JOURNAL OF ATHLETIC TRAINING

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Dear NATA Members and Friends:

We are pleased to present the annual Supplement to the Journal of Athletic Training. This Supplement contains abstracts presented at the 2015 NATA Clinical Symposia & AT Expo in St. Louis, Missouri as part of the NATA Foundation Free Communications Program.

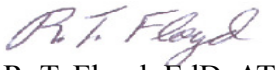
The Free Communications Program provides certified athletic trainers, students and other healthcare providers an opportunity to present and learn about the latest in athletic training research. Research is presented in oral and poster formats and includes general research, NATA Foundation-funded research, 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 Convention in Missouri 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: Steven Broglio, PhD, ATC; Thomas Buckley, EdD, ATC; Kenneth Cameron, PhD, MPH, ATC; Jeff Driban, PhD, ATC, CSCS; Jennifer Earl-Boehm, PhD, ATC; Blaine Long, PhD, AT, ATC; Stephanie Mazerolle, PhD, ATC; Brendan McDermott, PhD, ATC; Melanie McGrath, PhD, ATC; Sara Nottingham, EdD, ATC; Charles Thigpen, PhD, ATC, PT; Kavin Tsang, PhD, ATC; ATC; Erik Wikstrom, PhD, ATC, LAT 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 St. Louis. 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,

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

JOURNAL OF ATHLETIC TRAINING

Official Publication of the National Athletic Trainers' Association, Inc Volume 50, Number 6, Supplement, 2015

Table of Contents **Moderator** **Page**

Free Communications: Room 131
Wednesday, June 24, 2015

Thursday, June 25, 2015

Friday, June 26, 2015

Free Communications: Room 132
Wednesday, June 24, 2015

Thursday, June 25, 2015

Free Communications, Poster Presentations: America's Center Exhibit Hall C

Awards

Index

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

Brian Pietrosimone, PhD, ATC
University of North Carolina at Chapel Hill

Beginning at Springfield College with an interest in science and medicine, Brian Pietrosimone got into athletic training without knowing much about what the field entailed: "Maybe I'll apply because it seems like it would be interesting and easy." It wasn't easy, but the people at Springfield helped him to understand the importance of sports medicine and the influence that athletic trainers could have on athletes and the physically active. From the start, Pietrosimone was always asking, "Why certain interventions for certain injuries?" He learned that there often wasn't enough evidence to justify why he treated patients in a particular way. His time at Springfield College was one of the most inspiring periods of his life. Pietrosimone credits Sue Guyer, DPE; Mary Barnum, EdD, ATC; Charlie Redmond, PT, ATC; Barclay Dugger, ATC, LAT; Wayne Rodrigues, MEd, ATC; and Bob Bergquist, MSc for encouraging him to think past the obvious and helping to develop a sense of purpose for his career.

Pietrosimone pursued his master's and doctoral degrees at the University of Virginia's Curry School of Education. Although he read a great deal of research as a student, the thought that he would ever be able to create something himself to help health care professionals or improve clinical practice seemed impossible. However, he was encouraged by many mentors to develop new ideas that would improve the lives of the patients that he and other clinicians treated on a daily basis. During his time at the University of Virginia, he worked as a graduate assistant athletic trainer, gaining clinical experience, teaching undergraduate courses, and mentoring student research projects in the Exercise and Sports Injury Laboratory. Pietrosimone acknowledges the hard work and countless hours that his UVA mentors—Ethan Saliba, PhD, PT, ATC; Chris Ingersoll, PhD, ATC, FNATA, FACSM; Sue Saliba, PhD, PT, ATC, FNATA; Jay Hertel, PhD, ATC, FNATA, FACSM; Joe Hart, PhD, ATC; Kelli Pugh, MS, ATC, CMT; and Andy Baker, MS, ATC—spent challenging him and his ideas while developing his passion for sports medicine research.

Much of Pietrosimone's research has focused on lower extremity joint injury because "these injuries cause a lot of disability in the United States" and can be a gateway to many inactivity-related conditions later in life. Although sports medicine research is often directed at returning the athlete to play quickly, many patients will spend more years of their life as nonathletes than as competitive athletes. Maintaining physical activity throughout the lifespan can become difficult due to the long-term effects of joint injuries sustained during competitive sports.

Pietrosimone noted that when preparing patients for return to activity after anterior cruciate ligament injury, the goal of clinical rehabilitation is typically to recover 85% strength and function. He has often asked why: "What is magical about 85%? Why not try for 100%?" In an effort to improve physical function after multiple types of knee injuries, he has pursued research that seeks to improve neuromuscular activation with the goal of

enhancing the outcomes of traditional rehabilitation. In collaborations with faculty and students, Pietrosimone has already worked on developing multiple modalities to improve neuromuscular function and enhance the outcomes of traditional therapeutic exercise. When asked which modality he feels is currently most promising for achieving those goals, he stated, "It may be too early to tell. Transcutaneous electrical nerve stimulation (TENS) was the first modality I worked with. TENS is a practical modality for this purpose because it is cheap, easy to use, and better tolerated by patients than other forms of electrical stimulation." He looks forward to seeing how clinical trials of these modalities progress in the future.

Now in the Department of Exercise and Sport Science at The University of North Carolina at Chapel Hill, Pietrosimone continues to focus on treating the long-term effects of knee injury. An acute injury to a joint leads to a higher likelihood of chronic degeneration, which often affects the patient long after the competitive career is over. He hopes that his work will offer clinicians ways to return injured athletes to full function, maintain long-term joint health after injury, and develop programs that will prevent posttraumatic osteoarthritis.

Pietrosimone is excited by the role athletic trainers can have in preventing early chronic joint diseases after acute joint injury. Osteoarthritis is not an inevitable disease that occurs only in the elderly; instead, early-onset osteoarthritis may be the fate of many athletes who sustain joint injuries in their teens and twenties. Because there is no cure for osteoarthritis, preventing the development of osteoarthritis is critical after a traumatic joint injury. Athletic trainers are well positioned to prevent the development of early osteoarthritis after an injury, which will make a profound difference in the lives of their patients.

Outside of his research, Pietrosimone enjoys hiking with his dog and any outdoor activity, but he has a great deal of fun with his work. He has published more than 50 articles, presented more than 100 peer-reviewed papers, and been invited to speak at many symposia. He mentors undergraduate and graduate research and has served on master's thesis and doctoral dissertation committees at the University of Virginia, University of Toledo, and University of North Carolina at Chapel Hill. Pietrosimone is a member of the American College of Sports Medicine, Society for Neuroscience, and National Athletic Trainers' Association; serves on numerous advisory committees; and reviews manuscripts for several journals, including the *Journal of Athletic Training*, where is a member of the Editorial Board.

In addition, to his mentors at Springfield College and the University of Virgina, Pietrosimone is very grateful for the knowledge and inspiration that he has received from numerous colleagues. Some colleagues who have had a major influence on his previous work include Phillip Gribble, PhD, ATC, FNATA; Abbey Thomas, PhD, ATC; Kate Pfile, PhD, ATC; Terry Grindstaff, PhD, PT, ATC; Jeff Driban, PhD, ATC; Troy Blackburn, PhD, ATC; Joe Myers, PhD, ATC; and Darin Padua, PhD, ATC. Pietrosimone is especially thankful for being able to work with Adam Lepley, PhD, ATC; Hayley Ericksen, PhD, ATC; Masafumi Terada, PhD, ATC; Michelle McLeod, PhD, ATC; Matthew Harkey, MS, ATC; and Brittney Luc, MS, ATC, during their time as doctoral students, as their excitement for research and intellect inspire him on a daily basis.

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

David R. Howell, PhD, ATC
The Micheli Center for Sports Injury Prevention - Boston Children's Hospital

As a young student at Whitworth University in Spokane, Washington, David Howell was thrilled to learn that athletic training blended the fields of sports medicine and science. Program Director Russ Richardson, EdD, ATC, introduced Howell to the "service-based nature of athletic training": aiding others and working in conjunction with other sports medicine professionals sounded appealing. As he progressed in his undergraduate studies, Howell knew he was in the right field when he earned the Athletic Training Distinction Award.

Upon graduating, Howell began his professional career at Whitman College as an assistant athletic trainer. While covering a variety of sports, he saw numerous athletes with concussions and "started to realize I don't really know anything about what is happening to the brain during these injuries." The way he first learned to identify and manage a concussed athlete was not necessarily based on evidence. Not only is a concussion a scary injury for the athlete, but Howell also found that it was difficult to explain the injury to parents and coaches. When patients had prolonged symptoms, he felt helpless because little research at the time indicated how to best treat persistent concussion symptoms. This sparked his desire to investigate the theory behind how we diagnose and manage concussions. Howell was fortunate because his craving for discovery came at a time when the University of Oregon was looking for a graduate student to study the effects of concussion on gait in its biomechanical laboratory.

Howell pursued his master of science degree and then his doctorate in the Department of Human Physiology at the University of Oregon under the mentorship of Li-Shan Chou, PhD, and Louis Osternig, PhD, ATC. Combining laboratory research with clinical experience allowed Howell to see firsthand how athletes progressed after concussion over time on a variety of measurements.

The focus of his research has been on how concussions affect attentional abilities and how to effectively, accurately, and feasibly measure these deficits. By using a dual-task paradigm—walking and thinking simultaneously—his research investigates how individuals recover from concussion in real-life situations and has the potential to reveal deficits that might otherwise go unnoticed. "People must move and think all the time during sport. When returning to the field after concussion, it may be more difficult to rapidly process all incoming information and protect yourself from further injury than when healthy." Going forward, Howell hopes to adapt such test protocols into a cost-effective objective measurement that athletic trainers will be able to use on the sidelines and in the clinic to evaluate athletes with possible concussions. Accurate measurement techniques and proper treatment protocols for concussions may prevent athletes from returning to sport too soon or developing long-term symptoms or deficits by providing useful information to those making return-to-play decisions.

As a part of the sports medicine research community, Howell noted that it is difficult to stay up to date with the latest information, but failing to do so can put patients at risk. Keeping an open mind in clinical evaluation and management and "being open to using new, evidence-based methods to work with the sports medicine team" to best treat the patient will best serve the athletic community.

Howell's newest pursuit is as a postdoctoral researcher at the Micheli Center for Sports Injury Prevention in Waltham, Massachusetts, and the Division of Sports Medicine at Boston Children's Hospital, where he works with a multidisciplinary group of researchers and clinicians. In addition to continuing his research, he hopes to eventually teach at the undergraduate or graduate level and include young scholars in his investigations.

Howell won the 2014 World Congress of Biomechanics' doctoral-student article competition in the category of Human Locomotion. He is a member of numerous professional associations, including the International Society of Biomechanics, Society for Neuroscience, National Athletic Trainers' Association, and American Society of Biomechanics.

His wife, Emily, who is originally from Colorado, has given unconditional, tremendous support to all he does, and both are thriving in their new New England home. They enjoy being outside hiking, running, and skiing and view the cross-country move as an opportunity to explore a new area.

Others Howell would like to thank from the University of Oregon are Li-Shan Chou, PhD, for his amazing guidance and mentorship and for allowing him to develop as an independent researcher and to Louis Osterning, PhD, ATC, for paving the way for athletic training research and providing never-ending support. Sierra Dawson, PhD, ATC, and Jon Runyeon, MS, must also be thanked for their innumerable contributions to his professional development, as well as Kim Terrell, MS, ATC; Travis Halseth, MS, ATC; and Kevin Steill, MS, ATC, for their support of his research goals during his clinical responsibilities as part of the master's program at the University of Oregon. At the Micheli Center, Howell is grateful for his mentor, William Meehan, III, MD, who is a staunch supporter of his research interests. At Whitworth University, Russ Richardson, EdD, ATC; Mike Ediger, DHSc ATC; Todd Sandberg, MS, ATC; Jon Bosh, MS, ATC; and Melinda Larson, MS, ATC, were instrumental in his progression as an athletic trainer and as a professional. Howell also recognizes and thanks David Perrin, PhD, ATC, FNATA, FACSM, for providing a research framework for athletic trainers. Finally, Howell is grateful to his parents, Bob and Patty Howell, who have supported every endeavor he has pursued.

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.

Ankle Evidence-Based Forum: Improving Sensory Function After Ankle Sprain

Wednesday, June 24, 2015, 8:00AM-9:00AM, Room 130; Moderator: Erik Wikstrom, PhD, ATC, FACSM
Discussants: Matthew Hoch, PhD, ATC; Alan Needle, PhD, ATC, CSCS

Free Communications, Oral Presentations: Interventions to Increase Stability in Patients With Chronic Ankle Instability

Wednesday, June 24, 2015, 9:30AM-10:30AM, Room 130; Moderator: Adam Rosen, PhD, ATC

Effects of a 4-Week Biomechanical Ankle Platform System Protocol on Balance in High School Athletes with Chronic Ankle Instability

Cain MS, Garceau SW, Linens SW: Georgia State University, Atlanta, GA

Context: Multiple rehabilitation exercises have decreased residual symptoms of CAI; however, multiple exercises can be difficult to conduct due to lack of space, time and equipment in the high school setting. Research is lacking on an effective rehabilitation tool that improves balance and is easy to use in this setting. **Objective:** To determine the effectiveness of a 4-week Biomechanical Ankle Stability Platform (BAPS) Board protocol on balance of high school athletes with CAI. **Design:** Randomized control trial. **Setting:** Athletic Training Facility **Patients or Other Participants:** Twenty-two high school athletes with "giving way" and a history of ankle sprains (i.e. CAI) were randomized into a rehabilitation (REH) or control (CON) group. CON group consisted of 11 patients (173.86±8.88cm, 84.51±21.28kg, 16.55±1.29yrs). REH group consisted of 11 patients(166.23±0.93cm, 67.0±9.47kg, 16.45±0.93yrs). **Interventions:** Pretests were administered in counterbalanced order. Time in balance test (TIB) required patients to stand on involved leg and remain motionless for as long as possible up to 60 seconds, foot lift test (FLT) required patients to stand on involved leg for 30 seconds and minimize foot motions or touching down with contralateral leg, Star Excursion Balance Test (SEBT) in three directions (anteromedial (AM), medial (M), and posteromedial (PM)) required patient to stand on involved leg and reach with contralateral foot as far as possible while maintaining balance, and side hop test (SHT) required patient to hop 30cm side-to-side fast as possible for 10 repetitions. Following baseline testing, REH group completed a progressive BAPS rehabilitation program (3 times a week for 4 weeks). Each session consisted of 5 trials of clockwise/counterclockwise rotations changing direction every 10 seconds during each 40 second trial. After four weeks, baseline measurements were repeated. 2x2 repeated measure ANOVAs were used for data analysis (α=.05). Tukey's HSD post-hoc tests were conducted on significant interactions. **Main Outcome Measures:** Dependent measures included longest time (TIB), average number of errors (FLT), SEBT (average reach distance (cm) normalized to leg length for each reach direction (SEBT) and fastest time (SHT). Longer balance time, fewer foot lifts, longer reach distances and shorter time to complete indicated improved performance. **Results:** Main effects for time were significant for all dependent measures ($P<0.05$) except SHT ($P>0.05$). Main effects for group were significant for all dependent measures ($P<0.05$) except FLT and SHT ($P>0.05$). Significant group by time interactions were found for TIB ($F_{1,20}=9.89$, $P=0.005$), FLT ($F_{1,20}=41.18$, $P<0.001$), SEBT-AM ($F_{1,20}=5.34$, $P=0.032$), SEBT-M ($F_{1,20}=7.51$, $P=0.013$), SEBT-PM ($F_{1,20}=12.84$, $P=0.002$), SHT ($F_{1,20}=7.50$, $P=0.013$). Post-hoc testing showed that the REH group improved performance on all measures at posttest, whereas the CON group did not. **Conclusions:** A 4-week BAPS rehabilitation protocol improved balance and can be used as an efficient means of improving clinical outcome measures in high school athletes suffering from CAI.

Plantar Massage Enhances Mediolateral Postural Stability in Those With Chronic Ankle Instability

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 sensorimotor deficits in those with chronic ankle instability (CAI). Targeting other viable sensory receptors may then enhance sensorimotor control in these patients. **Objective:** To evaluate the effects of 2 weeks of sensory-targeted rehabilitation strategies (STARS) on eyes closed single limb stance time-to–boundary (TTB) scores in those with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients:** 80 patients with self-reported CAI (33 males, 47 females; age: 22.7 ± 4.4 yrs; height: 171 ± 9.4 cm; mass: 74.3 ± 16.0 kg) participated. CAI was defined as at least two episodes of "giving way" within the past 3 months; scoring <90% on the Foot and Ankle Ability Measure (FAAM), and scoring <80% on the FAAM-Sport. **Interventions:** All patients performed 3, 10-second trials of eyes closed single limb stance on a force plate standing on the self-reported CAI limb. After baseline testing, patients were randomly allocated to 4 STARS groups: joint mobilization (JM), plantar massage (PM), triceps surae stretching (TS), or control (CON). Each patient in the intervention groups received 6, 5-minute treatments of their respective STARS over 2 weeks. All subjects were reassessed on eyes closed single limb balance after the 2 week treatment window. **Main Outcome Measures:** For each trial, the TTB minima mean was calculated in the mediolateral (TTBML) and anteroposterior (TTBAP) directions. The 3 trial mean for each variable was used for further analysis. Change scores (Δ) from 2-weeks post- to pre-STARS were generated. 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:** One subject from the PM group withdrew during the 2-week interval due to an injury unrelated to the study. PM (Δ:0.01±0.18s; ES:0.63 (0.09 to 1.17)) resulted in improved TTBML minima mean scores (p=0.04) with a moderate ES and a CI that did not cross zero compared to the CON (Δ:-0.18±0.34s). JM (Δ:-0.15±0.34s; ES:0.08 (-0.44 to 0.60)) and TS (Δ: -0.09±0.42s; ES:0.21 (-0.31 to 0.73)) failed to improved TTBML minima mean scores (p=0.78 and p=0.46, respectively) with small ES compared to the CON and CIs that encompassed zero. PM (Δ:-0.12±01.03s; ES:0.21 (-0.31 to 0.73)), JM (Δ: -0.22±1.03s; ES:0.15 (-0.38 to 0.67), and TS (Δ:-0.16 ±1.00s; ES: 0.19 (-0.34 to 0.72) failed to improve TTBAP minima mean scores (p=0.47, p=0.61, and p=0.51 respectively) compared to CON (-0.43±1.53s) with small ES and CIs that encompassed zero. **Conclusions:** PM was the only STARS intervention that had a lasting effect on TTBML minima means during eyes closed single limb stance. Our findings suggest that targeting the sensory information from the plantar surface of the foot via PM for 2 weeks appears to enhance sensorimotor control for those with CAI.

A Randomized Controlled Trial Investigating the Effect of Rehabilitation on Functional Outcomes in Chronic Ankle Instability

Linens SW, Wright CJ, Cain MS: Georgia State University, Atlanta, GA, and Whitworth University, Spokane, WA

Context: To correct chronic ankle instability (CAI), clinicians rehabilitate individuals to return to physical activity without functional instability. Evidence indicates that performing multiple rehabilitation exercises has improved balance or decreased ankle sprain incidence. While outcomes such as these are desired, evidence is lacking on how each specific exercise in rehabilitation programs contribute to improving clinical impairments and outcomes. More specifically, more evidence is needed to quantify how a single rehabilitation exercise affects clinical test outcomes. **Objective:** To assess the comparative efficacy of two common ankle rehabilitation techniques [wobble board (WB) balance training and ankle strengthening using resistance tubing (RT)] using clinical tests. **Design:** Randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Forty physically active patients with CAI were randomized into two treatment groups: RT and WB. CAI inclusion criteria were a history of an ankle sprain, giving way ≥1 month, and a Cumberland Ankle Instability Tool (CAIT) score ≤ 25. Groups included 20 RT participants (5 males, 15 females, age = 21.5 ± 3.2 years, height = 1.66 ± 0.87 m, weight = 76.4 ± 19.34 kg), and 20 WB participants (6 males, 14 females, age = 22.6 ± 5.9 years, height = 1.66 ± 0.15m, weight = 70.3 ± 15.08kg). **Interventions:** Patients performed 5 clinical tests in a counterbalanced order. Patients performed 2 static balance tests: 1-Time-In-Balance (TIB); and 2-Foot Lift Test (FLT). Static balance tests required patients to remain as motionless as possible. Patients performed 3 dynamic balance tests: 1-Star Excursion Balance Test in posteromedial direction (SEBT-PM); 2-Side Hop Test (SHT); and 3-Figure-Of-Eight Hop (FEH). The SEBT-PM required patients to stand on their involved limb and reach for maximum distance with their contralateral leg in posteromedial direction. Patients completed SHT and FEH tests as quickly as possible on their involved limb. Following baseline test, participants were randomized to treatment group (WB or RT), and then completed 12 sessions over 4 weeks of graduated WB or RT exercise according to the treatment protocol. After 12th session, patients repeated all baseline tests. For each test, a separate 2x2 repeated measures ANOVA analyzed differences between groups over time (alpha Bonferroni corrected to p=0.01). **Main Outcome Measures:** Dependent variables were pre- and post-intervention score on the TIB (longest time), FLT (average number of errors), SEBT-PM (average reach distance normalized to leg length), SHT (fastest time), FEH (fastest time). **Results:** There were no significant interactions or main effects for group (all P>0.01). There was a significant effect for time on all 5 tests (FLT: $F_{1,38}$ = 24.402, P<0.001; TBT: $F_{1,38}$ = 12.458, P = 0.001; SEBT-PM: $F_{1,38}$ = 35.411, P<0.001; SHT: $F_{1,38}$ = 21.298, P<0.001; F8T: $F_{1,38}$ = 36.085, P<0.001). All tests improved post-intervention regardless of treatment group. **Conclusions:** Both RT and WB interventions were successful at increasing clinical test outcome measures. Comparatively, neither intervention was more effective than the other. However, results show that participation in a basic 1 exercise, 4 week intervention increases functional test performance in individuals with CAI.

Extended Use of Kinesiology Tape Improves Balance in Subjects with Chronic Ankle Instability

Tetuan KL, Simon JE, Docherty CL: Indiana University, Bloomington, IN; Bradley University, Peoria, IL; University of Toledo, Toledo, OH

Context: Individuals with chronic ankle instability (CAI) often have balance deficits related to decreased proprioception. Kinesiology tape (KT) has been proposed to have a variety of benefits including increased proprioception. **Objective:** Determine if KT can improve balance deficits in people with CAI. **Design:** Cohort study **Setting:** Research laboratory. **Patients or Other Participants:** Thirty participants with CAI (12 males, 18 females, 20.4 ± 2.0 years; 170.8 ± 10.9 cm; 73.4 ± 14.9 kg) volunteered to participate in the study. Presence of CAI was determined by scoring an 11 or higher on the Identification of Functional Ankle Instability questionnaire. Participants were randomly assigned to the KT or control group. **Interventions:** Only individuals in the KT group received the KT application. The KT application consisted of four strips of tape (Kinesio Tex Tape (Albuquerque, NM)) that were pulled approximately 30% of full stretch from origin to insertion of the tibialis posterior and anterior, peroneus longus, and transverse arch. Balance was assessed using the Balance Error Scoring System (BESS). The BESS consists of participants standing unassisted with eyes closed and hands on their hips for 20 seconds during six different conditions (two test surfaces: flat and foam; and three stances: double leg, single leg, and tandem). Errors were identified during each condition and the sum of all errors were used for statistical analysis. Errors included: (1) lifting hands off iliac crests, (2)opening eyes, (3)stepping, stumbling, or falling, (4)moving the hip >30° of flexion or abduction, (5)lifting the forefoot or heel, and (6)remaining out of the testing position for more than five seconds. Subjects in the KT group completed four BESS assessments: baseline, immediately post-tape application, 48 hours post-tape application, and 72 hours after KT was removed. Subjects in the control group completed four BESS assessments at the same intervals, but received no intervention. A RMANOVA was conducted to determine differences over the testing period. **Main Outcome Measures:** Total BESS errors. **Results:** At baseline the two groups had similar balance deficits ($p>.05$; Control group=13.7±3.9 errors, KT group=14.9±3.1 errors).There was a significant improvement in balance in the KT group between baseline and 48 hours post-tape (mean difference: 5.9±0.9 errors, $p<.01$, 95% CI:3.7 to 8.2 errors) and 72 hours post-tape removal (mean difference 4.7±1.0 errors, $p<.01$, 95% CI:2.3 to 7.2 errors). Therefore, in the KT group, the balance improvements were retained after the tape was removed for 72 hours. No significant changes were identified in the control group at any time period ($p>.05$). **Conclusions:** The results indicate that KT can improve balance after it was applied for 48 hours when compared to baseline and the control group. The most clinically important finding is that balance improvements which were created with the KT were retained after the tape was removed.

The Dynatron Solaris® Ultrasound Machine Heats Slower Than Textbook Recommendations at 3 MHz, 1.0 W/cm²

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Context: The therapeutic ultrasound heating rates used to determine the clinical parameters in modality textbooks are based on research with the Omnisound. There is evidence to support ultrasound machines from different manufacturers produce varying power outputs, which can result in differences in heating rates. Also, the heating rates are reported to be the same throughout the 3MHz range. **Objective:** To determine the rate of tissue temperature increase in the medial triceps surae with the parameters of 3MHz, 1.0 W/cm² at 1.0, 1.75, and 2.5 cm depths with the Dynatron Solaris® 708. **Design:** We used a 2 x 3 Factorial design with independent variables as time (pre- and post- treatment) and tissue depth (1.0, 1.75, and 2.5 cm). The dependent variable was the medial triceps surae intramuscular temperature change. **Setting:** University Research Laboratory. **Patients or Other Participants:** A sample of 30 healthy college-aged individuals volunteered (11 females, 19 males; 21.30 ± 1.95 years). The adipose thickness was 0.54 ± 0.15 cm measured by a Diagnostic Ultrasound. **Intervention:** Three IT-21 intramuscular thermocouples were inserted into the medial triceps surae at the depths of 1.0, 1.75, and 2.5 cm. The Dynatron Solaris® 708 was set at Continuous, 3 MHz, 1.0 W/cm² for 20 minutes. A template 2 times the ERA was used. The treatment was performed until all depths reached a 4°C increase, the subject reported discomfort, or 20 minutes. **Main Outcome Measures:** The intramuscular temperature was recorded every 5 seconds for 20 minutes. We calculated the time and rate/min to reach a 4°C increase at each depth. **Results:** For the 1.0 cm depth, intramuscular temperature increased 4.18 ±1.29°C in 6 minutes at a rate of 0.70°C/min. The 1.75 cm depth increased 4.18 ± 2.01°C in 11 minutes at a rate of 0.38°C/min. The 2.5 cm depth did not reach a 4°C increase in the 20 minute treatment. It reached 3.39 ± 1.86°C with a rate of 0.17°C in 20 minutes. When comparing common clinical ultrasound treatment times, the temperature increases at the 1.0 cm depth were significantly greater than the 1.75 cm depth temperatures at 3 ($P = .002$), 5 ($P = .001$), 7 ($P < .001$), and 10 ($P < .001$) minutes. The 1.75 cm depth temperature increases were significantly greater ($P < .001$) than the 2.5 cm temperature increases. **Conclusions:** The Dynatron Solaris® 708 heated at varying rates within the 3 MHz depth. The 1.0 cm depth is the only depth that heated at rates similar to textbook information and this could be due to the differences in manufacturers and BNR. An increased intensity may need to be utilized clinically to reach similar heating rates with the textbook. More research is needed on the Dynatron Solaris® machine to determine appropriate treatment parameters.

