tolerated and in February 2012 she reported with increased pain, swelling, visual muscle bulge, medial lower leg pain and shooting pain into her toes. By April 2012 she presented with decreased dorsal pedal pulse

and "cold toes" on the left. She was evaluated by an orthopedic foot specialist diagnosing her with chronic exertional compartment syndrome. He recommended excising the accessory soleus. The athlete received a second opinion and chose to undergo surgery for bilateral compartment syndrome in the summer of 2012. This surgeon did not excise the accessory soleus muscle in the left leg because she felt the cause of the symptoms was primarily related to the compartment syndrome. The athlete was able to return to activity, but the pain, swelling and compartment symptoms returned after 3 months. While she continues to participate in lacrosse at the collegiate level, her symptoms persist. **Uniqueness:** The accessory soleus muscle occurs in only 0.7-5.6% of the population and can present with one of many alternate origins and insertions. The prevalence is 2:1 with male predominance. The accessory soleus muscle occurs very early in development and patients are rarely symptomatic. Those who have symptoms are typically adolescents and present with lower leg swelling. This female athlete was asymptomatic until college and presented with a wide variety of symptoms that are noted in the literature; however these symptoms are also representative of other common lower extremity conditions seen in the physically active population. The literature suggests that in symptomatic patients the accessory soleus muscle can be surgically removed because it is enclosed in its own fascia, which is known to be inflexible and cause exercise-induced compartment syndrome. The fact that this athlete continues to have symptoms post fasciotomy indicates that the accessory soleus muscle was, and still is, the root cause of her symptoms.

Conclusions: While the presence of an accessory soleus is rare, the symptoms can easily be confused with other more common lower extremity overuse conditions. A lack of familiarity with this condition can lead to misdiagnosis. Clinicians should consider the presence of an accessory soleus muscle when treatments for other common lower extremity overuse injuries have failed.

Os Odontoideum In A Collegiate Softball Player

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Background: 18-year old female college softball player presented with parasthesia into her right hand when throwing. The patient also complained of cervical instability during prolonged sitting, such as test-taking, noting it felt as if (her) "head was slipping forward." No history of shoulder, neck, or back injury, and no history of neurologic disorders. **Differential Diagnosis:** Thoracic Outlet Syndrome, Subacromial impingement, Brachial plexus neuropathy. **Treatment:** Physician evaluation revealed decrease in sensation and grip strength in patient's right hand. A nerve conduction EMG and x-rays in the anterior-posterior, lateral, and transverse views yielded no significant findings. Initial physician diagnosis was thoracic outlet syndrome due to positive Military Brace, Adson's, and Allen's tests. When conservative treatment failed, patient was referred to cervical spine surgeon. X-rays with an open mouth revealed nonunion of the odontoid process. Flexion and extension views revealed cervical instability in both the anterior and posterior directions. Patient underwent a posterior fusion and fixation with posterior wiring of C1-C2 using an autograft of the Iliac Crest. Rehabilitation lasted 1 year with only temporary relief of instability or parasthesia symptoms. A follow-up appointment 13 months post-surgery revealed incomplete bony fusion on radiographs. The patient was then referred to a neurosurgeon for another opinion. Eighteen months after the first surgical intervention, the patient underwent a lateral mass with pedicle screw and plate fixation, again using an iliac crest autograft. This surgery successfully created stability of the atlantoaxial joint, but decreased the patient's range of motion by 20 degrees in rotational and lateral flexion directions bilaterally. The loss of range of motion

resulted in medical disqualification from contact sports. Follow-up interviews with the patient revealed that she is active playing golf. **Uniqueness:** Diagnosis of os odontoideum typically occurs in children and often involves falling from a height as a mechanism of injury. No cases of diagnosis or treatment in competitive athletes have been reported. In addition, it is rare even in diagnosed cases to experience neurologic symptoms, and even rarer to have radiographic evidence of both anterior and posterior instability. The best method of surgical repair is still inconclusive. In most published literature, both surgical techniques resulted high rates (96-100%) of successful bony fusion. This patient required two different techniques before stability was achieved. **Conclusion:** Os odontoideum is a rare but serious cervical instability condition in which the diagnosis and surgical management is still being researched. With no mechanism of injury, it is imperative to continue searching for underlying causes of cervical instability when conservative treatment and diagnostic options fail.

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