Accelerated Recovery Through Ultrasound Therapy: Lactic Acid Clearance and Muscle Recovery

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Context: In the competitive world of professional athletics, enhanced muscle functioning and rapid recovery from exercise can provide a critical edge. The breakdown of nutrients and oxygen transport within muscles, along with the accumulation of lactate, lead to impaired athletic performance. Although there is no standard protocol for post-workout recovery, research has shown that short-duration treatments with low intensity therapeutic ultrasound (LITUS) increase blood flow, fluid circulation, vasodilation, and cellular metabolism. **Objective:** To examine the effect of long-duration LITUS on muscle performance, recovery, and lactate build up during anaerobic (Study 1, strength building) and aerobic (Study 2, cycling) activity. **Design:** Two ongoing studies, both double-blind crossover designs. **Setting:** Convenience samples of professional athletes in athletic training facilities. **Patients or Other Participants:** *Study 1* Ten males (age=22.1 yrs, target enrollment=20) were recruited through referrals and flyers. *Study 2* Nine cyclists (males=8, target enrollment=10) were recruited through a network of professional cyclists. **Interventions:** *Study 1* One-repetition maximum (1-RM) for each participant was estimated for five load-bearing eccentric lower body exercises. During the next two visits, participants performed two circuits of the exercises at 70% of their 1-RM. Participants wore 8 ultrasound transducers (all active or all placebo) one-hour before and during exercise on bilateral quadricep and hamstring

muscles. *Study 2* Cyclists were given a 7 day training regimen (completed twice over 14 days) that consisted of 4 easy cycling workouts followed by 3 max effort workouts. Output power was recorded on a bicycle-mounted power meter. Cyclists wore devices (one week of active, one of placebo) the night before each max effort workout (same placement as Study 1). **Main Outcome Measures:** *Study 1* Blood lactate levels (2 samples at each timepoint) measured at baseline, 0, 2, 5, 10, 20, 40, and 60 min post-exercise. Paired-samples t-tests were used to compare effects. *Study 2* Cyclist's total power output from max workout days and pain levels before and after each workout (10-point visual analog scale; VAS) were recorded. **Results:** *Study 1* Blood lactate levels were significantly decreased with active ultrasound treatment compared to placebo at 0, 2, 5, 20, and 40 minutes post-exercise (group differences of 1.78±2.31, 1.26±1.70, 1.54±2.13, 0.97±1.44, 0.83±0.67 mmol/L; respectively, Ps<.05). *Study* 2 Data will not be analyzed until recruitment is completed, but a separate pilot study of n=4 using an identical protocol found a 2% increase in power following ultrasound treatment compared to placebo. A power analysis suggests that a sample of n=10 will provide 85% confidence. **Conclusions:** The preliminary findings from these ongoing studies suggest that long-duration LITUS effectively reduces the accumulation of lactic acid and can improve muscle recovery to enhance athletic performance. Long-duration LITUS has the potential to change the way athletes compete and recover.

The Effect of 2 MHz Ultrasound on Intramuscular Temperature at 1.5, 2.5, and 3 cm Depths

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Context: The recommended clinical parameters in athletic training modality textbooks on thermal ultrasound are based on research with the Omnisound machine. While there is evidence to support therapeutic ultrasound machines from different manufacturers produce varying power outputs, there is very little evidence on 2 MHz ultrasound which is an option on the Dynatron Solaris® 700 Series. Therefore, we wanted to research the rate of heating with a 2 MHz frequency on the Dynatron Solaris® 700 Series for depths that fall in the 3 MHz, 1 MHz, and medium ranges. **Objective:** To determine the rate of tissue temperature increase in the medial triceps surae with the parameters of 2 MHz, 1.0 W/cm² at 1.5, 2.5, and 3 cm depths until a 4°C increase was reached. **Design:** A 2 x 3 Factorial Design. Independent variables were time (pre- and post treatment) and tissue depth (1.5, 2.5, and 3cm). The dependent variable was the medial triceps surae intramuscular temperature change. **Setting:** University Research Laboratory. **Patients or Other Participants:** A convenience sample of twenty healthy college-aged individuals (11 males and 9 females; 20 ± 2.2 years). The average adipose tissue thickness was 0.52 cm ± 0.16 cm. **Intervention:** Three thermocouples were inserted into the medial triceps surae muscle at the depths of 1.5, 2.5, and 3 cm. Therapeutic ultrasound was delivered until a 4°C increase was reached with the following parameter settings: 2 MHz, continuous, 1.0 W/cm^2. **Main Outcome Measures:** The temperature was recorded every 5 seconds for 20 minutes. **Results:** The mean rate per minute temperature increase for the 20 minute ultrasound treatment was the greatest at the 1.5 cm depth (0.42°C/min), followed by the 2.5 cm depth (0.26°C/min), and then the 3 cm depth (0.17°C/min) at 1.0 W/cm2. Mean intramuscular temperature increase at 10 minutes was the greatest at the 1.5 cm depth (increase = 4.18°C ± 2.45°C), then the 2.5 cm depth (increase = 2.56°C ± 1.82°C), and finally the 3 cm depth (increase = 1.74°C ±1.52°C). There was a significant difference in temperature increase in the depths from baseline to ending temperature for depth and time ($P < .001$). There was also a significant difference between the 1.5 and 3 cm depths ($P < .001$). **Conclusions:** There was a significant difference in intramuscular temperature increase of 2 MHz therapeutic ultrasound at all depths; however, only the 1.5 cm depth reached a 4°C increase within 20 minute treatment. Treatment goals and the type of machine need to be taken into account when delivering an ultrasound treatment. Further research needs to be conducted with the different frequencies and intensities of the Dynatron machine, as well as other brands to establish parameters for all ultrasound machines. **Key Words:** therapeutic ultrasound, thermal, 2 MHz, parameter settings.

Short Term Effects of Long Duration Low Intensity Continuous Ultrasound for Trapezius Muscle Pain

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Context: Upper trapezius pain can be debilitating and often lead to chronic headaches, myofascial pain syndrome and loss of range of motion. The clinical effectiveness of long duration low intensity therapeutic ultrasound (LITUS) for neuromuscular injury is unknown. **Objective:** To determine if LITUS is effective at treating upper trapezius trigger point pain compared to an inactive placebo treatment during a 4-week period. **Design:** Randomized control trial. **Setting:** Patient clinic. **Patients or Other Participants:** 33 participants (M=10 and F=23, age=34.76 ± 12.51 y, ht=167.64 ± 11.51 cm, mass=77.51 ± 17.61 kg) who were diagnosed by a healthcare practitioner as having chronic upper trapezius pain and reporting a score of 3.0 or higher on the visual analog scale (VAS) scale 3-4 times per week. **Interventions:** Participants were randomly assigned into an active (N=22) or sham (N=11) ultrasound treatment group. Both the participant and clinician were blinded to the treatment assignment. Treatments were applied for 4 weeks. Participants were instructed to apply the ultrasound device (model: sam®, ZetrOZ, Inc., Trumball, CT; 3 MHz, 0.132 W/cm2) on days they reported trapezius pain of ≥ 3.0 on a VAS scale. Applied ultrasound treatments lasted 4 h. **Main Outcome Measures:** Participants completed a daily pain diary, indicating their daily pain on a VAS scale and Global Rating of Change (GROC) after the treatment. Participants' trigger point pressure sensitivity assessed via pressure algometer was measured at baseline, week 2 into the treatment and week 4 at the conclusion of all treatments. Repeated-measures ANOVAs were used to examine differences over time and between groups. **Results:** Age (P=0.15), height (P=0.09), and mass (P=0.49) did not differ between treatment groups. Pain scores also did not differ between the active (5.59 ± 1.26) and sham (6.45 ± 2.01) groups at baseline, P=0.14. Pain was significantly reduced by 3.58 ± 1.55 points from baseline (5.87 ± 1.57), to two weeks (4.31 ± 1.67), to the conclusion of the study (2.87 ± 1.31), P<0.001; however, the amount of reduction did not significantly differ between the two groups, P=0.13. There was also an average reduction in pain of 1.15 ± 1.49 points over the course of a 4 h treatment (P<0.001), but this reduction did not differ between groups, P=0.85. GROC scores also increased by 0.32 ± 1.41 over the study, but the increase were not significant (P=0.17) and did not differ between groups (P=0.30). Pressure sensitivity was decreased by 0.46 ± 1.29 and 0.44 ± 1.73 kg for active and sham groups, respectively, but was not different between groups, P=0.89. **Conclusions:** Four week LITUS use created a meaningful clinical important difference (MCID) reduction of upper trapezius pain. However, a strong placebo effect is hypothesized to cause the pain reduction.

The Effect of Magnesium Sulfate in Conjunction with Water Therapies on Delayed Onset Muscle Soreness

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Context: A treatment that alleviates pain, disability, and joint angle changes associated with delayed onset muscle soreness (DOMS) does not currently exist; if identified, the treatment could assist with increased adherence to exercise. **Objective:** To determine the effects of magnesium sulfate and contrast water therapy (CWTMS), magnesium sulfate and cryotherapy (CTMS), and magnesium sulfate and thermotherapy (TTMS) on the signs and symptoms of DOMS. **Design:** A randomized controlled study. **Setting:** Research laboratory. **Patient or Other Participants:** Volunteer sample of 16 female college students, between the ages of 18 and 30 years (M=22±2.85 years). **Interventions:** DOMS was induced in the elbow flexors of the non-dominant arm using an eccentric bicep curl protocol. There were four treatment groups: no treatment, CWTMS, CTMS, and TTMS. Treatments were done after DOMS induction, then at 24, 48, and 72 hours post-exercise. Water temperature and treatment time varied according to the water therapy protocol (CWTMS: 30 minutes; CTMS: 50-60°F for 15 minutes; TTMS: 90-110°F for 15 minutes). Joint angle changes and pain measurements were collected pre-exercise, then at 24, 48, 72, and 96 hours post-exercise. Joint angle changes were measured using a goniometer, pain was measured using a Graphic Pain Rating Scale, and perceived disability was measured using a Pain Activity Survey. **Main Outcome Measures:** The dependent variables were resting joint angle (RA), flexion angle (FA), extension angle (EA), perceived disability (PD), and perceived pain (PP). Separate 4x5 (GroupxTime) ANOVA with repeated measures for time were used to analyze the dependent variables. All significant ANOVA main effects (p≤.05) were further analyzed with Tukey's post-hoc

tests. **Results:** No statistically significant differences were found for the interaction of treatment by time (RJA: $F(12,48) = .693$ $p = .668$, $\eta^2 = .148$; FA: $F(8.8,35.1) = .844$ $p = .579$, $\eta^2 = .174$; EA: $F(12,48) = .614$ $p = .717$, $\eta^2 = .133$; PD: $F(7.7,31) = .758$ $p = .637$, $\eta^2 = .159$; PP: $F(7.2,28.8) = .968$ $p = .474$, $\eta^2 = .195$). No significant main effect for treatment was found (RJA: $F(3,48) = 2.784$, $p = .086$, $\eta^2 = .410$; FA: $F(3,35.1) = 2.449$, $p = .114$, $\eta^2 = .380$; EA: $F(3,48) = 1.75$, $p = .21$, $\eta^2 = .304$; PD: $F(3,31) = .649$, $p = .573$, $\eta^2 = .148$; PP: $F(3,28.8) = 2.525$, $p = .107$, $\eta^2 = .387$). There was a main effect for time (RJA: $F(4,48) = 10.021$, $p = .000$, $\eta^2 = .410$; FA: $F(2.9,35.1) = 3.126$, $p = .039$, $\eta^2 = .207$; EA: $F(4,48) = 7.907$, $p = .002$, $\eta^2 = .397$; PD: $F(2.6,31) = 17.382$, $p = .000$, $\eta^2 = .592$; PP: $F(2.4,28.8) = 19.768$, $p = .000$, $\eta^2 = .622$). **Conclusions:** Treatments of CWTMS, CTMS, and TTMS were not effective in treating DOMS.

The Professional Socialization of Doctoral Students Seeking Careers in Athletic Training

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Context: Athletic training faculty members are critical due to their role as educators and mentors to aspiring athletic trainers. Role strain and burnout have been reported by program directors and athletic training faculty, possibly due to a failure to gain appropriate training or mentoring regarding their responsibilities. Therefore, it is important to understand the process whereby athletic training doctoral students learn what their future career will require. **Objective:** Gain perspective regarding the professional socialization process for athletic trainers who are pursuing doctoral degrees and subsequent careers in higher education as athletic trainers. {Banerjee, 2004 #30}**Design:** Qualitative study. **Setting:** Universities with athletic training doctoral students. **Patients or Other Participants:** Twenty-eight doctoral students (19=females, 9=males, average age=28±3 years) participated in our study. All participants had 1 year of doctoral coursework completed and were employed in an assistantship at the time of data collection. The doctoral students were certified for 6±3 years and represented 5 different NATA districts and 9 different institutions. Data saturation drove recruitment. **Data Collection and Analysis:** We completed one-on-one telephone interviews with all participants following a semistructured script. Upon completion, we transcribed each interview verbatim and analyzed the data using an inductive approach. We used peer review, multiple analyst triangulation, and stakeholder checks to ensure trustworthiness. **Results:** We determined themes for how doctoral students are socialized regarding future teaching, research, service, and administrative tasks; common responsibilities for athletic training faculty. The majority of our respondents became socialized into the teaching role by engaging in teaching experiences, typically through independent teaching or by serving as a teaching assistant. Only one participant mentioned coursework in pedagogy as a means to become familiar with teaching theory. Autonomous research experience allowed participants to have the confidence that they could plan and execute future studies themselves. Participants' were ready to take on the responsibilities of a researcher within a higher education environment because they had engaged in all aspects of research previously. While participants gained familiarity with faculty service obligations through committee work, most pursued these independent of the doctoral program. Although some respondents indicated their doctoral studies included experience with administrative duties, especially clinical education coordinating, that would assist them in assuming an administrative role, many students did not have such experiences. **Conclusions:** Mainly, role occupation as a teaching assistant, completion of research projects, engagement in committee work, and assisting with administrative responsibilities allowed doctoral students to prepare for a future career in the professoriate. However, participants identified some limitations toward fully understanding their role as future faculty. Doctoral student advisors and mentors are encouraged to provide students with experiences in all areas of the roles of athletic training faculty members to adequately socialize them to future expectations.

Investigating the Relationship Between Doctoral Candidates and Athletic Training Faculty Mentors

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Context: Mentorship has been established as a key facilitator for professional socialization of an athletic trainer into various roles within the profession. Understanding how current doctoral students are trained to enter faculty roles is critical as there is an increased demand for athletic trainers to serve in this capacity. **Objective:** Gain an understanding of the relationship that develops between a doctoral student and the faculty mentor in athletic training. {Banerjee, 2004 #30}**Design:** Qualitative study. **Setting:** Universities with athletic training doctoral students. **Patients or Other Participants:** Twenty-eight doctoral students (19=females, 9=males) participated in our study. All participants must have had one full year of academic coursework completed and were employed in an assistantship at the time of the study. The average age of our participants was 28 ± 3 years. The doctoral students were certified for 6 ± 3 years and represented 5 different NATA districts and 9 different universities. Data saturation was met at twenty-eight. **Data Collection and Analysis:** One-on-one telephone interviews following a semistructured phone interview script were completed with all participants. Upon completion, each interview was transcribed and analyzed using a thematic approach. The six-step process allowed us to systematically evaluate the data. Peer review, multiple analyst triangulation, and stakeholder checks were completed to ensure trustworthiness. **Results:** All doctoral students identified having a mentor in their experiences, and directly acknowledged their academic faculty advisor as that mentor. All of our participants,

except one, acknowledged that the relationship forged with their mentor was positive. Three themes developed from our thematic analysis procedure. 1) The relationship between the student and the faculty mentor needs to be one that is *supportive,* yet viewed as yielding *autonomy* and *collaboration*. The theme was summarized by the mantra "work together, collaborate together." 2) The relationship between the student and the faculty mentor needs to include opportunities for professional development specifically related to *skill acquisition and development* related to a future academic role. Our participants wanted the autonomy to learn independently, but still required the guidance of their mentors through feedback and communication as means to grow. 3) The relationship between the student and the faculty mentor must demonstrate a mutual *investment* in the educational experience. Our participants discussed the importance of having a common and shared vision for research and teaching, which allowed for a successful relationship. **Conclusions:** Mentoring is necessary to help ensure a quality experience for the doctoral student preparing for a future in higher education or research positions. Like previous research in socialization, doctoral students want the chance to gain autonomy in their roles, but value the feedback and support from their mentors. Faculty mentors should demonstrate strong communication skills and provide opportunity for diversity in learning experiences for their doctoral students.

Exploring the Perceptions of Newly Credentialed Athletic Trainers' Transition to Practice

Walker SE, Thrasher AB: Ball State University, Muncie, IN, and Arkansas State University, Jonesboro, AR

Context: It is unclear what unique challenges newly credentialed athletic trainers (ATs) face when during the transition to practice from student to autonomous practitioner. Understanding their transition could provide insight to assist employers and professional programs in developing initiatives to enhance the transition. **Objective:** Explore newly credentialed ATs' experiences and feelings during their transition from student to autonomous practitioner. **Design:** Phenomenological qualitative. **Setting:** Individual phone interviews. **Patients or Other Participants:** 33 ATs certified between January and September 2013 participated in this study (17 female, 16 male; 23.8±2.14 years; work settings included college, high school, clinic, and other). Data saturation guided the number of participants. **Data Collection and Analysis:** Participants were interviewed via phone using an interview guide. All interviews were recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via member checks, peer review and intercoder reliability. **Results:** Four themes emerged that described the participant's experiences as they transitioned: 1) Orientation, 2) Transition to practice preparation, 3) Challenges, and 4) Mentoring. Participants in the college and clinic setting were oriented via informal (e.g., independent review of emergency action plan) and formal (e.g., review policies and procedures manual) methods. Those in the high school setting received informal orientation but little to no formal orientation and many were immediately immersed into their role. Transition to practice was rarely discussed during professional preparation, but participants felt information in the organization and administration or a capstone course (e.g., insurance, documentation, development of emergency action plan) assisted in their transition. Participants felt preceptors influenced their transition by providing or hindering the number and quality of patient encounters. Many challenges were faced during the transition including decision-making, communicating with coaches, parents, and patients, confidence in their role, and role ambiguity. Participants developed confidence and began to trust themselves as they gained more experience, made decisions, and received positive feedback from patients, physicians, parents, and coaches. Some participants were assigned a formal mentor while those who were not took the initiative to ask for help and/or find a mentor. Supervisors, peer ATs in the same athletic conference, and previous instructors and preceptors were commonly sought out as mentors. **Conclusions:** Newly credentialed ATs face many challenges as they transition into their new role. Employers could enhance the transition by providing formal mentorship and orientation initiatives. Professional programs could prepare students for the transition by discussing challenges they may face during their transition, discussing how to find support and mentoring, and utilizing preceptors who provide students with opportunities to provide patient care and develop the students' confidence and decision making abilities.

Examining the Transition to Practice of Newly Credentialed Athletic Trainers

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Context: Annually, approximately 2500 athletic trainers (ATs) are credentialed and obtain their first professional positions, yet little is known about their experience as they transition into their new role as healthcare providers. **Objective:** To explore the feelings and experiences of newly credentialed ATs as they transition to practice. **Design:** Cross sectional. **Setting:** Online survey. **Patients or Other Participants:** 332 of 1835 newly credentialed ATs (18%) employed between January and September of 2013 completed the survey (129 males, 203 females, 23.58 ± 2.54 years old). **Interventions:** Participants completed an online survey via Qualtrics that consisted of demographic information (e.g., employment setting, job title, assignment of mentor) and sections regarding: 1) feelings of comfort level during transition (CL), 2) feelings of mentorship and support (MS), and 3) feelings of organizational transition (OT) using a Likert scale (1=strongly disagree, 4=strongly agree). Content validity was established by a panel of experts. Chronbach's alpha established reliability for each section: CL: α=.77, MS: α=.82, and OT: α=.66. **Main Outcome Measures:** Descriptive statistics (frequencies and percentages) regarding feelings during the transition were calculated on each survey item. Mann-Whitney U (*U*) and Kruskall Wallis (KW) tests were used to determine differences between demographic characteristics and the total composite score for each feelings section (CL, MS, and OT). Pearson's correlations determined relationships between sections. A Bonferroni correction accounted for multiple comparisons. Alpha was set at $P<0.05$. **Results:** Most participants agreed or strongly agreed they felt nervous about the transition (n=264, 79.2%) and the transition was stressful (n=227, 68.1%), but felt prepared for their job (n=262, 78.7%). There were no differences in CL between job settings (KW=2.698, $P=0.610$) and job title (KW=4.88, $P=0.087$). Most participants (n=233, 67%) were not assigned a mentor, but felt they could go to their unassigned mentor or direct supervisor and ask questions (n=264, 87%). Those assigned mentors reported significantly higher feelings regarding MS ($U=6250$, $P<0.001$) and were less likely to consider leaving the athletic training profession ($U=12311$, $P<0.003$). There was a moderate positive correlation (r=0.50, $P<0.001$) between feelings of MS and CL. Males experienced higher feelings regarding MS than females ($U=9325$, $P=0.024$). For OT, most participants felt adequately oriented to organizational values (n=252, 75.7%) and a little over half felt supervisors adequately explained administrative procedures during orientation (n=169, 54.3%). Participants reported higher OT if they received a policies and procedures manual ($U=7121$, $P<0.001$), felt orientation adequately prepared them for their roles ($U=4039$, $P<0.001$), and were assigned a mentor ($U=7821$, $P=0.004$). **Conclusions:** While nervous during the transition, most felt prepared for their role. Assigning a mentor may enhance comfort levels and feelings of support and may impact persistence in the profession. During orientation employers should provide and review the policies and procedures manual.

Transitioning to Practice: Changes in Self-Reported Confidence Levels of Athletic Trainers During the First Two Years of Clinical Practice

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

Context: Many newly certified athletic trainers (ATs) transition into clinical practice through the graduate assistantship model. Clinical experience, mentoring, and graduate coursework will likely impact ATs' skills and knowledge. Little is known regarding how ATs' confidence in their knowledge and skills change during the first years following certification. **Objective:** To examine changes in ATs' self-reported confidence levels during the first two years of clinical practice. **Design:** Retrospective database analysis. **Setting:** Self-reported online clinical tracking system. **Patients or Other Participants:** 16 post-professional athletic training program (PPATP) students (male = 4, female = 12; Year 1 = 8; Year 2 = 8) participating in graduate assistantships. **Interventions:** Self-reported confidence levels for knowledge and skills in the five domains of athletic training (Injury Prevention and Wellness Protection [IPW], Clinical Evaluation and Diagnosis [EVAL], Immediate Emergency Care [EC], Treatment and Rehabilitation [REHAB], Organizational and Professional Health and Well Being [ORG]) and five of the PPATP core competencies (Evidence-Based Practice [EBP], Patient-Centered Care [PCC], Healthcare Informatics [HI], Professionalism [PROF], and Quality Improvement [QI]) were obtained via the AHST™ (Typhon Group, LA) online clinical tracking system between August 2013-August 2014. Via online survey, participants rated their perceived level of confidence for each domain/competency on a 5-point Likert scale ranging from no confidence (1) to very confident (5). ATs in their first (Year1) or second (Year2) years of practice completed these surveys at the start of the fall (T1) and spring, (T2) quarters. **Main Outcome Measures:**

Mann-Whitney U tests ($P < .05$) were used to assess between-group differences at the start of the second year. Aggregate confidence scores for each domain/competency were tabulated by adding values and normalizing to the Likert scale. Confidence scores were compared using Wilcoxon Signed-Rank tests to assess within-group differences during the first or second year of clinical practice. **Results:** There was a significant between-group difference for PCC at T2 ($U = 13.0$, $P = .028$); no other significant between-group differences for the domains/competencies were found. Year1 had significant increases in confidence from T1 to T2 for EVAL (3.77/5.0-to-4.25/5.0, $Z = -2.00$, $P = .046$), PCC (3.88/5.0-to-4.63/5.0, $Z = -2.07$, $P = .038$), and QI (3.33/5.0-to-4.13/5.0, $Z = -2.07$, $P = .038$). Confidence in IPW decreased from T1 to T2 (4.22/5.0-to-3.75/5.0, $Z = -2.00$, $P = .046$). Year2 had significant increases in confidence from T1 to T2 for IPW (4.13/5.0-to-4.63/5.0, $Z = -2.00$, $P = .046$), REHAB (3.63/5.0-to-4.50/5.0, $Z = -2.33$, $P = .020$), and PCC (3.88/5.0-to-4.5/5.0, $Z = -2.23$, $P = .025$). **Conclusions:** Results indicate that ATs transitioning into clinical practice have relatively high levels of confidence upon certification; confidence levels in several domains appear to increase from the fall to spring of both first and second years. These increases in confidence may be related to clinical experiences, mentoring, or graduate coursework. ATs enrolled in PPATPs may benefit from structured coursework and mentoring, facilitating increases in confidence. Further research is warranted to examine longitudinal changes over multiple years, as well as to identify correlations between types of clinical experiences, coursework, and mentoring and changes in confidence.

Head Evidence-Based Forum: Risk Factors. Delayed Symptom Recovery

Thursday, June 25, 2015, 8:00AM-9:00AM, Room 130; Moderator: Jason Mihalik, PhD, CAT(C), ATC, Discussants: Dawn Comstock, PhD; Janna Fonseca, MEd, ATC, LAT

Validity and Reliability of Pediatric ImPACT in Five to Twelve Year Olds

Moore MT, Murphy B, Seramur D, Lovell MR: Northern Michigan University, Marquette, MI, and University of Pittsburgh Medical Center - Sports Medicine Concussion Clinic, Pittsburgh, PA

Context: There is a paucity of information about kids and sport related concussions, particularly in the 5-12 age range. In addition, there is not a suitable neurocognitive assessment tool for this age group. In this age bracket testing needs to be short in duration, fun, and not require quick reading skills. **Objective:** To examine the validity of a new Pediatric ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing) that was designed to test neurocognition in kids 5-12 and determine test retest reliability. **Design:** Cohort. **Setting:** Laboratory. **Patients or Other Participants:** Students 5-12 who participated in soccer or hockey in a rural community participated in up to three tests. There were 142 students (40 females, 102 males, mean age 8.239 $\pm$ 2.190, mean BMI 17.390 $\pm$ 3.261) who completed baseline with 68 completing a second test one week after baseline and 39 completing a third test after one month. **Interventions:** Students were partnered with a trained Certified Athletic Trainer or athletic training student who assisted them one-on-one with testing in a quiet environment. Students were rewarded with a small snack of their choice each time they participated. Baseline tests were followed by a second test one week later and a third test one month from baseline. Informed consent was obtained from both the student and the parent. We measured correlations within four levels of age (5-6, 7-8, 9-10, and 11-12). **Main Outcome Measures:** Intraclass correlation coefficient (ICC) and repeated measures ANOVA were used to determine the relationship between the three intervals. Pearson's correlations were used to examine relationships within each age level. A priori alpha was set at α= 0.05. **Results:** Intraclass correlation coefficients were strongly significant for Word List [ICC = 0.833, $P < .001$], Memory Touch [ICC = 0.806, $P < .001$] and significant for Stop and Go [ICC = 0.630, $P < .001$], Design Rotation [ICC = 0.669. $P < .001$] and Picture Match [ICC = 0.539, $P < .001$]. Repeated Measures ANOVA's revealed there were no differences between trials (P = 0.667-0.994). As expected correlations between tests improved with increasing age group (ex. Word List 5-6 year olds r = 0.661, $P < .001$ 11-12 year olds r = 0.880, $P = .004$). **Conclusions:** This preliminary testing indicates strong relationships in test re-test reliability within multiple modules for Pediatric ImPACT tests.

The Effect of Sex, Sport, and Concussion History on Vision and Sensorimotor Performance in Healthy College Athletes

Teel EF, Lynall RC, Appelbaum LG, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC, and Duke University, Durham, NC

Context: Sex, sport, and concussion history affect concussion risk in college athletes. Emerging evidence is pointing to the role that vision and sensorimotor function may play, both prior to and following injury. Before effective vision assessments and post-injury rehabilitation interventions can be implemented, we must understand how extrinsic factors may impact these outcomes in healthy athletes. **Objective:** To determine the effects of sex (female vs. male), sport (baseball, basketball, football, lacrosse, soccer), and previous concussion history (none vs. 1+ concussion) on vision and sensorimotor performance in Division I college athletes. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** We enrolled 126 Division I college varsity athletes (age = 21.3±1.6 years; no concussion history = 87; concussion history = 39) from the following sports: baseball (male = 15), basketball (female = 2; male = 11), football (male = 47), lacrosse (female = 9; male = 14), and soccer (female = 13; male = 15). **Interventions:** Participants completed a valid and reliable vision and sensorimotor performance evaluation (Nike SPARQ Sensory Station) prior to the start of the athletic season. Participants were categorized by sex (female vs. male), sport (baseball, basketball, football, lacrosse, soccer), and self-reported concussion history (none vs. 1+ concussions). **Main Outcome Measures:** The SPARQ employs a battery of 9 vision and sensorimotor tasks including; Static Visual Acuity, Contrast Sensitivity, Depth Perception, Dynamic Visual Acuity, Near-Far

Quickness, Perception Span, Eye-Hand Coordination, Go/No-Go, Hand Reaction Time, and Hand Motor Time. We employed one-way ANOVA for each outcome across each of our 3 independent variables: sex, sport, and concussion history. **Results:** Males outperformed females on Near-Far Quickness (males = 27.4 ± 5.0 correct repetitions; females = 24.4 ± 6.6 correct repetitions; $F_{1,125} = 6.50$; $P = 0.012$) and Eye-Hand Coordination (males = 54.7 ± 3.7 s; females = 56.7 ± 4.4 s; $F_{1,125} = 5.45$; $P = 0.021$). We observed a sport main effect for Hand Motor Time ($F_{4,121} = 2.92$; $P = 0.024$), such that basketball players (432.9 ± 37.9 ms) had faster motor response times than football players (487.3 ± 91.1 ms). There were no differences for any other dependent variable, and none based on concussion history ($P > 0.05$). **Conclusions:** Clinical best-practice standards for concussion assessment and rehabilitation continue to evolve. Understanding the effects that sex, sport, and concussion history may have on clinical measures of concussion may strengthen concussion management. As visual assessments are an emerging complement to the traditional concussion management paradigms, studying these measures in the context of healthy cohorts is an important step towards optimizing clinical standards. Our data suggest that vision and sensorimotor tasks may be sensitive to sex and sport differences. As such, researchers and clinicians should consider these differences when designing and implementing concussion assessment and intervention protocols targeting visual-sensory and visual-motor performance.

Cerebral Blood Flow Changes Following Sport-Related Concussion in High School and Collegiate Athletes Using the Brain Acoustic Monitor

Acocello S, Broshek D, Hart JM, Hertel J, Saliba S: University of Tennessee at Chattanooga, Chattanooga TN, and Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville, VA

Context: A need exists for field-based tools that can objectively assess physiological changes that occur following concussion. The Brain Acoustic Monitor (BAM) may offer a solution by detecting the presence of cerebral arterial dysfunction through the recording of acoustic signals emitted by the cerebral vasculature. **Objective:** To determine if changes in cerebral blood flow can be detected using the BAM and to compare present changes to current assessment methods. **Design**: Case-control, repeated measures. **Setting**: Sports Medicine Clinic. **Patients or Other Participants**: Seventeen concussed athletes (10 males, 7 females; age:18.8±2.1 years; height:182.1±25.6 cm; mass:77.1±23.2 kg) were recruited and matched to healthy controls by age, gender, and sport contact category (age:18.9±1.8 years; height:176.5±11.3 cm; mass:75.9±20.6 kg). Concussed subjects were recruited an average of 1.2±0.4 days following injury. **Interventions**: Sideline Concussion Assessment Tool, version 3(SCAT3) and BAM testing were performed 24-48 hours post-injury, at resolution of symptoms (average 5.1±3.4 days), and upon return-to-play (average 10.2±4.9 days) as determined by the team athletic trainer or physician. Healthy controls were assessed prior to the athletic season. **Main Outcome Measures**: The BAM records acoustic signals emitted by the cerebral vasculature and generates an arterial pressure wave. Outcomes extracted included systolic interval(SI), steepest rise gradient(SRG), peak interval(PKInt), and augmentation index(AIx). Subcomponents of the SCAT3 that were used for comparison included the Standardized Assessment of Concussion(SAC) and Modified Balance Error Scoring System(BESS). Due to non-normal distribution, within-subject comparisons were made for the concussed group between each clinical time point using Friedman's Rank tests and follow-up Wilcoxon Signed-Rank tests. Mann-Whitney U tests were used for comparisons between the concussed group and healthy controls. **Results:** No significant differences were found between any time points for all BAM outcomes within the concussed group. Right SI was significantly higher in the concussed group than the healthy group at initial assessment ($p = 0.042$) and symptom resolution ($p = 0.016$; Initial assessment: $SI_{concussed} = 0.13 \pm 0.05$s, $SI_{healthy} = 0.11 \pm 0.04$s; Symptom resolution: $SI_{concussed} = 0.12 \pm 0.04$s, $SI_{healthy} = 0.11 \pm 0.04$s). These findings were repeated for the BESS with the concussed group displaying a greater number of errors at initial assessment (concussed = 4.5 ± 3.0; healthy = 2.1 ± 2.2, $p = 0.011$). No differences were found between groups for SAC scores at initial assessment or symptom resolution, but the concussed group performed significantly better than the healthy controls at return-to-play (concussed = 28.2 ± 3.0; healthy = 26.5 ± 2.2, $p = 0.035$). **Conclusions:** These results suggest the presence of minor changes in blood flow regulation following concussion 24-48 hours post-injury and at symptom recovery. As deficits in balance ability were found only initially and no deficits in SAC performance were seen, it seems that the BAM may be useful in identifying physiological deficit that functional assessments do not. Future studies should seek to compare BAM, SAC, and BESS assessments to baseline performance to obtain a better understanding of BAM utility in post-concussion assessment.

Prevalence of Neurocognitive Test Failure Following Exertion in Athletes Recovering From Concussion

Gallion CJ, Zaring LC, Dean T, Kontos AP, Elbin RJ: University of Arkansas, Fayetteville, AR; Concussion Solutions, LLC, Youngsville, LA; University of Pittsburgh, Pittsburgh, PA

Context: Exertional return-to-play (RTP) protocols are recommended to determine the resolution of post-concussion symptoms and impairments. Progression through these step-wise protocols is determined by symptom reporting of the concussed athlete. However, athletes may minimize symptoms in hopes of expediting RTP, therefore prompting the use of other assessments such as computerized neurocognitive testing. Clinically significant declines in neurocognitive performance have been documented in 28% of athletes successfully (i.e., asymptomatic) completing RTP exertion protocols (McGrath et al. 2013). However, additional research using a prospective, systematic exertional protocol is warranted to corroborate these findings. **Objective:** To prospectively examine the prevalence of post-exertional (PE) neurocognitive test failure in a sample of concussed high school athletes **Design:** Prospective repeated measures design **Setting:** High school setting **Patients or Other Participants:** Forty-seven concussed high school athletes (age = 16.2 $\pm$ 1.2 years, mass = 71.1 $\pm$ 19.1 kg, height = 173.0 $\pm$ 8.5 cm) participated in the study. **Interventions:** The independent variables were time (return to baseline, post-exertion) and group (PE fail, PE pass). Percent of cases outside reliable change estimates (RCI) following the exertional RTP protocol were calculated to determine PE fail and PE pass groups. A series of 2 group X 3 time repeated measures ANOVAs were conducted for each neurocognitive composite score and symptom totals. **Main Outcome Measures:** The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) composite scores (e.g., verbal and visual memory, processing speed, reaction time) and total symptoms on the Post-Concussion Symptom Scale (PCSS). **Results:** Approximately, 23.4% (11/47) of athletes demonstrated decline in neurocognitive performance outside of RCI for one or more composite scores. Neurocognitive decrements in reaction time following the exertional RTP protocol was documented for the PE fail group ($p \leq .01$), despite no increased symptom reports ($p = .63$) **Conclusions:** Relying on symptom reports during the post-exertional RTP protocol may not be best practice as a small percentage of athletes may still be experiencing neurocognitive decrements from concussion. These data corroborate previous findings (McGrath et al. 2013) that advocate for post-exertional neurocognitive testing as part of the RTP process.

Concussion Recovery Time Course of the High School Athletes Using Stepwise Return to Play Protocol; Effect of Age and Gender

Oba Y, Tamura K, Furutani T, Oshiro RS, Stickley CD, Shimizu A, Murata N: University of Hawaii at Mānoa, Honolulu, HI, and the State of Hawaii Department of Education, Honolulu, HI

Context: Implementation of the stepwise return-to-play (RTP) protocol has become the standard management strategy for high school (HS) athletes to ensure a safe RTP after suffering from concussion. The detailed characteristics of recovery time course throughout steps in the RTP protocol have not been delineated among the HS population. **Objective:** To investigate the days spent for each step within stepwise RTP protocol in the HS population, and to examine the effects of gender and age on recovery time. **Design:** Retrospective **Setting:** Field **Patients or Other Participants:** Student athletes from 57 high schools **Interventions:** The State of Hawai`i implemented a comprehensive concussion management program (CMP) which monitors and tracks the recovery of concussed athletes. Once HS athletes are diagnosed with a concussion, the school athletic trainer (AT) implements a standardized RTP protocol (Step0:Onset, Step1:Cognitive rest, Step2:Return to school, Step3:Light exercise, Step4:Sports specific exercise, Step5:Non-contact practice, and Step6:Full contact practice). Criteria to start exercise portion (step 3) included physician's clearance and premorbid scores of Graded Symptom Checklist, Neurocognitive Testing, and BESS. All concussion cases were reported to CMP by school AT. Of 1883 reported concussions during 2010 to 2012, 726 cases (454 males, 272 females, Age:15.5±1.2) met the inclusionary criteria. Independent variables included gender and age groups of 14, 15, 16, and 17. **Main Outcome Measures:** A total days spent from step 0-6, and days spent for each step were calculated. Two-way Analysis of Variance was conducted to examine the gender, age, and gender by age interaction effects. **Results:** An average total RTP days was 20.2 ± 13.9 days (step 0-1: 0.8d ± 1.3; step 1-2: 2.6d ± 3.0; step 2-3: 10.2d ± 10.0; step 3-4: 1.9d ± 2.5; step 4-5: 2.3d ± 5.1; and step 5-6: 2.4d ± 4.4). The duration of the rest portion (steps 0-3) was 13.6 ± 10.6 days, while that of the exercise portion (steps 3-6) was 6.5 ± 7.2 days. Female took significantly longer to RTP compared to male (female: 21.6d ± 15.5, male: 19.3d ± 12.74, p = .048). The duration of rest portion of female was significantly longer than male (female: 14.7d ± 11.4, male: 13.0d ± 10.0, p = .045). The age groups of 14, 15, and 16 took significantly longer to RTP compared to age group of 17 (14 y/o: 21.7d ± 15.6, p = .028, 15y/o: 21.4d ± 12.4, p = .032, 16 y/o: 21.4d ± 14.5, p = .030, vs. 17 y/o: 17.0d ± 14.3). The duration of rest portion was significantly longer in age groups of 14, 15, and 16 than 17 (14 y/o: 11.2d ± 10.7, p = .025, 15 y/o: 11.7d ± 10.6, p = .005, 16 y/o: 10.9d ± 10.2, p = .019, vs. 17 y/o: 7.7d ± 9.2). There were no significant differences in the duration of exercise portion between genders or age groups. **Conclusions:** When the standardized stepwise RTP protocol was used, the average total RTP days among HS athletes was 20.2±13.9 days, with the longest time spent between steps 2-3 (10.2d±10.0). Female HS athletes took longer to become asymptomatic which resulted in longer RTP, compared to male counterparts. Similarly, younger HS athletes (14, 15, and 16y/o) took longer to become asymptomatic which resulted in longer RTP compared to 17y/o.

Standardized Concussion Assessment Tool 3 (SCAT3) Tandem Gait Test in High School Athletes: A Study of Pass Rate, Sex Effect, and Reliability

Littleton AC, Guskiewicz KM, Lynall RC, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: The Standardized Concussion Assessment Tool 3 (SCAT3) includes a timed tandem gait test (heel-to-toe walking along a straight line) administered with a dichotomous pass/fail scoring system. Functional movement and dynamic balance may provide important clinical information following suspected concussion. However, research on the efficacy of the tandem gait test is limited, especially in high school athletes. **Objective:** To determine the pass rate (ability to complete the test in 14 seconds or less) and sex effect at pre-injury baseline on the tandem gait test in high school athletes. A secondary purpose was to determine the test reliability across the four administered trials required by the SCAT3. **Design:** Cross-sectional. **Setting:** Four high schools. **Patients or Other Participants:** Participants included 158 high school athletes (93 males, 65 females; age = 15.5 ± 1.7 years; height = 171.2 ± 9.1 cm; mass = 65.5 ± 17.5 kg). **Interventions:** Participants were administered the SCAT3 tandem gait test prior to the fall athletic season. Participants walked along a 3m line ensuring their heel and toe touched on each step, turned 180 degrees once they crossed the end of the line and returned to the starting point using the same gait. Four trials were completed. **Main Outcome Measures:** Descriptive statistics were used to describe the pass rate. An independent t-test was used to determine the sex effect on best time across the four trials. Intraclass correlation coefficients (ICC2,1) were calculated to determine the reliability of performance across the four test trials. **Results:** Only 20% of athletes passed

the test. The mean time for the best trial on the tandem gait test was 17.79 ± 4.81s, with males performing better than females (males = 16.47 ± 4.64s; females = 19.77 ± 4.50s; t156 = 4.39; P < 0.01). We observed strong reliability across all four trials (ICC2,1 = 0.86). **Conclusions:** While assessment of functional movement and dynamic balance following suspected concussion is warranted, the 80% fail rate in healthy high school student-athletes using the current SCAT3 tandem gait test is inadequate for informing post-injury clinical decision-making. There were differences in time for the best trial between males and females, despite a single pass/fail cutoff score for the test. Given the reliability we observed, the need for the SCAT3 to include all four trials should be reconsidered. The high failure rate and differences in sex observed in our study underscore the need for further investigation as to the best method to evaluate functional movement and dynamic balance in assessing concussion. At a minimum, a higher cutoff score should be considered for the tandem gait test in high school athletes.

Preliminary Investigation of Clinically Practical Dual-Task Tests as a Concussion Assessment Tool: A Comparison of Single- and Dual-Task Tests on Healthy Young Adults

Kocher MH, Tamura K, Finer LM, Ling A, Murata N, Oba Y, Stickley CD, Oshiro RS, Furatani T: University of Hawaii at Mānoa, Honolulu, HI

Context: Dual-Task testing, which involves concurrent performance of neurocognitive and postural stability tests, has been suggested for concussion assessment; as it is the closest approximation of sports participation available in the clinical setting. Previous laboratory-based research on Dual-Task testing for concussion assessment has utilized equipment not commonly available in the clinical setting. To our knowledge, clinically practical Dual-Task combinations are currently not available for physically-active individuals. **Objective:** The purpose of this study was to examine the effects of clinically practical Dual-Task testing combinations on outcome measures in healthy college-aged individuals. **Design:** Randomized repeated measures. **Setting:** Clinical athletic training laboratory. **Patients or Other Participants:** 54 college-aged participants (21 ± 1.6 y/o, 21 male, 33 female) free from concussion or lower extremity injury. **Interventions:** Two separate testing sessions consisting of two physical tasks, Modified BESS (mBESS) and Expanded Timed Get-Up-And-Go (ETGUG), and three cognitive tasks, Backward Digit Recall (BDR), Serial Sevens (SS), and Auditory Pure Switch Task (APST), were completed. The Single-Task trials were conducted first, followed by the six Dual-Task combinations in each of the two sessions. Each participant was assigned to one of two examiners for both sessions. **Main Outcome Measures:** Differences between Single- and Dual-Task performances of the physical tasks were assessed using a one-way ANOVA, while paired t-tests were used to assess differences in the cognitive tasks. Test-retest reliability for all tests was assessed using Intraclass Correlation Coefficients. **Results:** Total mBESS errors increased [mBESS: 11.39 ± 5.26, mBESSSS:13.46 ± 7.11, p = 0.003; ICCmBESS = 0.71(Tester 1) & 0.67 (Tester 2), ICCmBESS + SS = 0.60 & 0.54, ICCmBESS + BDR = 0.71 & 0.76, ICCmBESS + APST = 0.70 & 0.65] under Dual-Task combination with SS. ETGUG time significantly increased under Dual-Task combination as compared to Single-Task (ETGUG: 19.98s ± 2.71, ETGUGBDR: 26.02s ± 6.29, ETGUGSS: 25.51s ± 5.63, ETGUGAPST: 22.21s ± 4.50, p < 0.001 for all; ICCETGUG: 0.73 & 0.90, ICCETGUG + BDR: 0.87 & 0.85, ICCETGUG + SS: 0.71 & 0.94, ICCETGUG + APST: 0.77 & 0.77). Statistically significant changes occurred in cognitive outcome measures under Dual-Task conditions; however, these changes were not clinically significant. **Conclusions:** Decreases in performance under Dual-Task conditions was most apparent in ETGUG with an average increase of 4.6 seconds. ETGUGAPST had excellent reliability and no observed learning effect as indicated by no significant mean difference between sessions. Our findings using clinically practical Dual-Task combinations supports previous research that reported similar effects using laboratory equipment. Further research should investigate the ability of the Dual-Task combinations of ETGUG and APST with an outcome measurement of time to complete the ETGUG in assessing deficits due to concussion.

Knee Evidence-Based Forum: Return to Play after Anterior Cruciate Ligament Reconstruction

Friday, June 26, 2015, 8:00AM-9:00AM, Room 130; Moderator: Joseph Hart, PhD, ATC
Discussants: David Bell, PhD, ATC; Benjamin Goerger, PhD, ATC

Free Communications, Oral Presentations: Return to Play Factors After Anterior Cruciate Ligament Reconstruction

Friday, June 26, 2015, 9:15AM-10:15AM, Room 130; Moderator: Christopher Kuenze, PhD, ATC

The Relationship Between Personality, Knee Braces, and Stiffness Regulation After Anterior Cruciate Ligament Reconstruction

McGuire KE, Swanik CB, An YW: University of Delaware, Newark, DE

Context: Despite having anterior cruciate ligament (ACL) surgical repair, many patients (ACLR) experience repetitive episodes of "giving way" or re-injury. Recent research, and anecdotal evidence, suggests that personality traits (Risk Taking, Mental Toughness, Fear) may interact with the application of functional knee braces to influence the joint stiffness regulation strategies necessary for functional stability; however there is limited data on this subject. **Objective:** To determine how a relationship between personality and functional knee braces influence joint stiffness regulation strategies. **Design:** Case-control study. **Setting:** Athletic Training laboratory. **Patients or Other Participants:** Fifteen ACLR subjects (11 females, 20.9 ± 1.9 yrs, 173.1 ± 12.9cm, and 173.1 ± 12.9kg) with clearance to return to full participation and 14 controls (10 females, 20.9 ± 3.0 yrs, 170.4 ± 8.6cm, and 67.7 ± 16.8 kg) with no history of knee injury volunteered for this study. The average time since reconstruction was 3.3 years, ranging from 9 months to 7 years. **Interventions:** Personality was examined by psychometric surveys: Sensation Seeking Scale-V, Mental Toughness Questionnaire-18, and Tampa Scale of Kinesiophobia. Knee outcome surveys (KOS-ADL, IKDC) and single legged hop tests were used to asses function with and without a functional knee brace (DonJoy Full Force, DJO Global). Joint stiffness was examined using a custom-built device with and without the brace. Subjects were instructed to relax and immediately provide maximum resistance to a perturbation from 30-degree to 70-degree flexion randomly applied in two conditions: control and acoustic startle (100dB, 50ms duration, 1000Hz). **Main Outcome Measures:** Individual t-tests were used to detect personality differences between groups. Normalized knee stiffness (Nm/°/kg) was compared across groups (2-levels), conditions (2-levels), and brace (2-levels) by using a 3-way repeated-measures ANOVA. Knee functional outcomes were compared across groups (2-levels) and brace (2-levels) by using 2-way repeated-measures ANOVAs. Pearson correlation coefficients were used to assess relationships between personality, function and stiffness. **Results:** Significant main effects for the brace ($F_{1,27}$ = 7.09, p = .013) revealed the brace (0548 ± .0108Nm/°/kg) caused greater knee stiffness than the non-braced (.0483 ± .0107Nm/°/kg), and the startle condition ($F_{1,27}$ = 5.03, p = .033) demonstrated diminished knee stiffness in the acoustic startle condition (.0450 ± .0159 Nm/°/kg) compared to control condition(.0518 ± .0119 Nm/°/kg). The hop test ($F_{1,27}$ = 5.25, p = .030) revealed increased time in the brace (2.48 ± .55sec) compared to non-brace (2.40 ± .57sec). The ACLR (35.6 ± 8.11) had greater Kinesiophobia than controls (28.0 ± 3.64) (p = .004). Knee stiffness showed moderate positive relationships with both sensation seeking (r = *.41*, p = .026) and mental toughness (r = *-.37*, p = .049). **Conclusions:** ACLR patients recovered the knee stiffness needed for stability, but have less predictable stiffen strategies and remain more fearful of activity. Functional knee braces facilitate higher knee stiffness in everyone, but may benefit mentally tough people even greater. A startling event diminishes everyone's ability to stiffen their knees; however "risk-takers" could stiffen better when startled. Lower self-confidence was related to lower joint stiffness.

Comparison of Individuals Who Do and Do Not Return-to-Play Following ACL Reconstruction

Howard JS, Whale CE: University of Kentucky, Lexington, KY

Context: Large variations in return-to-sport rates following anterior cruciate ligament(ACL) injury have been reported for a variety of sports at different competition levels. Factors proposed to possibly influence return-to-sport include preoperative function, gender, age, level of sport competing in at time of injury, and occurrence of concomitant injuries. **Objective:** Our purpose was to compare characteristics between individuals who have and have not returned to sport following ACL Reconstruction. **Design:** Retrospective Case-Comparison **Setting:** Outpatient Sports Medicine Clinic Patient Outcomes Registry **Patients or Other Participants:** Data for patients with a minimum of 1-year follow-up from ACL reconstruction was extracted for patients who reported returning to the same level of sport or higher (RTS:n = 34, 13 female/21 male, age = 27 ± 11yrs, mean follow-up = 2 ± 1yr) and those who reported a lower level of sports activity post-surgery (NRTS:n = 28, 9 female/18 male, age = 28 ± 13yrs, mean follow-up = 2.5 ± 1yrs). **Intervention:** All patients were enrolled prospectively and completed patient reported outcome measures pre-surgery and annually post-surgery. Return-to-sport status and current level of sport participation were self-reported. **Main Outcome Measures:** The following measures were collected pre and post-surgery: International Knee Documentation Subjective Knee Form(IKDC), Knee Osteoarthritis Outcomes Score(KOOS) (only available post-operatively), and the ICRS Cartilage Standard Evaluation Form which includes self-report sport level and return-to-sports status, and main reasons for not returning to sport. Additionally, the effect of age, gender, and concomitant meniscal surgery on return-to-sport status was examined.

Mann-Whitney U-test for continuous variables and chi square tests for categorical variables were used to compare characteristics between patients who returned to sport and those who did not($P < .05$). Finally, those variables observed to be significantly different between groups were entered into a backwards logistic regression to determine which variables or combination of variables best predicted return-to-sport status. **Results:** There were no between group differences for preoperative IKDC ((Median(Range) RTS = 43 (17-85), NRTS = 43(14-83), p = 0.587) or patient age (P = 0.573). Postoperatively, the return-to-sport group demonstrated greater IKDC ((Median(Range)) RTS = 91 (33-100), NRTS = 64 (21-98) $p < 0.001$) $KOOS_{pain}$ (RTS = 97 (67-100), NRTS = 89 (39-97), p = 0.005) $KOOS_{ADL}$(RTS = 100 (74-100), NRTS = 95 (43-100), p = 0.008) and $KOOS_{QOL}$ scores (RTS = 75 (31-100), NRTS = 57 (19-100), p = 0.014) scores. $KOO_{symptoms}$ (RTS = 68 (46-100), NRTS = 67 (36-96), p = 0.107) and $KOOS_{sports\&rec}$ (RTS = 90 (45-100), NRTS = 73 (0-100), p = 0.089) scores did not differ between groups. The frequency of returning to sport did not differ based on gender (male = 53%, female = 59%, p = 0.618), preoperative sport level ("Professional/High level competitive sports" = 60%, "Well-trained frequent sports" = 60%, "Sports sometimes" = 46%, p = 0.545), or occurrence of concomitant meniscal injury (Yes = 58%, No = 53%, p = 0.701). The only factor remaining in the final logistic regression was IKDC postoperative score ($Exp(\beta) = 1.05$, p = 0.002). Fear of re-injury was the most commonly reported reason for not returning to sport (54%). **Conclusions:** Unlike with other procedures, preoperative level of function does not appear to influence return-to-sport outcomes following ACL reconstruction. Furthermore, gender, age, level of sport, and meniscal involvement did not influence outcomes. These results suggest that postoperative outcomes concerning pain, function, and quality-of-life, which may be modifiable, are more associated with the return-to-sport than patient or surgical characteristics such as age, gender, and meniscal status.

Understanding Return-to-Sport Factors Following Anterior Cruciate Ligament Reconstruction

Werner JW, Toonstra JL, Iannicelli JP, Mattacola CG, Howard JS: University of Kentucky, Lexington, KY, and Salisbury University, Salisbury, MD

Context: Anterior cruciate ligament reconstruction (ACLR) is the standard for regaining function and returning athletes to pre-injury activity levels following ACL injury, especially in the USA. Outcomes after ACLR suggest athletes have returned to a level of function that would support return-to-sport; however, a recent meta-analysis reported pooled return rates of only 44% (Arden et al. 2011). It is unclear whether this discrepancy is a result of functional impairments. **Objective:** To compare patient-reported-outcomes (PROs), dynamic balance, dynamic functional performance, strength, and muscular endurance in athletes that have returned to sport (RTS) compared to athletes that have not returned to sport (NRTS) following ACLR. **Design:** Quasi-experimental, case-comparison study. **Setting:** University research laboratory. **Patients or Other Participants:** Two groups of participants with primary, unilateral ACLR: 19 individuals RTS (age = 25 ± 10, height = 172.7 ± 8.0cm, weight = 74.2 ± 15.0kg, years-since-surgery = 4 ± 3) and 11 individuals NRTS (age = 23 ± 6, height = 172.4 ± 8.3cm, weight = 71.4 ± 9.3kg, years-since-surgery = 4 ± 3). **Interventions:** PROs included the International Knee Documentation Committee Subjective Form (IKDC) and Knee Injury and Osteoarthritis Outcomes Score (KOOS). Functional performance outcome measures included the anterior and posteromedial reaches on the Star Excursion Balance Test (SEBT), a battery of single-leg hop tests (single-leg hop for distance, cross-over triple hop, and 6-meter timed hop), and isokinetic quadriceps and hamstring strength at 60 and 180°/s. All testing occurred in a single two-hour session. **Main Outcome Measure(s):** Limb symmetry index (% LSI) for SEBT, single-leg hop tests, and peak knee-flexor and knee-extensor torque. **Results:** The NRTS group reported statistically lower scores on the IKDC (RTS = 90.07 ± 8.17, NRTS = 82.69 ± 10.76, P = 0.046) and $KOOS_{Symptoms}$ (RTS = 83 ± 16, NRTS = 70 ± 11, P = 0.022) compared to the RTS group. No other statistical differences were observed in the PROs**:** Lysholm (RTS = 90.11 ± 8.8, NRTS = 86.63 ± 13.65, P = 0.41)**,** $KOOS_{Pain}$ (RTS = 82 ± 20, NRTS = 79 ± 29, P = 0.76)**,** $KOOS_{ADL}$ (RTS = 99 ± 2, NRTS = 97 ± 5, P = 0.15)**,** $KOOS_{Sport}$ (RTS = 89 ± 7, NRTS = 85 ± 14, P = 0.25)**,** and $KOOS_{QOL}$ (RTS = 84 ± 12, NRTS = 75 ± 21, P = 0.13). No statistical differences were observed for any functional performance measures: $SEBT_{Anterior}$ (RTS = 102 ± 10%, NRTS = 100 ± 7%, P = 0.71), $SEBT_{Posteromedial}$ (RTS = 102 ± 10%, NRTS = 96.61 ± 5.04, P = 0.13), Single-leg-hop (RTS = 96 ± 10%, NRTS = 93 ± 11%, P = 0.43), Cross-over-hop (RTS = 95 ± 11%, NRTS = 99 ± 18%, P = 0.46, Timed-hop (RTS = 95 ± 13%, NRTS = 95 ± 12%, P = 0.95), 60°/s Quadriceps-Concentric (RTS = 87 ± 23%, NRTS = 93 ± 13%, P = 0.26), 60°/s Quadriceps-Eccentric (RTS = 84 ± 23%, NRTS = 79 ± 16%, P = 0.53), 180°/s Quadriceps-Concentric (RTS = 85 ± 28%, NRTS = 87 ± 25%, P = 0.88),180°/s Quadriceps-Eccentric (RTS = 86 ± 33%, NRTS = 85 ± 16, P = 0.99), 60°/s Hamstring-Concentric (RTS = 82 ± 16%, NRTS = 76 ± 11%, P = 0.29), 60°/s Hamstring-Eccentric (RTS = 84 ± 17%, NRTS = 79 ± 11%, P = 0.41), 180°/s Hamstring-Concentric (RTS = 93 ± 24, NRTS = 91 ± 15%, P = 0.77), 180°/s Hamstring-Eccentric (RTS = 87 ± 12%, NRTS = 87 ± 12**%,** P = 0.95). **Conclusions:** Those that did not return-to-sport reported significantly lower IKDC and $KOOS_{Symptoms}$ scores, despite demonstrating similar function on a variety of physical performance measures. Although exceeding 90% LSI on various functional performance measures, both groups exhibited below the clinical recommendation of 85% LSI for isolated hamstring and quadriceps strength following ACLR. These results further support existing evidence that dynamic physical performance alone, should not be the

only postoperative outcome measure. Patients' symptoms and self-perceived physical function appear to be more associated with the chance to return-to-sport than multiple objective measures of physical function.

To Return or Not Return? A Qualitative Investigation of Factors Influencing Return to Sport Following ACL Reconstruction.

Iannicelli JP, Werner JL, Toonstra JL, Mattacola CG, Howard JS, Howell DM: University of Kentucky, Lexington, KY; Salisbury University, Salisbury, MD; Eastern Kentucky University, Richmond, KY

Context: Return to sport criteria following anterior cruciate ligament (ACL) injury is often based on "satisfactory" functional and patient-reported outcomes. However, an individual's decision to return to sport is likely multifactorial and may be dependent not only on physical factors but environmental and psychological influences as well; psychological and physical readiness to return to sport may not be synonymous. **Objective:** To determine the various psychosocial factors that influence athletes' decisions regarding return to sport following ACL reconstruction. **Design:** Qualitative study utilizing phenomenology. **Setting:** Research Laboratory **Patients or Other Participants:** A total of 12 participants (6 male, 6 female, mean age 24±9 years) with a history of having undergone ACL reconstruction were purposefully selected from a large cohort to participate in this study. Participants were chosen so as to insure that both those who returned and those who did not return were equally represented. To be eligible for inclusion, participants were required to have regularly participated in competitive athletics at the time of injury and were a minimum of 1-year post-operative. Data saturation guided the total number of participants enrolled in this study. **Data Collection and Analysis:** Data was collected through semi-structured interviews. Qualitative analysis using a descriptive phenomenological process was used to derive categories and themes that represented the data. The dynamic biopsychosocial model was used as a theoretical framework to guide this study. **Results:** Interviews revealed 6 predominant themes that describe and fully represent the experiences of the participants following ACL reconstruction: 1.) Hesitation and lack of confidence led to self-limiting tendencies, 2.) Heightened awareness of the knee often led to feelings of anxiety and fear when considering return to sport, 3.) Expectations and assumptions about the recovery process influenced the decision to return to sport, 4.) Coming to terms with ACL injury led to a re-prioritization, 5.) Athletic participation helped reinforce intrinsic personal characteristics, 6.) Having a strong support system both in and out of rehabilitation was a key factor in building a patient's confidence. Each of the themes was placed in a component of the dynamic biopsychosocial model to help us better understand how our themes influenced return to sport. Cognition was evident in themes 1 & 3, affect in theme 2, behavior in themes 5 & 6 and outcome in theme 4. **Conclusions:** Following ACLR, the decision to return was largely influenced by psychosocial factors. Some factors, including hesitancy, lack of confidence, or fear of re-injury, may be related to knee function and have the potential to be addressed within the rehabilitation setting. Other factors such as changes in priorities or expectations, may be independent of physical function, but remain relevant to the patient-clinician relationship and should be considered during post-operative rehabilitation.

Free Communications, Oral Presentations: Effect of Knee Injury on Neuromechanics

Friday, June 26, 2015, 10:30AM-11:30AM, Room 130; Moderator: Abbey Thomas, PhD, ATC

Influence of Knee Injury on Quadriceps Torque-Generating Capacity and Voluntary Activation

Grindstaff TL, Pietrosimone BG, Ingersoll CD: University of Virginia, Charlottesville, VA; Creighton University, Omaha, NE; University of North Carolina at Chapel Hill, Chapel Hill, NC; Central Michigan University, Mount Pleasant, MI

Context: Meniscus and anterior cruciate ligament (ACL) injuries are among the most common knee injuries. Deficits in quadriceps torque-generating capacity and voluntary activation are common consequences of knee joint injury that can persist for years, but the magnitude of these deficits across knee injuries of differing complexity has not been determined. **Objective:** The purpose of this study was to quantify differences in quadriceps torque-generating capacity and voluntary activation in individuals who have who have undergone arthroscopic partial meniscectomy (APM), isolated ACL reconstruction (isolated ACL-R), or ACL-R in conjunction with other ligament or cartilage injury (complex ACL-R). We hypothesized that complex ACL-R would demonstrate the greatest deficits in quadriceps torque-generating capacity and voluntary activation while the APM group would demonstrate the smallest deficits. **Design:** Cross-sectional. **Setting:** University research laboratory. **Patients or Other Participants:** Eighteen individuals with a history of APM (age = 23.2 ± 5.2 years; height = 171.4 ± 9.6 cm; mass = 73.2 ± 11.8 kg; time since surgery 4.4 ± 3.5 years), 31 individuals with a history of isolated ACL-R (age = 20.5 ± 1.8 years; height = 169.6 ± 8.3 cm; mass = 72.1 ± 9.7 kg; time since surgery 2.6 ± 1.5 years), and 16 individuals with a history of complex ACL-R (age = 22.9 ± 4.4 years; height = 174.2 ± 7.4 cm; mass = 79.0 ± 10.9 kg; time since surgery 4.3 ± 2.8 years) participated in this study. **Main Outcome Measures:** Quadriceps torque-generating capacity and voluntary activation were measured during a maximal voluntary isometric contraction (MVIC) knee extension task while seated on an isokinetic dynamometer. A supramaximal electrical stimulus was used to augment quadriceps torque-generating capacity during the MVIC. Quadriceps activation was calculated using the central activation ratio (MVIC/MVIC + supramaximal stimulus). Participants performed two trials with the maximum value utilized for data analysis. Differences in quadriceps torque-generating capacity normalized to body mass (Nm/kg) and voluntary activation (percentage) between groups were determined using a one-way analysis of variance ($P \leq 0.05$). **Results:** There was a significant difference in quadriceps torque-generating capacity (P = 0.003) and voluntary activation (P = 0.04) between groups. Individuals with a history of APM (MVIC 2.41 ± .73 Nm/kg; CAR 80.66 ± 15.41) demonstrated significantly lower quadriceps torque-generating capacity (P = 0.001) and voluntary activation (P = 0.01) compared to an isolated ACL-R group (MVIC 3.36 ± .94 Nm/kg; CAR = 89.89 ± 9.31). There were no significant differences in quadriceps torque-generating capacity (P > 0.06) and voluntary activation (P > 0.14) for individuals with complex ACL-R (MVIC 2.81 ± 1.08 Nm/kg; CAR 86.86 ± 12.86) compared to the other groups. **Conclusions:** Individuals with a history of APM demonstrated less quadriceps torque-generating capacity and voluntary activation compared to individuals with isolated ACL-R. Contributing factors to these deficits following arthroscopic partial meniscectomy are not known, but may include less formalized rehabilitation following surgery, a more expedited return to activity, or loss of joint integrity. It is possible that the standard of care following APM may need to better address deficits in quadriceps strength.

Relationship Between Quadriceps Strength, Activation, Pain, and Function in Patients with Knee Osteoarthritis

McGrath ML, Spenceri MM, Grindstaff TL: University of Nebraska at Omaha, Omaha, NE, and Creighton University, Omaha, NE

Context: Osteoarthritis (OA) is a leading cause of disability and pain in the United States, and is a known consequence of knee joint injury. Quadriceps dysfunction and loss of strength are associated with knee OA, but the precise relationships between these factors and patient-reported pain, activity level, and function are unclear. **Objective:** To determine the relationships between patient-reported function, symptoms, activity level, and quadriceps muscle strength and activation in participants with symptomatic knee OA. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Ten participants (4M,6F; 52.8(12.6 yrs, 169.9.7 (10.7cm, 80.7 (13.3kg) with prior physician diagnosis and current knee OA symptoms volunteered for the study. **Interventions:** Participants completed three patient reported outcome measures: the Western Ontario and McMaster Universities Arthritis Index (WOMAC), Lysholm questionnaire, and Tegner activity scale. Participants performed five concentric knee extension contractions on an isokinetic dynamometer at 60°/s and 120°/s. Next quadriceps activation was determined as participants performed a series of three maximal voluntary isometric contractions (MVIC), augmented with a superimposed electrical stimulus, followed by a resting twitch (RT). **Main Outcome Measures:** WOMAC items were scored on a 5-point ordinal scale (0 = none, 4 = extreme) and we calculated total WOMAC scores (range 0-96) and subscale scores (range: pain 0-20, stiffness 0-8, function 0-68). Higher scores indicate greater pain and disability. Total Lysholm score was calculated

by taking the sum of the eight individual item scores (range 0-100). Lower scores indicate greater pain and disability. The Tegner is a 10-point scale (10 = elite-level sport, 0 = sick leave/disability). Peak torque during the isokinetic contractions at each speed was normalized to body mass (Nm/kg) and used for analysis. Quadriceps activation was calculated by determining maximal RT torque, peak torque during the electrical stimulus (superimposed twitch), and the MVIC (average torque over a 100ms epoch prior to the electrical stimulus). Quadriceps activation was quantified by ((1-superimposed twitch–MVIC}/RT)*100). Pairwise bivariate Pearson correlations were performed on all variables (<0.05). **Results:** Maximum quadriceps strength at 60°/s (1.68 ± 0.52Nm/kg) and 120°/s (1.40 ± 0.44Nm/kg) was strongly associated with current Tegner activity level (4.0 ± 1.3) (60°/s: r = 0.892, $P < 0.001$; 120°/s: r = 0.850, $P = 0.002$). Maximum quadriceps activation (92 ± 8%) was correlated with total WOMAC (17.0 ± 10.7) (r = -0.740, $P = 0.014$), the pain (3.9 ± 2.6) (r = -0.687, $P = 0.28$) and function (11.1 ± 7.7) (r = -0.722, $P = 0.018$) subscales, and the Lysholm (71.2 ± 19.7) (r = 0.672, $P = 0.033$). No other significant correlations were identified. **Conclusions:** While increased quadriceps strength was significantly related to higher reported activity levels, strength was not associated with patient reports of pain or function. However, decreased quadriceps activation was associated with increased pain and decreased function, suggesting that quadriceps strength and activation are independent constructs when evaluating neuromuscular function in individuals with knee OA. Clinicians are encouraged to consider neuromuscular function, specifically muscle activation, rather than just strength, when designing rehabilitation programs for patients with knee OA. This study was funded by the University of Nebraska Omaha University Committee on Research and Creative Activity and the Creighton Department of Physical Therapy.

Quadriceps Strength is Associated With Self-Reported Function in Arthroscopic Partial Meniscectomy Patients

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Context: Arthroscopic partial meniscectomy (APM) is the most commonly performed orthopedic procedure. APM is favored for its minimal invasiveness and rapid return to daily physical and work activities. There is no standard consensus on postoperative physical therapy for patients after APM and quadriceps weakness has been demonstrated to persist in a portion of this population. Quadriceps weakness is a known predictor of physical function following acute knee injury, such as anterior cruciate ligament injury, and in patients with knee osteoarthritis. There is little evidence demonstrating how quadriceps strength associates with self-reported function following APM. Knowing how strength and disability associate following APM may illustrate the need for formalized rehabilitation to improve strength following APM. **Objective:** Determine associations between involved-limb quadriceps strength and self-reported function in APM patients. **Design:** Cross-sectional **Setting:** Controlled laboratory **Patients or Other Participants:** Nine APM patients (5M, 4F; 34.11 ± 13.71yrs; 171.73 ± 12.76cm; 104.53 ± 31.80kg, 34.75 ± 37.49wks post-APM, range: 2.00-104.00wks) participated in this study. **Interventions:** Involved-limb quadriceps strength was assessed at 90° of knee flexion via maximal voluntary isometric contractions (MVIC) with patients secured in an isokinetic dynamometer. All patients completed self-reported function questionnaires: International Knee Committee Documentation subjective form (IKDC), Knee Injury and Osteoarthritis Outcomes Score (KOOS), Western Ontario Meniscal Evaluation Tool (WOMET) and Visual Analog Scale (VAS) for pain. **Main Outcome Measures:** Averages of three quadriceps MVICs were normalized to body mass (Nm/kg) and used in our analysis. Average IKDC, KOOS, WOMET and VAS scores (%), total number of repetitions of the 30s-CST and 30s-KB and time (s) to complete a SCT were recorded and used in our analysis. Spearman's rho (ρ) correlations for non-normally distributed variables were performed to determine associations between quadriceps strength and self-reported and physical function outcomes. **Results:** There were significantly strong and positive associations between quadriceps MVIC (1.69 ± 1.00Nm/kg) and self-reported function measured on the IKDC subjective (62.66 ± 20.36%, ρ = 0.862, P = 0.006), KOOS symptoms (72.11 ± 18.78%, ρ = 0.850, P = 0.007), WOMET physical function (35.36 ± 26.91%, ρ = -0.905, P = 0.002), sports, recreation and work-life (46.23 ± 27.15%, ρ = -0.786, P = 0.021), and aggregate scores (58.68 ± 27.93%, ρ = 0.905, P = 0.002). MVICs were not significantly associated with time since surgery, the KOOS pain, activities of daily living, sports and recreation, and quality of life scales, or with the WOMET emotions scale. **Conclusions:** Quadriceps strength is significantly associated with self-reported function following APM. Greater quadriceps strength was associated with better self-reported function related to knee symptoms and function during activities commonly encountered in daily life. These outcomes suggest a need to specifically assess and address deficits in quadriceps strength following APM to improve patient oriented outcomes. This study was supported by the Datalys Center for Sports Injury Research and Prevention.

Patellar Tendon Straps Reduce Pain and Decrease Peak Vertical Ground Reaction Forces During a Single Leg Landing

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Context: Patellar tendinopathy (PT) is a common condition characterized by chronic overloading and degenerative changes in the quadriceps tendon. Prior studies suggest those with PT land with greater impact forces which may aggravate symptoms. Patellar tendon straps have been recommended by healthcare practitioners to alleviate pain in those with PT, however, there is little empirical evidence to support their use. **Objective:** To determine if patellar tendon straps decreased pain and altered peak anterior-posterior (APGRF) or vertical ground reaction forces (VGRF) during a single-limb landing in individuals with and without PT. **Design:** Case-control. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Sixty recreationally-active individuals participated: 30 (15 female, 15 male: 21.5 ± 3.0yrs, 72.0 ± 14.7kg, 174.9 ± 10.5cm) with current signs and symptoms of PT, including self-reported pain within the patellar tendon during loading activities for at least 3 months and ≤ 80 on the Victorian Institute of Sport Assessment Scale-Patella (VISA-P) indicating decreased function. Thirty gender, age, mass and height matched controls (21.3 ± 3.2yrs, 72.8 ± 12.4kg, 174.5 ± 9.4cm) had no history of PT or other knee pathology with VISA-P scores of ≥ 90. **Interventions:** For test trials, participants started 70cm from a force platform, performed a 2-legged jump to a target height set at 50% of their maximum vertical jump, and landed on a single test-limb. Participants performed 5 jumps wearing a Universal Matt-Strap™ and 5 with no-strap in a counterbalanced order. Participants completed 100mm visual analogue scales (VAS) prior to testing (baseline) and after each strap condition to assess pain; participants were blinded to previous VAS scores. **Main Outcome Measures:** Dependent variables included VAS scores and peak VGRF and APGRFs normalized to body weight (BW) during the single-limb landing. A three-way repeated measures ANOVA was used to assess differences in VAS among baseline, no-strap and strapping conditions in PT participants. Multiple mixed model two (between-subjects: PT vs. control) x two (repeated-measures within-subjects: strap vs. no strap) ANOVAs were performed to determine differences in the GRF variables ($p <$ .05). **Results:** There were no significant interactions between PT status and strapping conditions. Participants with PT displayed increased pain during jump landing trials (strap = 28.0 ± 18.5mm, p = .03, no-strap = 37.1 ± 22.1mm, $p <$ .01) compared to baseline VAS (19.6 ± 15.0mm). PT participants also displayed significantly ($p <$ .01) less pain during the strapped condition compared to no-strap. All participants demonstrated significantly decreased VGRF's during strapping (4.3 ± 0.8 BW, $p <$ .01) compared to the no-strap condition (4.5 ± 0.8 BW). **Conclusions:** Pain was reduced 25% during strapping in PT participants. The pain reduction observed may be due to the decreased VGRF recorded during strapping. The APGRF remained unchanged during strapping, indicating shearing on the tendon during a single-limb landing may potentially be unaffected when wearing a patellar tendon strap. Participants may "soften" their landing to reduce pain during single-limb landings when wearing a patellar tendon strap.

Motor Neuron Activity of Lower Leg Muscles Following Acute Lateral Ankle Sprain

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Context: Many studies have reported alterations in motor neuron activity, as assessed by Hoffmann reflex (H-reflex), in patients with chronic ankle instability (CAI) and provided insights into neurophysiological mechanisms of muscle dysfunction associated with CAI. Yet few studies have assessed the motor neuron activity in patients with acute lateral ankle sprain (ALAS) even though CAI arises from an initial ALAS. **Objective:** To determine the effects of ALAS on motor neuron activity of lower leg muscles. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Eleven participants with ALAS within 72 hours of the injury onset (8 males, 3 females; age = 23 ± 6.0 years; height = 177.3 ± 9.4cm; mass = 78.9 ± 9.7kg) and 11 healthy controls without any history of ankle sprains (8 males, 3 females; age = 22 ± 1.8 years; height = 178.5 ± 10.4cm; mass = 75.5 ± 13.3kg) participated. **Interventions:** Both the ALAS and control groups have completed H-reflex tests of the soleus, fibularis longus, and tibialis anterior that were performed bilaterally in the prone position. The recruitment curve of the H-reflex was mapped for each muscle. Maximum amplitudes of H-reflexes (H-max) and motor waves (M-max) were identified in the curve. **Main Outcome Measures:** H-max was normalized to M-max to obtain H_{max}:M_{max} ratios for each muscle since H-max significantly varies between individuals. Latencies of the H-max were determined by the time it takes for the H-max to appear relative to the introduction of the stimulus for each muscle. Separate two-way ANOVAs with repeated measures were performed to compare groups (ALAS, control) and limbs (injured, uninjured) for each of the muscles. Tukey's HSD tests were conducted for post-hoc comparisons. The alpha level was set at < .05. **Results:** For H_{max}:M_{max} ratios, there were no significant group by limb interactions for any of muscles: soleus ($F_{(1,20)}$ = .091, P = .77), fibularis lognus ($F_{(1,18)}$ < .001, P = .99) and tibialis anterior ($F_{(1,17)}$ = .942, P = .35). Neither the main effect for group nor limb was significant (all P > 0.05). Similarly, for latencies of H-max there were no significant group by limb interactions or main effects for the fibularis longus ($F_{(1,18)}$ = .797, P = .38) and tibialis anterior ($F_{(1,18)}$ = .413, P = .53). However, there was a significant group by side interaction for the soleus ($F_{(1,20)}$ = 30.21, P < .001). The latency of the soleus H-reflex in the injured limb (37.1 ± 3.6ms) was significantly longer when compared to the uninjured limb (34.3 ± 2.7ms) in the AALS group and either limb in the control group (side-matched limb: 35.3 ± 2.5ms, the other limb: 35.9 ± 2.4ms) **Conclusions:** The strength of motor neuron activity, as determined by H_{max}:M_{max} ratio, in all lower leg muscles remained unchanged following AALS. However, slower reflexive responses, as assessed by H-reflex latency, in the soleus were present in patients with ALAS without the change in other muscles tested. The delayed response of the soleus may provide insights into muscle dysfunction following ALAS.

Deficits in Postural Control of Bipedal Stance Following Acute Lateral Ankle Sprain

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Context: Multiple systematic reviews suggest that bilateral impairments in postural control during unipedal stance following acute lateral ankle sprain (ALAS) may lead to deficits in postural control of bipedal stance, however, this hypothesis has not been tested. **Objective:** To determine effects of ALAS on postural control during bipedal stance. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Ten subjects with ALAS within 3 days of the injury onset (7 males and 3 females: 3 Grade I and 7 Grade II ALAS, age = 23.5 ± 6.3 years; height = 171.3 ± 7.7cm; mass = 78.1 ± 9.8kg) and 10 healthy controls without any history of ankle sprains (7 males, 3 females; age = 22.6 ± 1.8 years; height = 178.8 ± 14.0cm; mass = 75.7 ± 14.0kg) participated. **Intervention:** Subjects in both the ALAS and the control groups completed the NeuroCom Sensory Organization Test (SOT) consisting of 6 different postural tasks; 1) Eyes open, fixed surface and visual surround 2) Eyes closed, fixed surface, 3) Eyes open, fixed surface, sway-referenced visual surround, 4) Eyes open, fixed visual surround, sway-referenced surface, 5) Eye closed, fixed visual surround, sway-referenced surface, and 6) Eyes open, sway-referenced surface and sway-referenced visual surround. Subjects were asked to stand on bare feet with shoulder width apart for 20 s for each SOT task and three trials were recorded. **Main Outcome Measures:** Postural stability was determined with an equilibrium score that was computed using the equation as specified by Clinical Interpretation Guide of the NeuroCom International, Inc. Higher

scores indicate better postural stability. The Man Whitney U test was performed to determine a difference between the two groups on equilibrium score because the Shapiro-Wilk's tests of normality and visual inspection of the data histograms showed that the SOT data were not normally distributed. Alpha levels were set a priori at P≤.05. **Results:** Subjects in the ALAS group demonstrated significantly worse postural control when compared with the group without ALAS during SOT 1 task [U = 78, P = .035, AALS (median = 95.0, range = 91.3-96.3) and control (median = 96.2, range = 94.7-97.3)] and SOT 2 task [U = .81, P = .019, ALAS (median = 91.7, range = 69.3-95.7) and control (median = 95.0, range = 91.0-96.0)]. No significant group differences were found in other SOT tasks (P > .05). **Conclusions:** Patients with ALAS presented deficits in postural control of bipedal stance on stable surface with eyes open and closed, but these impairments were not found during other SOT tasks involving moving surface or visual surround. These results suggest that patients with ALAS may benefit from balance training involving bipedal standing at the early phase of rehabilitation.

Acute Effects of Lateral Ankle Sprains on Range of Motion, Balance, and Self-Reported Function

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Context: One in three individuals who suffer a lateral ankle sprain (LAS) subsequently develop chronic ankle instability; characterized by life-long residual symptoms, recurrent injury, and decreased physical activity. Collectively, the high incidence of chronic ankle instability indicates that intervention effectiveness for acute LAS is poor. However, our inability to properly treat acute LAS is not surprising given our limited understanding of post-LAS consequences. **Objective:** To examine the acute effects of LASs on dorsiflexion range of motion (DFROM), single limb balance (SLB), and self-reported function (SRF). **Design:** Prospective longitudinal study. **Setting:** Research Laboratory. **Patients or Other Participants:** 11 patients (5 males, 6 females; 21.5 ± 0.9yrs; 171.9 ± 4.2cm; 75.8 ± 6.1kg) with an acute LAS participated. All patients suffered a first time ankle sprain or a first recurrent sprain that was ≥ 12 months after the initial sprain. **Interventions:** All patients were evaluated for DFROM and SLB at 3-days, 1-week, 2-weeks, and 4-weeks post injury. SRF was evaluated 1-week, 2-weeks, and 4-weeks post injury. Both the involved and uninvolved limbs were measured during the patients first test session with follow-up sessions testing only the involved limb. **Main Outcome Measures:** The weight-bearing lunge test (WBLT) assessed DFROM as the farthest distance (cm) from the great toe to the wall achieved when the knee touched the wall without the ipsilateral heel lifting off the ground. The foot lift test assessed SLB (errors) during 3, 30-second eyes closed trials on a firm surface. SRF was measured using the Foot and Ankle Ability Measure (FAAM) and FAAM-Sport (FAAM-S). Post injury time points were compared to a control condition; uninvolved limb for DFROM and SLB and preinjured data for SRF using univariate ANOVAs with an alpha level of 0.05. **Results:** Relative to the control condition (FAAM: 98.8 ± 3.4%, FAAM-S: 97.7 ± 5.5%), FAAM and FAAM-S were significantly lower at 1-week (FAAM: 68.1 ± 28.2%; $p < 0.01$, FAAM-S: 43.6 ± 28.3%; $p < 0.01$), and 2-weeks (FAAM: 73.9 ± 21.6%; $p = 0.04$, FAAM-S: 55.2 ± 21.2%; $p < 0.01$) post injury. The FAAM-S (67.5 ± 19.7%; $p = 0.02$) was also significantly lower compared to the control condition 4-weeks post-injury. DFROM was not significantly different ($p = 0.22$) between the control condition (14.2 ± 3.6cm), 3-days (11.7 ± 3.6cm), 1-week (10.3 ± 5.4cm), 2-weeks (8.9 ± 5.6cm), and 4-weeks post-injury (10.5 ± 4.3cm). Similarly, SLB was not significantly different ($p = 0.47$) between the control condition (7.9 ± 4.1 errors), 3-days (11.7 ± 6.3 errors), 1-week (9.0 ± 5.3 errors), 2-week (8.0 ± 3.7 errors), and 4-weeks post-injury (8.1 ± 3.30 errors). **Conclusions:** Following acute LASs, SRF during activities of daily living returns to pre-injury levels in at least 4-weeks while SRF during sporting activities takes more than 4-weeks to return to pre-injury levels. Non-significant declines in DFROM and SLB were observed in this sample of acute LAS and appear to present with unique recovery patterns. Different recovery patterns among the tested outcomes indicate the need for further research with a larger sample and for a longer post-injury duration.

Patients Experience Significant and Meaningful Changes in Self-Report of Function During the First Two Weeks After an Ankle Sprain Injury: A Report From the Athletic Training Practice-Based Research Network

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Context: Ankle sprains are common during sport participation and associated with both short- and long-term impairments (eg, pain, decrease range of motion). While evidence indicates that ankle sprains can negatively impact self-report of function in the long-term, little is known of short-term changes following injury. **Objective:** To determine changes in self-report of function, as measured by the Foot and Ankle Ability Measure (FAAM), during the first two weeks after an ankle sprain injury. **Design:** Dependent sample. **Setting:** Athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** Thirty-nine patients (male = 20, age = 16.7 ± 1.4 years, height = 168.7 ± 10.7 cm, mass = 70.1 ± 3.2 kg; female = 19, age = 16.5 ± 2.3 years, height = 143.3 ± 23.4 cm, mass = 67.5 ± 3.0 kg) represented twelve different sports and were diagnosed with an ankle sprain injury by an athletic trainer within the AT-PBRN. **Interventions:** The independent variable was time. Patients received usual care from an athletic trainer and completed the FAAM during treatment sessions at post-injury Time 1 [(T1); range=0-5 days post-injury] and Time 2 [(T2); range = 10-15 days post-injury]. The FAAM is a patient-rated outcome measure consisting of two subscales: activities of daily living (FAAM-ADL; 21 items) and sport (FAAM-Sport; 8 items). Both subscales have established measurement properties including minimal clinically important difference (MCID) values (FAAM-ADL MCID = 8 points; FAAM-Sport MCID = 9 points). Subscale scores range 0-100, with higher scores indicating better function. **Main Outcome Measures:** Dependent variables were the FAAM-ADL and FAAM-Sport scores. Descriptive statistics (mean ± SD) were reported, and Wilcoxon Signed-Rank tests were used to identify differences between T1 and T2. Alpha was $P < .05$, two-tailed. **Results:** Significant differences were reported for both the FAAM-ADL ($P < .001$) and FAAM-Sport ($P < .001$) when comparing scores between T1 and T2. For FAAM-ADL, patients reported scores of 52.9 ± 26.1 (range 6-100) and 88.8 ± 13.4 (range = 49-100) at T1 and T2, respectively. For FAAM-Sport, patients reported scores of 30.8 ± 28.5 (range = 0-100) and 68.0 ± 28.1 (range = 6-100) at T1 and T2, respectively. When comparing scores on an individual level, most patients reported score changes between T1 and T2 that exceeded the MCID value for the FAAM-ADL (89.7%, n = 35) and FAAM-Sport (82.1%, n = 37). However, few patients (FAAM-ADL: 25.6%, n = 10; FAAM-Sport: 10.3%, n = 4) reported a complete recovery of self-report of function (ie, a score of 100) at T2. **Conclusions:** Patients who suffer an ankle sprain injury generally report significant and meaningful improvements in self-report of function during the first two weeks post-injury. However, most patients continue to experience deficits in self-report of general and sport function at two weeks post-injury. Clinicians should be aware of these deficits and ensure full recovery of self-report of function, even if the patient has returned to play during this time period. Research efforts should aim to identify effective treatment strategies to address short- and long-term functional deficits in patients following ankle sprain injuries.

The Effect of Soft Tissue Oscillation Therapy on the Management of Pain Associated With Delayed Onset Muscle Soreness

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Context: The objective of many health care interventions is to manage pain. However, many of the therapeutic interventions used to control pain are not supported by empirical evidence. An example of this is the application of soft tissue oscillation therapy. Previous research has shown soft tissue oscillation therapy to be effective when treating lymphedema, drainage, edema, muscle extensibility, and pain resulting from burns, but limited research has been conducted to examine its effectiveness on pain resulting from musculoskeletal injuries. **Objective:** The purpose of this study was to evaluate the efficacy of soft tissue oscillation therapy compared to a placebo in the management of pain associated with musculoskeletal injury; specifically, delayed onset muscle soreness (DOMS). **Design:** Experimental Crossover, Repeated Measure Design**.** **Setting:** Controlled laboratory setting. **Patients or Other Participants:** We recruited participants from health, physical education, athletic training, and leisure services classrooms at a Midwestern Division I university. Thirty physically active volunteers (17 females, 14 males; mean age = 21.30 ± 1.47) completed participation. Healthy physical activity was defined as moderate-intensity aerobic physical activity for a minimum of 30 minutes a day, 5 days a week or a vigorous intensity aerobic activity for a minimum of 20 minutes a day, 3 days a week. **Interventions:** Participants were induced with delayed onset muscle soreness to the elbow flexors of their non-dominant arm using a previously reported protocol. Participants were randomly divided into two groups; soft tissue oscillation therapy or placebo. Following DOMS induction, participants received treatment in 24 hour increments for a total of 5 treatment sessions or until pain was reported as resolved. Pain was measured using the 11 point Numerical Rating Scale (NRS; 0 = no pain, 10 = worst possible pain). **Main Outcome Measures:** Subjective rating of pain was measured via the Numeric Rating Scale (NRS). Three ANOVA tests were conducted to compare the two groups. Alpha was set *a priori* at $p \leq .05$. **Results:** The DOMS-induced arm had a significant increase in pain 48 hours after the induction of DOMS (t (29) = 12.0, $p < 0.05$), deeming DOMS to have been successfully induced. No treatment effect was found between the two groups (F (1, 28) = 0.06, $p > 0.05$), but there was a significant time effect (F (4, 112) = 87.6, $p < 0.05$), indicating that pain reported in the arm induced with DOMS decreased significantly over time, regardless of treatment. **Conclusions:** Based on the results, there was no difference in pain reduction in the treatment or placebo group. Soft tissue oscillation had no effect on the reduction of pain; pain resolved over time in both groups. Soft tissue oscillation therapy was not found to be a successful treatment for DOMS.

The Effect of Instrument Assisted Soft Tissue Mobilization Using the Graston Technique® On Plantar Fascia Pathology

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Context: Plantar fascia pathology is a condition affecting the plantar aponeurosis of the foot causing pain, especially during the first steps in the morning. In chronic musculoskeletal conditions, like plantar fasciosis, the injured tissue can become stagnate in the healing process. The Graston Technique®, a form of instrument-assisted soft tissue mobilization (IASTM), is believed to restart the inflammatory process in order promote healing. **Objective:** To examine the effects of two therapeutic techniques on treating the symptoms of plantar fascia. **Design:** Cohort study. **Setting:** Athletic training room. **Patients or Other Participants:** Thirty-four symptomatic subjects who have been diagnosed by a medical professional with plantar fascia pathology were recruited for participation (32.5 ± 17.2 years; 169.6 ± 9.7 cm; 74.2 ± 15.8 kg). Subjects were excluded if they had a history of surgery or previous use of IASTM. **Interventions:** Subjects were randomly assigned to either the IASTM (n = 17) or stretching (n = 17) group. Subjects in the IASTM group received modified Graston Technique® for 10-12 minutes focusing on the gastrocnemius, soleus, and plantar fascia. Subjects in the stretching group performed four 30-second bouts of slant board stretching with the knees fully extended. This process was repeated with the knees bent. Subjects received 6 treatments, which were 48-72 hours apart. All subjects were tested three times: prior to any treatment (PRE), following the 6 treatments (POST), and one-month after treatments were terminated (ONE_MO) (°). The researcher capturing the outcome data was blinded to group allocation. Patient reported outcomes were

assessed using the pain and quality of life (QL) subscales of the foot and ankle outcome score (FAOS). Disease oriented outcomes were assessed by measuring ankle dorsiflexion range of motion (ROM) using the weight-bearing lunge test (WBLT). A digital inclinometer (Acumar, v5, Lafeyette Instrument Co) was placed on the tibia during the WBLT and maximal ankle dorsiflexion was captured. Each dependent variable was analyzed separately using a repeated measures ANOVA. **Main Outcome Measures:** Score on the pain subscale of FAOS, Score on the QL subscale of FAOS, and ankle dorsiflexion ROM(°). **Results:** Results of the ROM analysis revealed a significant main effect for time ($p = .01$), but no significant treatment group by test time interaction ($p = .92$). Follow-up post hoc analysis identified that ROM improved for all participants from the PRE(43.5 ± 5.9°) to POST(45.8 ± 5.3°), and these improvements were retained at the ONE_MO follow-up(45.8 ± 5.1°). Similar results were identified for both subscales of the FAOS. For the pain and QL subscales respectively, all participants improved from PRE(71.8 ± 10.5 and 59.6 ± 17.6) to POST(83.3 ± 9.2 and 70.5 ± 14.2), and these improvements were retained at the ONE_MO follow-up(84.3.8 ± 8.3 and 73.8 ± 17.4). **Conclusions:** Results of this study indicate that both treatment strategies are viable options for patients with plantar fascia but further research is warranted to better understand how IASTM impacts the plantar fascia tissues.

Brachial Artery Blood Flow Does Not Increase Following a Single Session of Graston® Technique

Selkow NM, Keck AN, Stanek JM, Boyce K: Illinois State University, Normal, IL

Context: When musculature around the shoulder is tight, alterations in scapular positioning may result, such as forward shoulder posture. This positioning may compress the blood vessels to the upper extremity and decrease blood flow, leading to neurovascular injury. Graston® Technique (GT) mobilizes soft tissues to break up adhesions in fascia and lengthen tight musculature. It is unknown what the effect GT has on blood flow after treatment to the shoulder musculature. **Objective:** To determine if GT has an effect on brachial artery blood flow after one intervention session to upper extremity musculature. **Design:** Controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Sixty healthy participants volunteered (27 males, 33 females; Age: 21.9 ± 1.8years, Height: 173.0 ± 9.3cm, Weight: 72.1 ± 12.9kg). **Intervention(s):** Participants were randomized into 1 of 3 groups (GT, sham, or control). To begin, participants had blood flow of the brachial artery measured in the dominant arm (arm they would throw a ball with) in 2 positions: arm down at the side (resting) and 90° abduction/90° external rotation (overhead). Doppler ultrasound was used to measure blood flow in each position for 10 seconds. Next, all participants performed a 5 minute warm-up on a stationary bike with arm motion. Then the intervention was applied by an examiner who did not take the ultrasound measurements. For the GT group, 8 minutes of treatment to the upper trapezius, scalenes, deltoids, and pectoralis major and minor were performed in that order for designated times at each muscle. When restrictions were found (resonance felt through GT instrument), they were addressed accordingly based in GT training. For the sham group, the GT instruments were glided over the muscles listed above for 8 minutes, however, the contour of the skin was not broken and indentation did not occur. The control group just sat quietly for 8 minutes with no instruments touching the skin. Following the intervention, all participants had a light stretch applied to the anterior shoulder musculature for 30 seconds, 3 times. Following the stretch, the blood flow measures were taken again. **Main Outcome Measures:** Brachial artery blood flow (mL/sec) in the resting and overhead position pre and post intervention were calculated. Two univariate ANCOVAs were used to determine blood flow changes post intervention by using the pre-intervention measurement as the covariate for both arm positions. **Results:** There were no significant differences in resting blood flow following the intervention across groups ($F_{(2,56)} = .776$; $p = .465$), nor in the overhead position ($F_{(2,56)} = 2.905$; $p = .063$). Effect sizes were calculated and all crossed 0. **Conclusions:** GT had no effect on brachial artery blood flow following one intervention session in a non-symptomatic population. More research needs to be conducted utilizing instrument-assisted soft tissue mobilization, especially in overhead athletes to see if blood flow changes are noted.

Effects of Kinesiology Tape on Performance and Serum Creatine Kinase During Recovery From Delayed-Onset Muscle Soreness

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Context: Kinesiology Tape (KT) has become a common modality for reducing pain and regaining function. A proposed benefit of KT includes enhanced blood/lymph flow for reduction of inflammatory markers, thereby enhancing recovery. However, no study has measured the effects of KT on reducing the level of inflammatory markers such as creatine kinase (CK) during recovery from simulated injurious conditions such as delayed-onset muscle soreness (DOMS). **Objective:** Investigate the effects of KT on performance and serum CK over the 72-hour period after fatigue. **Design:** Randomized control trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Preliminary data were collected on twenty-eight volunteer college-age participants, who were randomly assigned to the KT (NiTREAT Kinesiology Tape, Nitto Medical, Osaka, Japan), Placebo (Omnifix, Hartmann-Conco Inc., Rock Hill, SC), and Control groups (8KT, 8Placebo, 12Control). **Interventions:** Participants reported to three separate sessions over the 72-hour period. The first session involved measurements of functional performance (single-leg hop for distance) and CK via finger prick, before and immediately after 30 maximum eccentric contractions of the quadriceps muscle to induce fatigue, which is intended to induce DOMS. At the end of the first session, taping groups received tape applied from the medial thigh to the patella, to enhance blood/lymph flow of the quadriceps muscle. Those in the Control group did not receive tape. Functional performance and CK level were measured at 48 hours and 72 hours post fatigue. **Main Outcome Measures:** Independent variables were changes in time (Pre-Immediate, Pre-48hr and Pre-72hr), and group (KT, Placebo, Control). Dependent variables were changes in hop distance normalized to leg length (HopD), and changes in CK, across time. For each dependent variable, repeated measures ANOVA was utilized to detect differences among groups and time. Alpha was set at $P = 0.05$. **Results:** For CK, no significant main effect of time was found ($F = 0.88$, $P = 0.44$). Also, no significant time-by-Group interaction was found for CK ($F = 1.14$, $P = 0.36$). There was a statistically significant difference among Groups on CK ($F = 4.13$, $P = 0.04$). Post-hoc pairwise comparison revealed that, regardless of time, KT group (-8.15 ± 47.13) had lower CK compared to the pre-fatigue value, than Placebo (70.72 ± 139.94) or Control groups (32.46 ± 73.17) (KT-Placebo $P = 0.037$; KT-Control $P = 0.27$). For HopD, there was a significant main effect of Time ($F = 5.343$, $P = 0.017$; Pre-Immed = -0.439 ± 14.30, Pre-48hr = 1.55 ± 13.81, Pre-72hr = 2.16 ± 12.09). However, no main effect of Group ($F = 1.22$, $P = 0.31$) nor Time-by-Group interaction ($F = 1.04$, $P = 0.38$) were statistically significant for HopD. **Conclusions:** Functional performance did not seem to be affected by different taping conditions. The CK level change across time seem to be lower in KT group compared to Placebo and Control groups. Application of KT may keep the CK level close to or below the pre-fatigue value more effectively than other taping conditions. However, this result should be interpreted cautiously due to large standard deviations.

Free Communications, Oral Presentations: Novel Techniques with Therapeutic Interventions

Friday, June 26, 2015, 2:15PM-3:15PM, Room 130; Moderator: Noelle Selkow, PhD, ATC

Low Level Laser Therapy for Cervicogenic Headache: A Case Report

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Background: A 31 year old Caucasian female complained of severe bidaily unilateral cranial pain originating from the left temporal region. She also complained of nausea and left arm paresthesia associate with the cranial pain. She reported being unable to attend her job as a secretary due to the reoccurring headache pain, dizziness and blackouts. Her previous history included asthma, anxiety disorder, gastroesophageal reflux disease and transient idiopathic headaches that began approximately three years prior. Upon referral, a primary care physician diagnosed the patient with tension type headaches. After numerous failed attempts to treat the patient with medication, magnetic resonance imaging (MRI) was ordered for further diagnosis. **Differential Diagnosis:** Migraine headache, intracranial aneurysm, cerebrovascular accident, space-occupying lesion, cerebral venous thrombosis, spontaneous internal carotid artery dissection, colloid cysts, ventricular tumors and Chiari malformations. **Treatment:** The MRI revealed abnormal demyelination in the left lateral ventral horn and the patient was referred for headache management and physical therapy. Upon assessment by the therapist, tonicity was noted and the patient was tender to palpation bilaterally in the cervical extensors, sternocleidomastoid and upper trapezius. She presented with forward head posture and a protracted scapulae. Her pain scale was 6/10 at best and 10/10 at worst during the previous 48 hours. The patient complained of an irritable work environment at a new job, which worsened the headaches. The physical therapist felt that the patient's signs and symptoms were consistent with cervicogenic headache and began treating accordingly. Treatment consisted of a multi modal approach using manual cervical traction, light postural exercises and low level laser therapy (LLLT). **Uniqueness:** This is a unique multimodal approach for cervicogenic headache. There is growing evidence in support of transcranial LLLT for its analgesic and anti-inflammatory effects and a faster return to function. Cervicogenic headache pain is thought to originate from the upper cervical region and is described as referred pain. The multimodal approach consisted of patient education of posture, light cardiovascular exercise, diaphragmatic breathing in sync with postural exercises, cervical manual traction and LLLT bilateral, to the temporal, masseter, parietal and frontalis regions. **Conclusions:** Mitochondrial failure has been linked to known major pathogenic aspects of neuronal dysfunction and neurodegeneration, including excitoxicity, abnormal protein aggregation, neuroinflammation, and oxidative stress. In addition, mitochondrial failure has gained attention as a major pathogenic event common to the broad spectrum of neurodegenerative disorders. It is proposed that LLLT will increase mitochondrial activity and activate transcription factors, stimulating angiogenesis, and increasing neurogenesis. The patient reported immediate pain relief after each treatment. This approach improved mobility in the cervical area and reduced the patient's overall daily pain level. It is difficult to know if any one component of the treatment was responsible for the improvement. However, this novel use of LLLT certainly raises questions regarding its potential as a treatment for many other neurological injuries and conditions. Trans cranial LLLT has also been shown to improve motor coordination in stroke patients. It is possible that LLLT could be used as an adjunct to concussion management and rehabilitation, however further research is warranted.

A Comparison of Red and Blue Light Therapy for Superficial Wound Healing

Trippedo NJ, Powers ME, Gildard M: Marist College, Poughkeepsie, NY, and Spartanburg Methodist College, Spartanburg, SC

Context: Athletic trainers routinely provide care for acute and chronic wounds. The risk of infection associated with this care presents a growing challenge requiring innovative approaches. The use of light emitting diode (LED) devices has become a novel treatment for wound healing in place of previously used laser therapy. While laser therapy studies have shown promise for promoting wound healing and tissue growth, the efficacy of LED therapy in wound healing is not yet clear. **Objective:** To examine and compare the effects visible red and blue light wavelengths on dermal abrasion healing. **Design:** Randomized sham-controlled trial. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Twelve healthy males and females (age = 20.6 ± 1.2 y, height = 168.5 ± 10.7 cm, mass = 67.6 ± 15.2 kg) who were not using immune suppressants or any medication that might affect blood viscosity, clotting or wound healing time volunteered. Potential subjects were excluded if they were tobacco users or suffered from any of the contraindications for light therapy. **Interventions:** A 1.5 cm diameter dermal abrasion was created in each subject's non-dominant anterior forearm using a previously published procedure. Subjects were then randomly assigned to one of three treatment groups in a double blind fashion; 624-nm visible red light therapy (R), 464-nm blue light therapy (B) and sham therapy (S). The blue and red light treatments were administered using a Dynatron Solaris 709 Plus (Dyantronics Corporation, Salt Lake City Utah) at a power density of 6 J/cm^2 once each day for ten consecutive days beginning the day after wound creation. Similar

procedures were followed for the S group, however no light was emitted. A bio-occlusive dressing without antibiotic or anti-inflammatory intervention was applied and maintained between treatments. **Main Outcome Measures:** Digital images (1600 x 1200 pixels jpeg format) of the wounds were recorded with a Nikon D5000 digital camera mounted 40-cm perpendicular to the subject's forearm immediately after wound creation and on days 2, 4, 6, 8 and 10 post injury. All images were analyzed for wound area (pixels) and chromatic red using image-measurement software (Professional Version; Bersoft Inc, Ottawa, ON, Canada). **Results:** Analysis of variance with repeated measures revealed a significant Time main effect for wound area ($F_{6,54} = 7.5$, $p = .001$) as a progressive decrease was observed after Day 4. The treatment had no effect, as a significant Time x Treatment interaction ($F_{10,45} = .550$, $p = .845$) was not observed. A significant Time main effect was also observed for chromatic red ($F_{5,45} = 48.19$, $p = .001$), as a progressive decrease in area was observed over the 10 days. The treatment had no effect, as a significant Time x Treatment interaction ($F_{12,54} = .921$, $p = .533$), was not observed. **Conclusions:** The results suggest that visible red light therapy and blue light therapy do not accelerate dermal abrasion healing over a period of ten days.

Sustained Acoustic Medicine: A Novel Therapeutic Modality for Accelerating Tendon Recovery

Moorman CT, Taggart RT, Henderson SE, Lewis GK: Duke University, Durham, NC, and ZetrOz Inc, Trumbull, CT

Context: Tendon injures account for 30% of sports-related injuries and 7% of all primary care physician visits, but there is currently no gold standard of treatment. Therapeutic ultrasound has been used for over 70 years to treat injuries, but treatment has been confined to the clinician's office, limiting the duration, frequency, and efficacy of application. Animal research has demonstrated that short durations of low-intensity ultrasound can effectively heal tendons (e.g., increased tensile strength, improved collagen deposition and alignment). Sustained acoustic medicine (SAM) is the application of continuous low-intensity long duration ultrasonic waves to accelerate repair processes deep within soft tissues. **Objective:** To examine the use of a SAM device to relieve pain and enhance strength, while also using ultrasonic imaging to evaluate tendon properties (e.g., size, shape, echogenicity) throughout healing. **Design:** Two phase study: a single-blind pilot phase and a double-blind randomized controlled phase. **Setting:** Patients with clinician-diagnosed tendon pain were seen in a clinical setting. **Patients or Other Participants:** In phase one, 22 patients (12 males, average age = 49.63 ± 11.35 yrs, average BMI = 25.38 ± 4.59) with clinician-diagnosed tendinopathy (lateral or medial epicondyle [n = 16], Achilles tendon [n = 5], patellar tendon [n = 1]) were recruited through doctor referrals, sports clubs flyers, and Craigslist ads. Target enrollment for the on-going second phase of the study is 20 epicondylitis patients, with 35% of enrollment completed at time of submission. **Interventions:** Patients used a portable SAM device on their injury for 4 hours a day, 5x/week, over 6 (phase 1) or 12 (phase 2) weeks. In phase one, all devices were active but patients were told they had a 50% chance of receiving a placebo device. Phase two patients were randomly assigned an active or placebo device (50% distribution). Repeated measures ANOVAs were used to examine the effect of treatment over time and between groups, when appropriate. **Main Outcome Measures:** Patients recorded their pain before, during, and after treatment using a 10-point visual analog scale (VAS), and strength measurements were taken every two weeks using a dynanometer. In phase two, patients also underwent bi-weekly sonography of healing tendons. **Results:** Patients reported significantly less pain compared to baseline (3.90 ± 2.50 decrease in VAS, $P < .001$). Grip strength in epicondylitis patients significantly increased from baseline for injured limbs (3.02 ± 5.71 kg increase, $P = 0.05$), but not uninjured limbs (0.5 ± 4.26 kg increase, $P = 0.67$). Anticipated sonography outcomes from phase two include changes in tendon thickness, neovascularity, foci, calcifications, enthosophytes, and intrasubstance tears. **Conclusions:** Treatment with SAM reduces pain from chronic tendinopathy and increases tendon strength. We expect the results of phase two to further elucidate the impact of SAM on tendon healing throughout the therapeutic regime. Given the prevalence and difficulty in treating tendon injuries, SAM represents a novel and promising new treatment modality.

Treatment Effect of Four Different Mild Hyperbaric Oxygen Therapy Treatments on Clinically Induced Delayed Onset Muscle Soreness

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Context: Many athletes report using a mild hyperbaric oxygen chamber to aid in recovery from strenuous workouts. Data is limited concerning whether it is the increased pressure, additional oxygen, or a combination of the two that leads to this purported benefit. **Objective:** To determine whether the use of a mild hyperbaric chamber with oxygen supplementation will affect the severity of induced delayed onset muscle soreness more than no treatment at all. **Design:** Cross-sectional study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Thirty-two (16 males, 16 females; height = 172.9 ± 9.5 cm, mass = 79.3 ± 21.1 kg, age = 21.3 ± 1.9 yrs) recreationally active individuals voluntarily participated. **Interventions:** Clinically induced delayed onset muscle soreness was produced by having each participate perform two sets of 35 calf raises to a metronome beat of 40 beats/min. The sets were separated by a 5 min recovery period. Immediately before, 30 minutes after, and 24, 48, and 72 hours later ankle dorsiflexion range of motion, calf girth, pain (100 mm visual analog scale), and two-legged force production (N) were measured. Following the 30 minute time point measurements, participants received one of four treatments: 1) no increase of pressure, no oxygen supplementation, 2) no increase of pressure with oxygen supplementation, 3) pressure increase to 1.3 ATA, no oxygen supplementation, and 4) pressure increase to 1.3 ATA with oxygen supplementation. Oxygen supplementation was delivered at the specified intervals via a non-rebreather mask at 10L/min using an oxygen saturation machine. Repeated measures ANOVA followed by multiple pairwise comparisons determined the treatment effect. Alpha set at $P \leq .05$. **Main Outcome Measures:** The difference between the treated leg and control leg for ankle dorsiflexion range of motion (°), calf girth (cm), pain (100 mm visual analog scale), and two-legged force production (N). **Results:** Within subjects differences existed for each measurement (ankle range of motion: range -.09 ± 2.42° to -2.25 ± 4.23°, $F_{4,112} = 4.921$, $P = .001$; calf girth: range -.09 ± .74 cm to .67 ± .89 cm, $F_{4,112} = 12.293$, $P \leq .001$; visual analog scale: range .71 ± 1.57 mm to 36.27 ± 31.26 mm, $F_{4,112} = 21.681$, $P \leq .001$; force production: range 3.12 ± 116.96 N to -32.52 ± 102.21, $F_{4,112} = 3.613$, $P = .008$), but no treatment effect (ankle range of motion: $F_{3,28} = .009$, $P = .999$; calf girth: $F_{3,28} = 1.751$, $P = .179$; visual analog scale: $F_{3,28} = 1.736$, $P = .182$; force production: $F_{3,28} = .325$, $P = .807$). **Conclusions:** Due to the decrease in range of motion and force production, as well as an increase in pain, we believe that delayed onset muscle soreness was successfully created. None of the treatments appeared to affect the severity of the soreness more than another. Based on these results, we question whether hyperbaric oxygen therapy as performed herein will benefit post workout recovery.

A Comparison of Hip ROM Values Across Sex and Sport

Hogg JA, Schmitz RJ, Nguyen A, Shultz SJ: University of North Carolina at Greensboro, Greensboro, NC, and High Point University, High Point, NC

Context: Greater passive hip range of motion (HIP_{ROM}) has been associated with greater hip adduction and internal rotation during cutting and jumping, thus the potential for increased knee injury risk. Normative data for HIP_{ROM} by sex and sport to aid identification of athletes with aberrant HIP_{ROM} is lacking. **Objective:** Establish and compare HIP_{ROM} values by sex and sport. We hypothesize females will exhibit greater internal HIP_{ROM} relative to external HIP_{ROM}, and total HIP_{ROM}, than males. Soccer and basketball athletes will display greater values of internal HIP_{ROM}, total HIP_{ROM}, and relative internal HIP_{ROM} than other sports. **Design:** Cross-sectional design. **Setting:** Station-based, pre-participation screening at a single institution. **Patients or Other Participants:** NCAA Division I intercollegiate athletes (168F = 19.2 ± 1.2 yrs, 169.0 ± 7.2 cm, 65.3 ± 10.2 kg; 171M = 19.4 ± 1.3 yrs, 200.0 ± 8.6 cm, 78.4 ± 12.0 kg) from six sports: soccer (58F, 67M), tennis (20F, 22M), basketball (28F, 22M), softball/baseball (38F, 31M), cross country (18F, 19M), and golf (6F, 10M) screened over 3 years. **Interventions:** HIP_{ROM} was measured with an inclinometer with the subject prone, hip abducted to 20-30 degrees, and knee flexed to 90°. The lower leg was passively internally rotated (IR) and externally rotated (ER) while monitoring sacral tilt. The transverse plane angle between the tibial diaphysis and true vertical at the point of sacral movement was measured as the subject's internal and external $HIP_{ROM,}$ respectively. Three measures in each direction on each leg were averaged for analysis. Two testers with good to excellent reliability collected all measures [$ICC_{2,3}$(SEM) Tester 1 = .87(2.5°) for IR and .83(1.8°) for ER; Tester 2 = .97(1.6°) for IR and .85(3.3°) for ER]. **Main Outcome Measures:** Internal HIP_{ROM}, external HIP_{ROM}, total HIP_{ROM} (IR+ER), and HIP_{ROM} ratio (IR:ER) were compared between sex and sport using separate 2x6 repeated measure ANOVAs. **Results:** Females vs. males displayed greater internal HIP_{ROM} (37.0 **± 8.**2°**,** 28.0 ± 8.4°; $p < .001$), total HIP_{ROM} (72.1 **± 11.0°,** 64.4 ± 10.6°; $p < .001$), and HIP_{ROM} ratio (1.3 ± 0.7, 0.9 ± 0.5; $p < .001$). No differences were found in external HIP_{ROM} ($p=.20$). Cross country, compared to all other sports, exhibited greater internal HIP_{ROM} (37.0 ± 9.2° v. 30.9 ± 9.4°-34.8 ± 9.5°; $p = .001$) and ratio HIP_{ROM} (1.6 ± .8 v. 0.9 ± .4-1.1 ± .5; $p < .001$) but less total HIP_{ROM} (62.7 ± 8.5° v. 66.1 ± 12.3°-72.4 ± 12.3°; $p < .001$) and external HIP_{ROM} (25.7 ± 7.5° v. 32.9 ± 6.6°-40.2 ± 12.0°; $p < .001$). An interaction revealed a greater sex disparity (F>M) in HIP_{ROM} ratio in cross-country, compared to other sports (F v. M mean difference of 0.8 v. 0.1-0.5; $p = .042$). **Conclusions:** Internal rotation magnitude, thus IR:ER ratio, differs substantially between sexes. As previous research suggests that increased internal HIP_{ROM} may increase hip adduction and internal rotation, thus dynamic knee valgus, the relative importance of the absolute magnitude (IR+ER) versus relative ratio (IR:ER) should be examined. With the exception of cross country, values were similar across sports. The clinical implications of cross-country's substantially different values require further study.

Comparison of Injury Rates Between Trunk and Hip Focused Neuromuscular Training Intervention Group and Speed Training Controls: A Double Blind Randomized Controlled Trial

Barber Foss KD, Thomas SM, Khoury J, Myer GD, Hewett TE: Cincinnati Children's Hospital, Cincinnat, OH

Context: There are an estimated 30 million school aged children (5-18 years) who participate in sports in the United States, a 21% increase in the past decade. These athletes generate approximately four million sport-related injuries annually, and require 2.6 million emergency room visits at a cost of nearly $2 billion. **Objective:** To determine if hip focused neuromuscular training would reduce injury incidence in athletes randomly assigned to a trunk (CORE) intervention group compared to a SHAM control group. **Design:** Double blind randomized controlled trial. **Setting:** 5 middle schools and 4 high schools from a single county public school district. **Patients or Other Participants:** A total of 474 female subjects participated in this study. Subjects had the opportunity to participate in multiple sports and/or incur multiple injuries, which resulted in a total of 243 injuries in 177 athletes, and 297 athletes with no injury. Of the 474 athletes, 222 subjects participated at the middle school level and 252 subjects participated at the high school level. 259 athletes were assigned to the CORE intervention and 215 to the SHAM training group. Training was implemented as teams (volleyball, basketball, and soccer), which resulted in greater than 95% recruitment and compliance with data monitoring. Injuries were recorded in the specific sport in which they occurred. **Interventions:** The CORE intervention consisted of trunk and hip focused neuromuscular control exercises, while the SHAM protocol consisted of linear resisted running with elastic

bands. Each intervention was implemented at the start of the season and continued until the last competition. From the first day of team practice until the first competition, teams were asked to perform the training for 20-25 minutes, three times per week. Once competition started, teams were asked to perform the training for 10-15 minutes, two times per week until the end of the competitive season. Athletes were evaluated weekly for any sports related injury by an athletic trainer (AT). Athlete exposures were recorded by the AT. **Main Outcome Measures:** Injury rates were estimated overall, by sport and by competition level, and reported per 1000 exposures. Statistical analyses were performed in SAS, version 9.3; a mixed model approach was used to account for multiple injuries per athlete. **Results:** Overall the CORE group reported 107 injuries (rate of 5.34) versus 136 injuries (rate of 8.72) in the SHAM group; $p < 0.0001$. Athletes in the CORE group had lower injury rate compared to the SHAM group for basketball (4.99 vs. 7.72, $p = 0.002$) and volleyball (5.74 vs. 12.30, $p = 0.001$). **Conclusions:** Participation in trunk and hip focused neuromuscular control exercises reduced injury incidence compared to a sham intervention. This positive protective effect was highly significant at both and high school and middle school level.

The Overhead Squat Clinical Movement Assessment Can Identify Athletes With Hip Range of Motion Abnormalities Predictive of Hip Pathology

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Context: Hip range of motion (ROM) abnormalities have been shown to be predictive of hip pathology, such as femoroacetabular impingement, hip labral tears, and groin disruption. The overhead squat (OHS) is a quick clinical functional movement assessment designed to identify movement abnormalities (errors) such as hip ROM, which are postulated to manifest as foot external rotation. The OHS may provide a quick method to assess hip ROM restrictions. **Objective:** To determine if foot external rotation, or the "foot turns out" (FTO) error during the OHS can differentiate between individuals with and without tri-planar hip ROM restrictions. **Design:** Cross-Sectional Study. **Setting:** Controlled research laboratory. **Patients or Other Participants:** 81 incoming NCAA Division I athletes (males (n = 41), females (n = 40); age = 18 ± 1 yrs, mass = 78.2 ± 22.2 kg, height = 177.8 ± 11.8 cm) participated in this study. All participants were injury free at the time of testing. **Interventions:** The OHS was completed as part of the athletes' pre-participation physical examinations. A certified athletic trainer who has experience evaluating the OHS assessed presence of the FTO error during the OHS. Additionally, tri-planar hip ROM was assessed on the athletes' right limbs. Hip extension with the knee extended and flexed was evaluated with a digital inclinometer. Hip internal (IR)/external (ER) rotation was assessed in a prone position, the hip in neutral, and the knee flexed to 90°. Supine hip abduction was measured with a standard goniometer. **Main Outcome Measures:** FTO errors, hip ROM means±standard deviations. Multivariate analysis of variance ($\alpha < 0.05$) was used to determine the relationship between FTO error and tri-planar hip ROM. **Results:** Overall, FTO error was significantly associated with tri-planar hip ROM (*T2* = 0.22, $F_{5,75} = 3.31$, $P = 0.009$, partial $\eta 2 = 0.18$, observed power = 0.88). FTO was significantly related to hip IR (Error: 30.6 ± 9.6º, No Error: 37.4 ± 12.6º; $F_{1,79} = 6.92$, $P = 0.010$, partial $\eta 2 = 0.08$, observed power = 0.74) and hip ER (Error: 51.3 ± 10.8º, No Error: 44.4 ± 13.6º; $F_{1,79} = 5.80$, $P = 0.018$, partial $\eta 2 = 0.07$, observed power = 0.66). FTO was not significantly related to flexed-knee hip extension (Error: 10.1 ± 16.8 º, No Error: 21.3 ± 25.4º) nor knee-extended hip extension (Error: 5.0 ± 7.6 º, No Error: 8.3 ± 8.2º). There was also no significant link between FTO and hip abduction (Error: 36.3 ± 7.5º, No Error: 39.0 ± 10.1º) nor total hip transverse plane ROM arc (Error: 81.9 ± 16.8º, No Error: 81.8 ± 13.6º). **Conclusions:** The FTO error during the OHS is able to discriminate between athletes with a more restricted hip IR ROM and those with greater hip ER ROM. Interestingly there is no difference in transverse plane arc of motion (~82º) between athletes with and without the FTO error. It appears that the FTO error is indicative of restricted hip IR ROM and an arc of motion shifted toward hip ER. Clinicians can use the OHS to identify individuals with restricted hip IR ROM, a movement pattern predictive of future hip injury in athletes.

Proximal Muscle Compensations in Hip Force Generation in Individuals With Femoroacetabular Impingement

Miller MM, Schussler E, Grooms D, Clifton D, McNally MP, Starkel C, Ellis T, Onate J: The Ohio State University, Columbus, OH, and Orthopaedic One, Columbus, OH

Context: A perceived decrease in hip strength is a common complaint associated with femoroacetabular impingement (FAI), despite reports that actual strength is unaffected. This perceived strength deficit may be due to a compensatory muscle recruitment strategy adopted to sustain overall muscle force production. **Objective:** The purpose of this study was to test our hypothesis that altered muscle activation would be exhibited on the involved limb as compared to the uninvolved limb. **Design:** Cross-Sectional Study. **Settings:** Movement analysis laboratory. **Patients or Other Participants:** Twenty-four patients (16 females, 8 males;169.0 ± 9.9 cm, 71.1 ± 14.9 kg, 35.5 ± 7.7 y) with radiographic and physician diagnosed FAI. **Interventions:** Muscle recruitment was measured bilaterally for the adductor magnus, biceps femoris, external oblique, erector spinae, gluteus maximus, gluteus medius, rectus abdominis, and rectus femoris using surface electromyography (Noraxon USA, Inc., Scottsdale, AZ) during a maximal isometric strength test completed in the standing position. A portable fixed-dynamometer (BTE) was used to assess isometric hip strength, with one end of the dynamometer fixed to the wall, and the other end secured to the ankle of the swing leg Muscle recruitment testing took place over three trials of a 5 second maximum effort trial of peak hip flexion and extension. Task activation was normalized to a maximum voluntary isometric contraction for each muscle. **Main Outcome Measures:** The peak amplitude of each muscle during each trial was averaged to yield the average peak activation for each muscle in both flexion and extension. A one-way ANOVA was used to examine differences between the involved and uninvolved limb for each muscle with an a priori alpha level established at 0.05. **Results:** No significant differences were noticed in the primary muscles responsible for hip flexion or extension. A significant difference for the external oblique (EO) muscles was noted during maximal hip flexion. Increased EO activation on the side of the swing leg was seen on the involved (INV = 67.93 ± 19.00%; NON = 44.40 ± 21.93%, p = 0.02). Decreased EO activation was seen on the side of the stance limb of the involved limb (INV = 50.22 ± 35.52%; NON = 72.57 ± 44.02%, p = 0.05). **Conclusions:** The differences in EO muscle activation may suggest a proximal compensation for distal force generation. Additional postural control provided by the trunk during single limb stance may serve to decrease the demand placed on the hip joint with higher-level activity.

The Effects of Gait Retraining on Iliotibial Band Syndrome in Runners

Guldstrand AE, Fuller AA, Petron DJ, Elliott HB, Hicks-Little CA: University of Utah, Salt Lake City, UT

Context: Iliotibial band syndrome (ITBS) is among the most common injuries in runners and is the leading cause of lateral knee pain. Gait retraining (GRT) is a therapeutic technique used to correct running or walking gait by addressing biomechanical errors contributing to pain and injury. Research has suggested that GRT is efficacious in the management of patellofemoral pain syndrome (PFPS) patients, and while there are similarities between PFPS and ITBS, the effects of GRT on ITBS remains unclear. **Objective:** To determine if the addition of GRT to the usual care hip-strengthening program is more efficacious than a hip-strengthening program alone in improving ITBS symptoms and lower extremity kinematic, kinetic and muscle activation data in runners with ITBS. **Design:** Randomized Control Trial. **Setting:** Orthopaedic Center Running Clinic. **Patients or Other Participants:** Fourteen participants diagnosed with symptomatic ITBS (2 males, age: 22.0 ± 5.7y, height: 181.5 ± 5.0cm, weight: 152.1 ± 2.1 lbs and 12 females, age: 31.0 ± 6.1y, height: 167.9 ± 6.4cm, weight: 130.2 ± 13.3 lbs) volunteered to participate in the study. **Interventions:** Participants were randomly assigned to either the intervention group or control group and completed 3 symptom related questionnaires. Participants then completed a 5 minute run on an instrumented treadmill whilst EMG, foot pressure and video capture data was recorded. Following this, the intervention group completed a 25 minute GRT session and returned for a second GRT session 2 weeks later. All participants completed a 4 week hip-strengthening program 3 times a week and then returned for post testing. **Main Outcome Measures:** University of Wisconsin Running and Recovery

Index (UWRI), Perceived pain (VAS), Global Rating of Perceived Change scale (GRPC) and Lower Extremity Functional Scale (LEFS) Survey scores, Hip Adduction angle (degrees), peak ground reaction force (Newtons, normalized to body weight), Gluteus Medius, Gluteus Maximus and Tensor Fascia Lata muscle activation (peak as a % of MVIC). **Results:** Two-way repeated measures ANOVA indicated no significant differences between groups on all pre-vs.-post test variables. Similarly, there was no significant group by time interaction effects. However, we did identify a significant improvement following training in subjective reporting for the VAS [$F(1,13) = 17.84$, $p = 0.001$], GRPC ($F(1,13) = 95.23$, $p < 0.0001$) and UWRI ($F(1,13) = 17.24$, $p = 0.001$) measures in both groups. Additionally we observed an increase in affected extremity Force [$F(1,13) = 5.23$, $p = 0.041$] in both groups. **Conclusions:** All participants demonstrated improvements in subjective reports of pain, symptoms and function thereby suggesting that benefits of a usual-care hip strengthening program is not augmented by GRT program in ITBS patients. Interestingly, all participants demonstrated an increase in peak force on their affected extremity which is surmised to be a result of improved compensatory patterns that differentiated the affected and non-affected limb prior to training. Further research is warranted regarding the effects GRT has in ITBS patients. This study was funded by an NATA Research & Education Foundation Masters Grant.

Shoulder Evidence-Based Forum: Influence of Trunk Motion on Shoulder Injury

Wednesday, June 24, 2015, 8:00AM-9:00AM, Room 131; Moderator: Kevin Laudner, PhD, ATC, FACSM
Discussants: Sakiko Oyama, PhD, ATC; Thomas Palmer, PhD, ATC, CSCS

Bony and Soft Tissue Adaptations of the Shoulder in Professional Baseball Pitchers

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Context: Baseball pitching requires tremendous forces to both accelerate and decelerate the arm. These large forces will lead to structural tissue adaptations that are represented by changes in rotational range of motion (ROM). These adaptations often include both bony and soft tissue, however the contribution of each tissue to the change in motion is not clinically attainable and clinicians often struggle to optimize treatment strategies. **Objective:** To compare ROM, bone, and soft tissue changes bilaterally and examine the correlation between clinical ROM and anatomically corrected ROM. **Design:** A single group post test only. **Setting:** This study was performed in a clinical setting. **Patients or Other Participants:** Thirty professional baseball pitchers (age = 22.5 ± 3.5 years, mass = 96.1 ± 8.8 kg, height = 190.8 ± 4.9 cm) with no current injury or surgery in the past six months. **Interventions:** Independent variables were arm (dominant and non-dominant). Humeral retroversion (HR) and posterior capsule thickness (PCT) was measured with an ultrasound system (Sonosite Titan, Sonosite Inc., Bothell, WA) and glenohumeral internal (IR) and external rotation (ER) was measured with a Saunders Digital Inclinometer (The Saunders Group Inc. Chaska, MN). Glenohumeral internal rotation deficit (GIRD) was calculated as the bilateral difference in IR and external rotation gain (ERG) was calculated as the bilateral difference in ER. Total ROM was calculated as IR + ER and total motion difference was calculated as the bilateral difference in total ROM. GIRD and ERG were also corrected for HR. Paired sample t-tests were performed for ROM, HR, and PCT. Pearson correlation coefficients assessed the relationships between total ROM difference and corrected GIRD and ERG. **Main Outcome Measures:** HR was measured supine with the arm abducted to 90° and elbow flexed to 90°. Glenohumeral IR and ER were measured supine with the scapula stabilized. PCT was measured seated with the arm at the side in neutral rotation. **Results:** The dominant arm had significantly more retroversion, ER, and PCT compared to the non-dominant arm (17.5°, p = 0.0001; 2.3°, p = 0.0001; 0.042 cm, p = 0.001), respectively. The dominant arm also had significantly less IR and total motion compared to the non-dominant arm (11.1°, p = 0.01; 8.8°, p = 0.0001), respectively. The total ROM difference was significantly correlated with HR corrected GIRD and ERG (0.460, p = 0.01; 0.465, p = 0.01), respectively. **Conclusions:** Healthy professional baseball pitchers present with anatomic adaptations. This may cause either soft tissue tightness or laxity, which are represented as the changes in ROM. Clinicians often are not able to measure HR and therefore rely on clinical ROM to determine clinical management. The significant correlations indicate that after accounting for HR there are additional ROM differences created by soft tissue changes, which can be assessed by measuring the difference in total ROM.

Glenohumeral and Hip Range of Motion and Strength Measures in Youth Baseball Athletes

Picha KJ, Harding JL, Huxel Bliven KC: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

Context: High loads and repetitive forces sustained in throwing leads to glenohumeral (GH) range of motion (ROM) and strength adaptations. However, less is known about alterations at the hip and at what age these changes occur in skeletally immature baseball athletes. **Objective:** To compare GH and hip ROM and strength between age, position, and side. **Design:** Prospective, cross-sectional. **Setting:** Multi-center data collection. **Participants:** Seventy-two healthy baseball players (experience: 5.5 years) age 7-11 years (n = 27) and 12-18 years (n = 42), including pitchers (n = 22) and position players (n = 47); unreported position (n = 3). **Interventions:** Self-reported data placed participants into age groups (7-11 years "younger", 12-18 years "older"), position (pitcher, position player), and side (throwing/non-throwing arm or lead/stance leg). **Main Outcome Measures:** GH and hip internal rotation (IR) and external rotation (ER) ROM were measured bilaterally using a goniometer (degrees). Total arc of motion (TAM) was the sum of IR and ER. Strength of GH and hip IR and ER in a seated position and gluteus medius in side-lying was measured using a hand-held dynamometer (pounds force). Analysis included a linear mixed model approach with three fixed factors (group, position, side) and subject as the random factor. **Results:** GH IR was less in throwing arms compared to non-throwing in all groups (P < 0.05), except younger pitchers (P = 0.86). There was significantly more GH ER and TAM in younger compared to older players (ER:103.3 ± 7.7° versus 97.5 ± 9.4°,P = 0.002, TAM:156.4 ± 8.7° versus 147.9 ± 10.9°, P = 0.041), and more ER in the throwing compared

to non-throwing arms (ER: 101.9 ± 1.2° versus 97.9 ± 1.1°, P < 0.001). GH TAM was less in throwing compared to non-throwing arms (150.5 ± 2.1° versus 154.9 ± 1.3°, P = 0.011). There was more hip IR and TAM ROM in younger compared to older players (IR:38.9 ± 6.8° versus 31.2 ± 7.5°, P < 0.001, TAM:68.4 ± 10.0° versus 60.7 ± 9.8°, P = 0.001). Hip IR ROM was greater in the lead compared to stance leg (34.8 ± 8.9° versus 32.8 ± 7.7°, P = 0.011). No significant hip ER ROM differences were found (P > 0.05). Overall, older players were stronger than younger for GH and hip motions (P < 0.05). The throwing arm was stronger in IR compared to the non-throwing (22.3 ± 8.2lbs versus 20.8 ± 7.0lbs, P = 0.047). No other strength differences found (P > 0.05). **Conclusions:** GH ROM adaptations typical in baseball players were present in both groups, with less IR and more ER, indicating changes in players as young as 8 years old. Greater ROM in younger players may be explained by less humeral ante-torsion, increased laxity, and less muscle mass compared to older players. This is the first report of hip ROM values in youth baseball and future research should establish whether decreased stance leg hip IR ROM is clinically meaningful and related to injury. As expected, older players were stronger than younger. GH IR strength in the throwing arm is necessary to produce high concentric forces required by IR musculature during the acceleration phase of the overhead throw.

Relationship Between Throwing Intensity, Pitch Volume, and Prevention Training on Shoulder Motion and Strength in Adolescent Baseball Pitchers

Harding JL, Picha KJ, Huxel Bliven KC: Post-Professional Athletic Training Program, A.T. Still University, Mesa, AZ

Context: Epidemiological studies indicate increased throwing intensity, pitch volume, and altered glenohumeral (GH) range of motion (ROM) and strength profiles contribute to increased injury risk in baseball pitchers. While these factors intuitively impact one another, a clear relationship between them has not been established in youth. **Objective:** To examine the relationship between throwing intensity, pitch volume, and participation in prevention program variables on GH ROM and strength in youth baseball pitchers. **Design:** Retrospective, cross-sectional. **Setting:** Multi-center data collection. **Patients or Other Participants:** 28 healthy baseball pitchers (age: 13.9 ± 2.9 years; height:167.4 ± 20.0cm; mass:61.3 ± 18.6kgs; experience: 6.4 ± 3.5 years; right-handed: n = 21, left-handed: n = 7). **Interventions:** Baseball pitchers were tested in a single session. A self-report questionnaire on demographics (6 questions), throwing intensity (2 questions), pitch volume in the past month (5 questions) and prevention training (1 question) was completed. The independent variables were: throwing intensity (years of competitive play, months played in past 12 months), pitch volume in the past month (pitch time limited, times per week pitched, innings pitched, pitches per game, days per week thrown more than 40 pitches), and participation in a prevention program (yes/no). **Main Outcome Measures:** Supine GH internal rotation (IR) and external rotation (ER) ROM was measured on the throwing arm using a standard goniometer. Total arc of motion was calculated as the sum of GH IR and ER. Strength of throwing arm GH IR and ER in a seated position, GH joint abducted 90°, was measured using a hand-held dynamometer. Frequency analyses and bivariate correlations were used to describe data and identify relationships between variables. Alpha was set a <0.05, two-tailed. **Results:** Significant correlations were found between throwing intensity, pitch volume, and prevention program variables and throwing arm GH ROM and strength measures. A moderate relationship was found between years of competitive play and IR (r = 0.51, P = 0.006) and ER (r = 0.64, P < 0.001) strength. A fair relationship exists between number of months played in the past year and ER strength (r = 0.42, P = 0.028). Pitch volume variables of limited pitch time (r = 0.41, P = 0.035) and number of pitches per game in past month (r = 0.45, P = 0.41) displayed fair correlations with ER ROM. Participation in a prevention program was moderately correlated with IR (r = 0.63, P < 0.001) and ER (r = .55, P = 0.002) strength. **Conclusions:** Fair to moderate relationships were found. Throwing intensity and participation in a prevention program was moderately correlated with IR and ER strength, whereas pitch volume displayed a fair correlation with ER ROM in healthy adolescent baseball pitchers. While much emphasis is placed on GH ROM, these results emphasize the need to account for how throwing variables affect both ROM and strength in the throwing arm. Thus, evaluation of GH ROM and strength are important to include during screening, assessment, and prevention training to mitigate injury risk.

Association Between Trunk Muscle Function and Excessive Contralateral Trunk Tilt During Pitching in Youth Baseball Pitchers

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Context: Upper extremity injuries are becoming increasingly common among young baseball pitchers. Pitching technique is one of many factors that affect injury risk. Exhibiting excessive contralateral trunk tilt (CLT) during pitching is a strategy that has been linked to higher ball speed at an expense of increased joint loading. Instructing youth pitchers to avoid this strategy may potentially lead to decreased joint loading, and ultimately injury risk. While it is unknown why some pitchers adopt this strategy, deficit in trunk muscle function has been suggested as one potential reason. **Objective:** To investigate the association between trunk muscle function and excessive contralateral trunk tilt during pitching in youth baseball pitchers. **Design:** Cross-sectional study. **Setting:** Baseball practice facility. **Patients or Other Participants:** Thirty-two youth baseball pitchers (age = 10.3 ± 2.1years, height = 146.3 ± 8.9cm, mass = 40.7 ± 8.5kg). **Interventions:** The participants pitched from a mound until at least 3 strike-pitches were captured using a high-speed (120fps) video camera and performed maximal isometric trunk strength and trunk muscle endurance tests. **Main Outcome Measures:** Three fastest strike pitches from each pitcher were analyzed. Pitchers were considered to exhibit excessive CLT when their head was deviated from the vertical line that passes through the stride foot ankle at the instant of maximal shoulder external rotation in at least two of the three pitches. Maximum isometric strengths (flexion, extension, and bilateral rotation) were measured using a dynamometer and the values were normalized to participant's body weight. Trunk muscle endurance was assessed using the number of sit-ups participants performed in a minute and length of time the participants were able to maintain a single-leg side-bridge. For the side-bridge test, average time from right and left sides was used for analysis. Independent t-tests were used to compare the variables between pitchers who did and did not exhibit excessive CLT. **Results:** The pitchers with excessive CLT (n = 15) demonstrated weaker trunk rotation towards the dominant side ($t30 = 2.4$, $p = .023$) and poorer performance on side-bridge test ($t30 = 2.2$, $p = .030$) compared to the pitchers without excessive CLT (n = 17). Pitchers with excessive CLT tended to pitch faster than pitchers without excessive CLT ($t30 = -1.8$, $p = .079$). There was no group-difference in trunk flexion, extension, and rotation strengths towards non-dominant side, and sit-up test ($p > 0.05$). **Conclusions:** The observations suggest that weakness in internal/external obliques may be linked to pitchers demonstrating excessive CLT. Strengthening the obliques may allow pitchers to avoid excessive CLT and decrease joint loading. Learning to utilize alternative strategies to produce ball speed, such as using trunk rotation and proper lower extremity movement, at a young age may help protect pitchers from injuries as they go through rapid musculoskeletal development in adolescence. Intervention study to examine the effects of strengthening of oblique muscles on pitching technique and joint loading is needed to evaluate this hypothesis.

Heat/Hydration Evidence-Based Forum: Effectively Facilitating Recovery Through Rehydration

Wednesday, June 24, 2015, 10:30AM-11:30AM; Moderator: Michelle Cleary, PhD, ATC, CSCS
Discussants: Brendon McDermott, PhD, ATC; Scott Anderson, ATC

An Exertional Heat Stroke Survivor's Return to Running: an Integrated Approach on the Treatment, Recovery, and Return to Activity

Adams WM, Hosokawa Y, Huggins RA, Mazerolle SM, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Appropriate recognition, treatment, and subsequent survival from exertional heatstroke (EHS) are well understood in the sports medicine community. However, current medical practices for returning the patient to athletic participation with evidence-based practice is lacking in the scientific literature. **Objective:** Gain a first-hand understanding of the self-recollection of a runner who suffered an EHS. Special attention was given to the treatment, recovery, and return-to-activity of this runner. **Design:** Single case study. **Setting:** Road Race. **Patients or Other Participants:** A recreationally active male runner (age, 53y; body mass, 79.5kg; body fat, 18.9%) with a history of EHS (peak rectal temp 42.05°C) from the 2013 Falmouth Road Race (FRR) (26.5°C, 39.3% RH) that completed in the 2014 FRR (25.3°C, 73.9% RH) participated in this study. **Data Collection and Analysis:** Data were collected on and surrounding the 2014 FRR. The runner responded to a series of open-ended questions by journaling his thoughts and experiences surrounding his EHS. Questions focused on the runner's treatment, recovery, return-to-activity, and preparation for the 2014 FRR and were based upon the existing literature on those topics. The data was analyzed borrowing from the principles of a general inductive approach and was triangulated by peer review and multiple analyst coding. **Results:** Four dominant themes emerged from the data: predisposing factors, ideal treatment, lack of medical follow up, and patient education with sub themes prior knowledge and current knowledge. The first theme, predisposing factors, identified three predisposing factors that contributed to the runner's EHS: hydration, sleep loss, and lack of heat acclimatization. The second theme, ideal treatment, highlighted the ideal treatment the runner received using evidence-based best practices for recognition (rectal thermometry) and treatment (cold-water immersion). The third theme, lack of medical follow up, describes the runner's recovery and return to activity following his EHS. Coordination of follow up with his primary care physician did not occur and there was no guided progressive return to exercise following the incident. The final theme portrays the transformation in the runner's knowledge regarding EHS. Prior to his incident at the 2013 FRR, the runner knew very little about EHS. He sought out the advice from experts in EHS after the race to become knowledgeable about the factors that led to his incident. Using this newly acquired knowledge, the runner successfully completed the 2014 FRR without incident. **Conclusions:** Our case provides a personal connection to the factors that can lead to EHS, illustrating that a combination of factors can lead to the condition and survival is likely when following the appropriate treatment protocols. Although evidence-based best practices regarding treatment of EHS ensures survival, future care needs to be taken in the return-to-activity following EHS with proper medical follow up and guidance for full return. Word Count: 449

Epidemiology of Exertional Heat Illnesses Across Youth, High School, and Collegiate American Football Teams

Yeargin SW, Kerr ZY, Casa DJ, Hayden RM, Parson JT, Dompier TP: University of South Carolina, Columbia, SC; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; University of Connecticut, Storrs, CT; National Collegiate Athletic Association Sport Science Institute, Indianapolis, IN

Context: Data on exertional heat illness (EHI) in youth football is limited. Furthermore, no studies have compared the epidemiology of EHI among various competition levels. **Objective:** To describe the epidemiology of EHI events in football across the youth, high school (HS), and college levels in the 2012-2013 seasons. **Design:** Descriptive epidemiology **Setting:** Football practice and game facilities **Patients or Other Participants:** A convenience sample of 13 youth (5-14y), 96 high schools (14-18y), and 24 college (18-23y) football programs participated across the United States. **Interventions:** Athletic trainers (ATs) provided health care services at all program-sanctioned practices and games. The ATs reported EHI events that were: classified as heat-related and/or dehydration-induced; occurred as a result of participation in a practice or game; and required medical attention by an AT or physician. ATs also reported athlete-exposures (AEs), defined as one athlete participating in one game or practice. De-identified data were reviewed for quality control prior to inclusion in the research database. **Main Outcome Measures:** ATs reported the number of EHI events by time in season and practice/game, associated time loss, and emergency transportation needs. EHI injury rates (IRs) were calculated as the number of EHI events per 10,000AE. Injury Rate Ratios (IRR) were calculated by dividing the practice IR by the game IR. **Results:**

A total of 28, 119, and 46 EHI events were reported in the youth, HS, and college levels respectively, resulting in IRs of 2.00, 1.26, and 1.46 per 10,000AE. Rates were highest during the preseason (youth: 3.65; HS: 3.06; college: 3.41 per 10,000AE). Practice IRs were higher than game IRs in youth [4.77 vs. 1.20 per 10,000AE; RR = 3.99; 95%CI: 1.90, 8.39] and college (4.38 vs. 1.15 per 10,000AE; RR = 3.80; 95%CI: 2.00, 7.21). However, in HS, the practice IR was smaller than the game IR (0.66 vs. 1.42 per 10,000AE; RR = 0.44; 95%CI: 0.25, 0.76). The percentage of EHI events resulting in time loss >1 day increased with competition level (youth: 25.0%; HS: 35.3%; college: 65.2%). Emergency transport was needed for EHI events (youth: 3.6%; HS: 3.4%; college: 2.2%). Common EHI events included Exertional Heat Exhaustion (youth: 42.9%; HS: 26.1%; college: 23.9%) and Exercise Associated Muscle Cramps (youth: 21.4%; HS: 26.9%; college: 34.8%). There were no reported cases of Exertional Heat Stroke as classified by the ATs. **Conclusions:** Higher preseason IRs across all competition levels may emphasize the need for continued modifications in preseason practices for college and the development of national standards for HS and youth. The lower game IR in HS may be attributable to traditional night games, whereas youth and college games can occur in the day, when environmental conditions are higher. Thus, EHI prevention guidelines may need to consider game modifications by competition level.

The Influence of Head Cooling Combined With Various Cooling Modalities on Cooling Rate After Exercise in the Heat

Hyde JL, Pryor RR, Adams WM, Adams EL, Vandermark LW, Huggins RA, Stearns RL, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Various body cooling modalities after exercise or between exercise bouts have been shown to decrease body temperature. The addition of head cooling (HC) to other commonly used cooling modalities may aid in reducing thermal strain. **Objective:** To determine the efficacy of head cooling on rectal temperature (Tre) compared to commonly implemented cooling modalities. **Design:** Randomized, counterbalanced, crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen recreationally active individuals (mean ± SD: male, n = 7, female, n = 7; age = 25 ± 4y; height = 171 ± 9cm; body mass=70.8 ± 8.3kg; percent body fat = 21.2 ± 7.6%). **Intervention:** Participants completed six bouts of treadmill exercise (55.2 ± 12.2min) in a hot environment (38.5 ± 1.5°C, 37.5 ± 7.6%RH) until one of the following occurred: Tre reached 39.75°C, 80 minutes of exercise, or the participant requested to stop. Exercise sessions were followed by body cooling until Tre reached 38.00°C or for a maximum of 10 minutes. Cooling treatments (HC, cold-water immersion (CWI), forearm ice towels (FT), CWI+HC, FT+HC, and passive rest) were performed in a thermoneutral environment (22.4 ± 1.6°C, 32.1 ± 12.3%). Participants then returned to the heat, equilibrated for 10 minutes, and conducted approximately 20 minutes of performance tasks. At 40 minutes post-cooling initiation, Tre was again obtained. **Main outcome measures:** Heart rate (HR) was measured before (PRE), after (POST) exercise while Tre was additionally measured immediately following performance tasks. Differences between cooling methods were determined using a repeated measures one-way ANOVA with preplanned dependent t-tests. An a priori alpha level was set at 0.05. **Results:** POST HR (168 ± 18 beats per minute), and POST Tre (39.17 ± 0.46°C) were similar between groups ($p > 0.05$). Upon initiation of cooling, Tre was also similar across groups (39.35 ± 0.48°C, $p > 0.05$). The cooling rate for passive rest (0.07 ± 0.02°C·min-1) was lower than all other cooling conditions ($p < 0.014$) except HC (0.09 ± 0.04°C·min-1; $p = 0.073$). Cooling rate for CWI+HC (0.13 ± 0.07°C·min-1) compared to HC (0.09 ± 0.04°C·min-1) trended towards significance ($p = 0.052$). The addition of head cooling to CWI did not result in an enhanced cooling rate compared to CWI alone (0.11 ± 0.02°C·min-1, $p = 0.425$). The addition of head cooling to FT did not result in an enhanced cooling rate (0.13 ± 0.07°C·min-1) compared to FT (0.11 ± 0.05°C·min-1, $p = 0.215$). Total drop in Tre after 40 minutes from the beginning of cooling for CWI and CWI+HC was similar (3.60 ± 1.02°C, 3.74 ± 0.95°C, respectively, $p > 0.05$) and resulted in lower Tre than all other conditions ($p < 0.05$). **Conclusions:** Adding head cooling to common cooling modalities did not provide additional cooling benefits. Cooling rate was greater for all cooling methods compared to passive rest, with the exception of HC. Cooling with CWI or CWI+HC resulted in lasting cooling effects after 40 minutes, which is likely due to Tre after-drop.

Necessity of Removing American Football Uniforms From Hyperthermic Humans Prior to Cold-Water Immersion

Miller KC, Long BC, Edwards JE: Central Michigan University, Mt. Pleasant, MI

Context: Current recommended treatment for an American football player with exertional heat stroke (EHS) is to remove equipment and clothing before cold-water immersion (CWI). Previously, we observed rectal temperature (Trec) cooling rates were higher when subjects underwent CWI while wearing a full football uniform than when they wore minimal clothing. We speculated the higher cooling rates were because subjects wore a full uniform, rather than just t-shirts and shorts, during exercise and thus had greater heat storage upon CWI. **Objective:** (1) Compare CWI durations and Trec cooling rates when hyperthermic subjects wear a football uniform during CWI or remove the uniform immediately before CWI. (2) Compare perceptual indicators of comfort (e.g., thermal sensation and environmental symptoms) before and after CWI in both conditions. **Design:** Repeated measures,cross-over. **Setting:** Laboratory. **Patients or Other Participants:** Eighteen, physically-active men (age = 22 ± 2 y; ht = 182.5 ± 6.1 cm; mass = 83.4 ± 12.4 kg; body fat = 10.7 ± 4.9%; body surface area = 2.07 ± 0.16 m2). **Interventions:** On two days, hydrated (urine specific gravity < 1.02) subjects exercised on a treadmill (~40°C, ~40% relative humidity) while wearing a full football uniform (i.e., helmet, shoulder pads, t-shirt, shorts, underwear, game pants, practice jersey, socks, and padding over the thighs, knees, hips, and tailbone) until their Trec reached 39.5°C. Then, subjects underwent CWI (9.9 ± 0.03°C) until Trec decreased to 38°C while wearing either shorts, underwear, and socks (NOpads) or a full football uniform (PADS). Thermal sensation was recorded pre-exercise, when Trec was 39.5°C, when Trec was 38.75°C during cooling, and immediately post-CWI. A 16-item environmental symptoms questionnaire was given pre-exercise and immediately post-CWI. **Main Outcome Measures:** CWI duration (min); Trec cooling rates (°C·min-1); thermal sensation (0 = unbearably cold; 8 = unbearably hot), and environmental symptoms questionnaire responses (0 = not at all; 5 = extreme). **Results:** Data are means ± SD; CWI duration is reported in median and interquartile range due to a lack of statistical normality. Subjects were well hydrated pre-exercise (NOpads urine specific gravity = 1.006 ± 0.006; PADS = 1.003 ± 0.004, t17 = 2.2, P = 0.04). They had similar exercise times (NOpads = 40.8 ± 4.9 min; PADS = 43.2 ± 4.1 min, t17 = 2.0, P = 0.06), hypohydration levels (NOpads = 1.5 ± 0.3%; PADS = 1.6 ± 0.4%, t17 = 1.3, P = 0.22), and thermal sensation ratings when Trec was 39.5°C (NOpads = 7.2 ± 0.3; PADS = 7.1 ± 0.5, P > 0.05). CWI duration (NOpads = 6.0 [5.4] min; PADS = 7.3 [9.8] min, z = 2.3, P = 0.01) and Trec cooling rates (NOpads = 0.28 ± 0.14°C·min-1; PADS = 0.21 ± 0.11°C·min-1, t17 = 2.2, P = 0.02) differed between conditions. Thermal sensation did not differ between conditions over time (F2,30 = 0.9, P = 0.42). However, environmental symptom scores were lower in PADS than NOpads (F1,17 = 5.3, P = 0.03). **Conclusions:** "Ideal" CWI cooling rates for EHS victims are >0.16°C·min-1. Though subjects cooled faster in NOpads, PADS cooling rate was still "ideal." Wearing PADS during CWI helps with some of the discomfort of CWI. If it is difficult to remove PADS or CWI treatment is delayed, clinicians may immerse fully-equipped hyperthermic football players in CWI without negatively affecting Trec cooling rates. Otherwise, PADS should be removed pre-immersion.

Cooling Effectiveness of Modified Cold-Water Immersion Method Following Exercise-Induced Hyperthermia

Luhring KE, Butts CL, Smith CR, Bonacci JA, Ylanan R, McDermott BP: University of Arkansas, Fayetteville, AR

Context: Populations exercising in the heat (i.e., athletes, military personnel, etc.) are at increased risk for exertional heat illness and exertional heat stroke (EHS). The recommended treatment of EHS is whole body cold-water immersion (CWI); however, monetary, remote locations, or spatial restrictions can sometimes challenge CWI feasibility. Thus, the development of a modified, portable CWI method would allow for optimal treatment of EHS when aforementioned restrictions apply. **Objective:** Determine cooling efficacy of a modified CWI method (tarp assisted cooling; TACO) following exertional hyperthermia. **Design:** Randomized, crossover controlled trial. **Setting:** Environmental chamber (33.4 ± 0.8°C, 55.7 ± 1.9% relative humidity). **Patients or Other Participants:** Fourteen (9 males, 5 females) volunteers (26 ± 4.8y, 1.77 ± 0.08m, 71.9 ± 9.0kg, 20.3 ± 7.6% body fat) with no history of compromised thermoregulatory function participated. **Interventions:** Participants completed volitional exercise (cycling or treadmill) until a rectal temperature (Tre) of at least 39.0°C was reached. Following exercise, participants transitioned to a semi-recumbent position on a tarp until Tre reached 38.1°C or until 15 minutes elapsed during both control (no immersion; CON) and TACO (immersion in 40 gallons of 2.1 ± 0.8°C water) with staff holding the tarp and oscillating the tarp. **Main Outcome Measures:** Tre, heart rate (HR), and blood pressure (reported as mean arterial pressure, MAP), and perceptual measures (muscle pain, thermal sensation, perceived thirst) were assessed pre- and post-cooling. Statistical analyses included repeated measures ANOVA to identify main and interaction effects with post-hoc analysis including t-tests with appropriate Bonferroni correction. Paired samples

t-tests were used to identify trial and time point differences where appropriate. **Results:** Tre prior to cooling was not different between conditions (CON: 39.25 ± 0.27°C, CWI: 39.29 ± 0.40°C, $p = 0.62$) whilst post-cooling Tre was further reduced in TACO (38.11 ± 0.17°C) compared to CON (38.72 ± 0.38°C, $p < 0.001$). Cooling rate was significantly faster during TACO (0.14 ± 0.05°C/min) compared to CON (0.04 ± 0.02°C/min, $p < 0.001$). Decreases in HR were significantly greater in TACO (29 ± 19bpm) versus CON (13 ± 10 bpm, $p = 0.04$). MAP was significantly greater post-cooling in TACO (85.2 ± 5.5 mmHg) compared with CON (67.7 ± 8.2 mmHg, $p < 0.001$). Post-cooling muscle pain was greater in TACO (2.4 ± 2.3) than CON (0.1 ± 0.3, $p = 0.006$). Post-cooling attenuations in thermal sensation were enhanced in TACO (1.0 ± 0.9) compared to CON (4.6 ± 0.8, $p < 0.001$). Perceived thirst was reduced post-cooling in TACO (2.8 ± 1.7) compared to CON (4.4 ± 1.9, $p < 0.001$). **Conclusions:** The TACO method provided significantly faster cooling than CON. When monetary and spatial restrictions are present, such as remote athletic events or military exercises, TACO represents a feasible and effective alternative to traditional CWI in emergency action plans for the treatment of exertional hyperthermia.

Miscellaneous Evidence-Based Forum: Clinical Application of Injury Risk Screening Methods

Thursday, June 25, 2015, 8:00AM-9:00AM; Moderator: Jennifer Medina McKeon, PhD, ATC, CSCS
Discussants: Carrie Baker, PhD, ATC; Gary Wilkerson, EdD, ATC, FNATA

Risk Factors for Sustaining a Lower Extremity Injury in an Army Reserve Officers' Training Corps (ROTC) Cadet Population

Scott SA, Simon JE, Van Der Pol B, Docherty CL: Indiana University, Bloomington, IN; University of Toledo, Toledo, OH; University of Alabama at Birmingham, Birmingham, AL

Context: Injuries are a large issue plaguing today's military, which costs the government time and money. Current research in the United States has not specifically evaluated the ROTC population. ROTC is a unique population because those college students enrolled in the program are our country's future military officers. **Objective:** To identify risk factors associated with lower extremity injuries in an Army ROTC cadet population. **Design:** Cohort study **Setting:** Athletic Training Clinic at a large University. **Patients or Other Participants:** There were 195 cadets enrolled in the study (165 males, 30 females; 20.5 ± 2.17 years, BMI 23.5 ± 2.85 kg/m2). **Interventions:** Injury data were retrospectively obtained from the electronic medical records maintained by a Certified Athletic Trainer. The following injury data was obtained: body region, diagnosis, mechanism, footwear, activity, venue, time loss, referral, and surgery. Medical physicals were reviewed to obtain demographic and historical data (sex, height, weight, army physical fitness test (APFT) score, military science (MS) year, and previous lower extremity injury). A footwear and activity history survey was used to collect information related to frequency of boot wear, prior and current organized physical activity participation, and prior collision sport participation. Physical training (PT) exposures were collected from the attendance records. PT exposures were counted as a singular time a cadet attended PT throughout the study (365 days). **Main Outcome Measures:** Incidence rate was calculated for physical training (PT). Descriptive statistics and frequencies were calculated for all variables. Survival analysis determined association between lower extremity injury and several variables MS year, APFT scores, BMI, sex, previous lower extremity injury, PT exposures, most frequent boot worn, current and prior physical activity, and collision sport participation). Kaplan-Meier curves using log-rank test of equality across the strata (non-parametric) were used for the categorical variables. **Results:** Overall, 41 (21.03%) cadets sustained a lower extremity injury. Incidence calculation revealed an incidence rate of 60 lower extremity injuries/100 person-years during PT. Survival analysis revealed MS year ($P < .001$) and PT exposures ($P < .001$) were significant in predicting risk of injury. Of the cadets that sustained a lower extremity injury 15 (28.3%) were MS I, 11 (20.0%) were MS II, 10 (20.4%) were MS III, and 5 (13.2%) were MS IV. Of the cadets that sustained a lower extremity injury 28 (68.29%) had >50 PT exposures and 13 (31.71%) had <50 PT exposures. In addition, the log-rank test of equality revealed that the frequencies of boot wear (P=.91), past physical activity (P=.91) and current physical activity (P=.69) were not significant indicators of sustaining a lower extremity injury. **Conclusions:** Based upon this preliminary data, footwear and activity have no implications on risk of lower extremity injury. Preventative measures should be focused towards younger cadets because of their increased risk for injury.

Does the Preparticipation Examination Aid in Identifying Future Risk of Concussion

Johns KE, Langdon JL, Shaver G, Buckley TA: Georgia Southern University, Statesboro, GA; University of Massachusetts - Lowell, Lowell, MA; Georgia Southern University, Statesboro, GA; University of Delaware, Newark, DE

Context: A pre-participation examination (PPE) is recommended by the NCAA and this examination commonly includes a multifaceted baseline concussion assessment. Recent evidence suggests that neuropsychological testing can aid in predicting individuals at an increased risk of lower extremity injury. However, no known previous study has investigated the relationship between PPE test components and potential risk of future concussion. **Objective:** This purpose of this study was to investigate a relationship between PPE tests and future risk of concussion. **Design:** Retrospective chart review. **Setting:** Laboratory. **Patients or Other Participants:** 164 participants were recruited for this study. Of these participants, 82 suffered a diagnosed concussion while participating as a student-athlete (Concussion group) and the other 82 did not suffer a concussion (Control group). The concussion group had a significantly shorter time frame from PPE to inclusion in the study (329.3 + 286.7 and 498.1 + 367.1 days respectively, $P = 0.002$). **Main Outcome Measurements:** The results of the PPE exam (BESS, SAC, Visual Memory, Verbal Memory, Reaction Time, and Processing Speed) were compared between groups with a one-way ANOVA. A receiver operating characteristic (ROC) curve and discriminant function analysis were also calculated. **Results:** There were no significant differences between concussion and control groups for ImPACT composite scores verbal memory (85.7 + 8.9 and 87.8 + 9.7, $P = 0.16$), visual memory

(73.1 + 13.5 and 75.9 + 11.6, P = 0.13), reaction time (0.577 + 0.067 and 0.597 + 0.076 seconds, P = 0.071), and processing speed (39.8 + 5.9 and 39.0 + 6.9, P = 0.398), or the BESS total score (12.5 + 5.4 and 13.1 + 5.9 errors, P = 0.483), and SAC score (27.1 + 1.7 and 27.2 + 2.7, P = 0.39). The ROC analysis determined the following cut off values for each PPE component, verbal memory composite: 83.5, visual memory composite: 81.5, reaction time composite: 0.63, processing speed composite: 33.05, BESS: 13, and SAC: 26. The discriminant function analysis revealed no significant predictors. **Conclusions:** The main finding of this study was the lack of a relationship between PPE tests performance and future risk of concussion. Currently, previous concussion history remains the best predictor of future concussion; however, a predictive model for the first concussion remains elusive. ImPACT composite scores may predict future non-contact ACL injury, but were ineffective at predicting future concussion. Interestingly, the reaction scores, the only variable close to significance, was better (quicker reaction time) in the future concussion group.

Collegiate Football Athletes' Perceptions of Future Risk and Consequences of Concussion

Kiernan PT, Baugh CM, Kroshus E: Boston University School of Medicine, Boston, MA; Harvard University, Cambridge, MA; Children's Hospital – Boston, Division of Sports Medicine, Boston, MA; Harvard School of Public Health, Boston, MA

Context: Sport-related head impacts have been linked to both short-term and long-term health consequences. However, athletes' perceptions of their risk of concussion and concussion-related impairment are unknown. **Objective:** Describe athletes' perceptions of their future risk of incurring a concussion and concussion-related health consequences and its relation to athletes' career concussion burden. **Design:** Cross-sectional survey-based study. **Setting:** Athletes' home institutions during the 2013 football season. **Patients or Other Participants:** Out of the 110 schools contacted, 10 teams participated in the study leading to a convenience sample of 721 NCAA Division I Football Championship Series athletes. **Interventions:** Following pilot testing for content and clarity, surveys were administered in-person in a group setting by the same member of the research team. Independent variables included self-reported number of diagnosed concussions and suspected but undiagnosed concussions during the athletes' football careers. **Main Outcome Measures:** Perceived likelihood of future concussion and concussion-related health consequences. Items were assessed using a 7-point Likert scale, which was analyzed as a linear variable. Percent agreement represents responses of slightly agree, agree, and strongly agree combined. **Results:** 42.0% of athletes agreed there was a strong possibility of incurring a future concussion. 10.8% of athletes agreed there was a strong possibility that they would incur longer-term consequences such as dementia, Alzheimer's disease, or chronic traumatic encephalopathy as a result of concussions. Linear regressions were used to assess how athletes' career concussion burdens affected their risk perceptions. There was a correlation between athletes' history of previous diagnosed concussion and their perceptions of future injury and impairment. There was a significant positive association (P < .001) between previous diagnosed concussions and athletes' agreement that there was a strong possibility of getting a concussion in the future. When suspected but undiagnosed concussions were included in the analysis, the associations for all outcomes were strengthened. For example, the association between previous diagnosed concussions and agreement that there was a strong possibility of long-term problems resulting from concussions was not significant (P = .087) but was significant (P = .002) when suspected but undiagnosed concussions were included. **Conclusions:** Collegiate football players in this study perceive a relatively high risk of future concussions as well as concussion-related health consequences. It is particularly interesting that over ten percent of athletes agreed that there is a strong possibility of developing neurodegenerative disease resulting from concussions given the incidence and prevalence of such consequences are unknown. Finally, athletes' career concussion burden increases their perception of the likelihood of concussion and related health outcomes. The directionality of this association is supported by existing evidence that suggests athletes who sustain one concussion are more likely to sustain subsequent concussive injury. This study serves as a starting point for more epidemiological work to accurately inform athletes' perceived risk of injury and impairment.

Clinical Tests in Female Marathon Runners With Running Related Musculoskeletal Injuries

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Context: Nearly 51 million Americans annually choose running as their primary form of exercise. However, this activity brings an increased risk for sustaining a running related musculoskeletal injury (RRMI), with prevalence as high as 79%. It is estimated females sustain approximately 54% of all RRMI. Runners with an RRMI often exhibit an imbalance in hip flexibility and decreased hip strength. Tests such as the Star Excursion Balance Test (SEBT) and Single Leg Hop for Distance (SLHD) have been used within athletic populations to identify individuals at an increased risk of injury; however these tests have not been applied to the recreational running population. **Objective:** To determine baseline differences on clinical screening tests between female runners who do or do not sustain a RRMI during a 16-week formalized training program. **Design:** Prospective cohort study. **Setting:** Research Laboratory. **Patients or Other Participants:** Fifty-six healthy female participants (39.07 + 9.6yrs, 1.65 + 0.07m, 66.75 + 13.31kg) enrolled in a 16-week formalized marathon running program volunteered. **Interventions:** All participants performed all clinical tests at one baseline testing session. The testing order was randomized and performed bilaterally. The SEBT in the anterior reach (SEBT-A) was normalized by true leg length (%), and the SLHD was normalized by height (%). Hip flexion and extension active range of motion (AROM) were measured using a standard goniometer (º). Hip flexion and extension strength were measured using a hand held dynamometer, and were normalized and reported as torque per kilogram of body mass (Nm/kg). At the conclusion of the program, all participants were designated into either the injured (INJ) or injury-free (IF) group, based on sustainment of a RRMI. A RRMI was a musculoskeletal injury of the lower extremity that occurred as a result of running, and resulted in the modification or removal of running for at least one training day. **Main Outcome Measures:** The independent variable was group (Injured, Injury-free), and the dependent variables were SEBT-A, SLHD, hip flexion and extension AROM, and hip flexion and extension torque. Scores of the affected limb of the INJ group were compared to the mean of the bilateral scores of the IF group. Independent t-tests with a Bonferroni Correction were used for each dependent variable; alpha was set a-priori at ($p < 0.008$). **Results:** There were no significant differences between INJ and IF for SEBT-A (INJ:66.6 + 5.18%, IF:62.62 + 5.06%; $p = 0.01$), SLHD (INJ:39.51 + 13.96cm, IF:34.19 + 9.3cm; $p = 0.17$), hip flexion (INJ:72.25 + 17.85º, IF:74.73 + 12.14º; $p = 0.55$) or extension (INJ:15 + 5.57º, IF:15.72+4.85º; $p = 0.62$) AROM, hip flexion (INJ:0.78 + 0.13nm, IF:0.73 + 0.17nm; $p = 0.28$) or extension (INJ:0.71 + 0.13nm, IF:0.73 + 0.17nm; $p = 0.48$) torque. **Conclusions:** Baseline hip AROM and strength measurements were not different between runners that did or did not sustain a RRMI during marathon training. Future research should focus on what batteries of clinical functional screening tools are most appropriate for running populations.

The Effects of an Injury Prevention Program in an Aquatic Environment on Landing Technique

Scarneo SE, Root HJ, Martinez JM, Denegar CR, Mazerolle SM, Casa DJ, Aerni GA, DiStefano LJ: Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Lower extremity musculoskeletal injuries, such as ACL injury, account for a majority of acute sports and recreation related injuries and are of concern to the physically active population. Land-based injury prevention programs (IPPs) have been shown to improve landing technique and reduce injury risk. Previous studies demonstrate that improvements after land-based IPPs may not be retained permanently. Aquatic-based IPPs may elicit similar improvements as land-based IPPs with decreased stress to the joints, allowing the inclusion of these programs earlier in rehabilitation. **Objective:** Examine the effects of a six-week aquatic-based IPP on landing technique, as measured by the Landing Error Scoring System (LESS), acutely and over time. We hypothesized the aquatic-based IPP would reduce LESS scores and that these improvements would be retained. **Design:** Repeated measures. **Setting:** Pool and laboratory. **Patients or Other Participants:** 15 healthy, physically active females (age: 21 ± 2 years; mass: 62.0 ± 8.2 kg; height: 164.7 ± 6.0 cm) volunteered to participate. All participants committed at least four landing errors as measured by the LESS during a screening test demonstrating room to improve their landing technique before the intervention. **Interventions:** Participants completed a 10-minute, aquatic-based IPP three times a week for six weeks. The IPP was modified from land-based IPPs and included balance, strengthening, flexibility, agility and plyometric exercises. Participants completed 3 test sessions before (PRE), after (POST) and four months following the intervention (RET). During all test sessions, participants completed three trials of a jump landing task. Participants were required to jump forward from a 30-cm box half the participant's height and jump for maximum height immediately upon landing. We conducted a within-subject analysis of variance to evaluate differences in total LESS score between the three test sessions (PRE, POST, RET) ($\alpha < 0.05$). **Main Outcome Measures:** All jump landing trials were videotaped from the front and side and graded by a single rater, blinded to time, using the LESS. The LESS is a valid and reliable clinical screening tool to evaluate landing technique and is predictive of lower extremity injuries. The average total LESS score from the three trials was used for the analysis. **Results:** We observed that the aquatic-based IPP reduced LESS scores between PRE (6.30 ± 1.78 errors) and POST (4.46 ± 1.69 errors) as well as between PRE and RET (4.2 ± 1.72 errors) ($P < 0.01$). No significant differences were observed between POST and RET ($P > 0.05$). **Conclusions:** Our findings support our hypothesis demonstrating that an aquatic-based injury prevention program improves landing technique and improvements are retained over time. These results show promise of utilizing an IPP when there is a desire to reduce joint loading, such as during the early stages of rehabilitation, to improve biomechanics and reduce injury risk.

Healthy Females Demonstrate Reduced Vertical Ground Reaction Force Following a 4-Week Feedback Intervention and 1-Week Retention

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Context: Excessive forces when landing from a jump could increase stress on the anterior cruciate ligament (ACL) and increase risk for injury. A reduction in landing forces can be acquired through feedback intervention programs. However, it remains unknown if participants can retain changes in jump-landing forces following the formal intervention period. **Objective:** To investigate the effect of a 4-week feedback intervention program, and 1-week no feedback retention on reducing peak vertical ground reaction force (vGRF) during a jump-landing task. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Healthy, recreationally active females were randomized into one of 2 groups: feedback (n = 32,19.6 ± 1.5yrs, 1.63 ± 0.1m, 58.1 ± 7.8kg), and control (n = 16,19.8 ± 1.7yrs, 1.6 ± 0.1m; 59.2 ± 8.8kg). **Interventions:** Participants completed 12 feedback sessions over a 4-week period. At each session participants performed six sets of 6 jumps off a 30cm box. Prior to the first set, participants were shown a PowerPoint explaining the goals of jump landing, which included feedback to land softly. Following each set of jumps, the investigator reviewed with the participant the goals she failed to accomplish in the previous set using the PowerPoint slides. Outcomes were assessed in both groups before (PRE) and immediate after the 4-week intervention (POST); outcomes were collected 1-week following the intervention in the

feedback group only (RETENTION). **Main Outcome Measures:** At each time point, peak vGRF were measured during 3 jump-landings off a 30cm box placed at a normalized distance (50% of body height) away from the force plates. After landing, participants immediately rebounded for maximum height. Peak vGRF during the first 25% of stance on the dominant limb was extracted using standard inverse dynamics analysis and averaged across trials. In the feedback group, separate one-way ANOVAs with repeated measures on time were performed for each outcome measure. If the ANOVA was significant, 2 separate dependent t-tests were performed to evaluate acquisition (PRE vs. POST) and retention (POST vs. RETENTION). Retention of biomechanical changes was considered to have occurred if a significant difference was not observed at retention. The control group was not tested at the retention time point, thus dependent t-tests only evaluated acquisition in the control group ($\alpha \leq 0.05$). **Results:** There were no (PRE vs. POST) differences in the control group for any of the outcome variables ($P > 0.05$). Feedback decreased peak vGRF at acquisition (PRE:1.9 ± 0.4N/kg, POST:1.4 ± 0.3N/kg, $P < 0.001$) and these changes were maintained at retention (RETENTION: 1.5 ± 0.3N/kg, $P = 0.76$). **Conclusions:** During the acquisition period, the feedback group demonstrated reduced vGRF, which was maintained during the retention period. Decreasing forces when landing from a jump could encourage changes in other biomechanical variables such as knee and hip flexion angles, which could translate to a reduction in ACL injury risk, especially in females. Future research should investigate feedback retention over longer periods of non-exposure, especially in clinically applicable settings. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Field-Based Assessment of Jump Landing Mechanics Following Participation in Traditional Versus Plyometric Lower Extremity Injury Prevention Programs: A Randomized Controlled Trial

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Context: Validated, field-based assessment tools for jump landing mechanics, such as the Landing Error Scoring System (LESS), provide clinicians with portable, low cost methods of assessing an individual's risk of anterior cruciate ligament (ACL) injury. Few studies have been conducted using this innovative low-tech method to quantify the influence of hip abductor strength on jump landing mechanics. **Objective:** To compare the abilities of two 4-week lower extremity injury prevention programs, traditional hip abductor exercises versus lower extremity plyometric exercises, to reduce the risk of ACL injury as evaluated by the LESS test. **Design:** Randomized controlled trial. **Setting:** Research laboratory setting. **Patients or Other Participants:** 35 physically-active women volunteered and were randomized to one of two groups: Traditional or Plyometric exercise; 32 women (mean age, 21.0 + 1.4 yrs; height, 1.63 + 0.06 m; mass, 61.31 + 8.59 kg) completed all aspects of this study. **Interventions:** Participation in one of two evidence-based lower extremity injury prevention programs 4 days per week for 4 weeks. **Main Outcome Measures:** Bilateral measures of concentric and eccentric hip abduction peak torque at 120o/s, right limb closed kinetic chain single leg press peak force at 60o/s, and LESS test score. Each of these measures was assessed at baseline (Week 0) and at the end of the study (Week 4). A Treatment (2) x Time (2) repeated measures ANOVA was used to analyze the data. **Results:** Left concentric hip abduction peak torque increased 27.9% in the Plyometric group (n = 15) and 19.9% in the Traditional group (n = 17) between Week 0 and Week 4 ($p < 0.001$, $\eta^2 = 0.362$), but no significant between group differences were observed ($p > 0.05$). Closed kinetic chain concentric right leg press improved by 21.3% in the Traditional group and by 12.4% in the Plyometric group between Week 0 and Week 4 ($p < 0.001$, $\eta^2 = 0.465$) but these gains were not significantly different between the groups ($p > 0.05$). The 4-week Plyometric lower extremity injury prevention program produced significantly greater improvements in LESS test scores between Week 0 (8.4 + 1.6 points) and Week 4 (7.0 + 1.8 points), a 16.7% improvement, in comparison to the Traditional exercise program which created a 9.0% improvement in LESS test scores between Week 0 (6.8 + 2.0 points) and Week 4 (6.1 + 1.9 points) ($p = 0.026$, $\eta^2 = 0.184$). **Conclusions:** The lower extremity injury prevention programs that we employed both resulted in significant gains in lower extremity strength after the 4 week exercise period. Both interventions produced significant improvements (decreases) in LESS test scores within their respective groups. However, the Plyometric exercise group demonstrated significantly greater improvements in LESS test scores, supporting previous research that indicates plyometric exercise is a crucial component of successful ACL injury prevention programs. This study was supported by The TheraBand Academy and a Graduate Student Research Grant from Texas State University's College of Education.

Coach Use of Injury Prevention Program Activities During Team Warm-ups in High School Sports

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Context: The use of lower extremity injury prevention programs (IPPs) during team warm-ups can reduce injury rates. IPPs generally include the following activities: 1) flexibility, 2) balance, 3) lower extremity/core strengthening, 4) plyometrics, and 5) agility performed at least 3 times per week, and 6) landing/cutting technique instruction. Despite their reported efficacy, IPPs are not widely used by high school coaches. However, it is unknown whether coaches utilize these types of activities without adopting a structured IPP. **Objective:** To assess high school coaches' use of activities commonly included in efficacious IPPs. **Design:** Cross-sectional. **Setting:** Online survey. **Patients or Other Participants:** Head coaches of 189 boys' or girls' soccer, basketball, or volleyball teams from 15 Oregon high schools were invited to participate. The survey response rate was 44.4% (84/189). **Interventions:** A web-based survey was developed and externally reviewed by two independent experts for face/content validity. Survey invitations were emailed to each school's athletic director and forwarded to eligible coaches. Coaches were asked to report whether they used activities common to efficacious IPPs as a part of their team's warm-up, and if so, how frequently those activities were performed. **Main Outcome Measures:** 1) The percentage of coaches reporting use of each activity as a part of their team's warm-up. 2) The average number of times per week each activity was performed. 3) The comprehensiveness of each coach's warm-up was assessed using a 7-point scale. Coaches were categorized from 0 (No activities) to 6 (All activities) based upon how many of the five types of activities they used at least 3 times per week and whether they provided landing/cutting technique instruction. **Results:** 1) The proportion of coaches (95% CI) reporting use of each activity were: Flexibility = 94.1% (89.1, 99.1), Balance = 25.0% (15.7, 34.3), Strengthening = 83.4% (75.4, 91.4), Plyometrics = 53.6% (42.9, 64.3), Agility = 53.4% (42.7, 64.1), and Landing/cutting Instruction = 78.6% (69.8, 87.4). 2) Coaches using these activities did so the following number of times per week [Mean (95% CI)]: Flexibility = 4.85 (4.64, 5.05), Balance = 3.81 (3.06, 4.56), Strengthening = 4.06 (3.74, 4.38), Plyometrics = 3.02 (2.54, 3.50), Agility = 3.33 (2.85, 3.81). 3) The distribution of coaches based upon categorization for warm-up comprehensiveness was: 0: 2.4%, 1: 7.1%, 2: 6.7%, 3: 35.7%, 4: 23.8%, 5: 8.3%, 6: 6.0%. **Conclusions:** The majority of coaches reported providing landing/cutting technique instruction and using flexibility and strengthening activities at least 3 times per week. Balance, plyometric, and agility activities were less commonly and/or less frequently used. Importantly, only 5/84 coaches reported incorporating landing/cutting technique instruction and all of the activities included in efficacious IPPs into their warm-up at least 3 times per week. These findings, coupled with the low rate of IPP adoption by coaches, highlight the need for improved injury prevention through increased dissemination and implementation of efficacious IPPs.

The Interrelationships Among Concussion-Related Biomarkers, Head Hits, and Impact Test in Collegiate Football Players

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Context: Head injuries are prevalent in collegiate athletics with concussions being common among contact sports such as football. Concussion assessment and diagnosis is complicated by the lack of objective and accurate biomarkers. This research study was conducted to increase the knowledge of concussion in athletics. The purpose of the study was to determine if there is a relationship between the level of S100B, head hits, and ImPACT test scores in college football athletes. **Design:** Prospective Study. **Setting:** Athletic Training Clinic and Athletic Event. **Patients or Other Participants:** 30 Division I college football athletes. After being recruited to participate, athletes submitted blood samples through a fingerstick blood draw. Intervention: One full contact practice was used as the test practice and occurred during the 2014 Spring season of football. Athletes submitted blood samples through a fingerstick blood draw. **Main Outcomes Measures:** Blood samples were processed and serum samples were tested using an ELISA kit to measure the amount of blood biomarker, S100B level, in each participant's sample. ImPACT test was completed by each subject to have a comparable objective number. Video recordings of the practice were used to count the number of hits each participant endured during the practice. **Results:** After testing was completed, it was realized that some samples were not reliable, exhibiting high variability between paired samples. Correlation tests were completed, verbal memory score had the greatest correlation ($R = -0.38$, $p = 0.04$) with the subjective Head Hit Index score. Four participants had a change in S100B levels. Only one of the four participants, designated as a control, had acceptable CV levels (> 15%) for all three blood draws. The S100B levels for participant 11 were pre-season 87.2 picogram/milliliters (pg/ml), pre-practice of 109.7pg/ml and post-practice 38.5 pg/ml. The video analysis was negatively correlated with all of the composite ImPACT test scores. The subjective Head Hit Index was negatively correlated with 3 of the 5 composite scores and the verbal memory score had the greatest correlation ($r = -0.38$, $p = 0.04$) with the subjective Head Hit Index. There were no concussions suffered during this study. **Conclusions:** Although the results of this study did not show a strong correlation between S100B and head hits and intensity or the ImPACT test, it did promote concussion awareness. Technology should be researched to make sideline S100B testing practical for the clinical setting.

Heavier Football Facemasks Influence Head Impact Location

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Context: The facemask protects football players from facial trauma. Facemasks with more bars have greater mass distributed further anteriorly from the center of mass of the head, which may promote a dangerous head-down tackling technique that could pose a threat of concussion or spinal cord injury. **Objective:** 1) To determine whether players with heavy facemasks have increased odds of sustaining impacts to the top of the head compared to other head locations. 2) To determine whether there is a significant difference in head impact severity between players with heavy versus light facemasks. **Design:** Prospective Cohort. **Setting:** On-field. **Patients or other Participants:** Twenty-five division I collegiate football players. **Interventions:** Facemask mass was measured following the 2013 season. Location and severity (peak linear - g and rotational acceleration - rad/s^2) were captured for 7,135 total head impacts that occurred at practices using the Head Impact Telemetry System. **Main Outcome Measures:** 1) Players' facemasks were categorized as either heavy (>484 grams, 6 non-linemen, 5 linemen, height = 73.1 ± 2.2 cm, mass = 107.1 ± 19.0 kg, age = 21.8 ± 1.2 years) or light (< = 484 grams, 10 non-linemen, 4 linemen, height = 74.1 ± 2.7 cm, mass = 104.4 ± 18.0 kg, age = 22.0 ± 1.4 years) using a median split. Odds ratios (OR) and 95% confidence intervals (CI) were computed for sustaining top of the head impacts between facemask groups using a random intercepts general linear mixed model. 2) We compared peak linear and rotational acceleration between facemask groups using two random intercepts general linear models ($\alpha = 0.05$). Player position was included in all models to control for possible differences between non-lineman and lineman. **Results**: Groups did

not significantly differ in height, mass, or age. The heavy facemask group sustained a higher proportion impacts to the top of the head (heavy = 15.1% vs. light = 7.0%), and had decreased odds of sustaining frontal (OR: 0.42, 95%CI: 0.22,0.81) and right side (OR: 0.47, 95%CI: 0.26,0.83) head impacts rather than top of the head impacts. Head impact severity did not significantly differ between the heavy (linear: 26.0g, 95%CI: 24.1,28.0, p = 0.37; rotational: 1419.8rad/s^2, 95%CI: 1342.6,1501.5, p = 0.41) and light (linear: 24.9g, 95% CI: 23.3,26.6; rotational: 1461.8rad/s^2, 95% CI: 1396.5,1530.4) groups. **Conclusions:** Heavier facemasks may cause players to sustain higher proportions of top of the head impacts, possibly because they adopt a head-down tackling technique. The moment arm created by the anterior displacement of the facemask's mass relative to the center of mass may draw a player's head and neck into a flexed position during tackling. We observed a difference of only 134 grams (0.3 lbs.) between the heaviest and lightest facemask, which may be greater for other teams that use a wider variety of facemasks. Facemask mass is not likely the only factor that promotes head-down tackling technique. Further research is needed to further identify factors that contribute to dangerous tackling techniques.

Do Head Accelerations Differ Across Impact Type in NCAA Division-I Women's Soccer Players at Risk for Concussion?

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Context: Purposeful heading of a soccer ball is an integral part of the game. Recent focus on sub-concussive impacts and concussion risk has increased awareness among athletic trainers who care for these athletes. The effects of these impacts have been linked to various head (concussion) and neck (strain) injuries. However, the head acceleration that these impacts cause has not been quantified and described during active soccer competition. **Objective:** To compare linear acceleration of the head across different types of impacts observed during game play. **Design:** Cross-sectional study. **Setting:** Real-time data collection on the sidelines during collegiate women's soccer matches. **Patients or Other Participants:** Twenty four female NCAA Division-I collegiate soccer players (age = 19.7 ± 1.2 years; height = 168.3 ± 4.2 cm; mass = 62.0 ± 4.5 kg). **Interventions:** Each athlete was equipped with a Smart Impact Monitor (SIM-G) (Triax Technologies, Norwalk, CT), which was worn throughout each soccer match. The SIM-G is secured via a headband, while the sensor is positioned on the back of the head just below the inion. Real-time accelerations are transmitted wirelessly to a computer on the sideline, which uploads the data to proprietary software. Simultaneously, via visual on-field monitoring of games, each impact was categorized as one of the following: shot, pass, clear, unintentional deflection, body contact, head-to-ground, head-to-head, upper-extremity-to-head, or lower-extremity-to-head contact. **Main Outcome Measures:** Accelerations for each impact were quantified. Only the upper quartile of head impacts was compared for each category of contact because these impacts are the most likely to produce head injury. A one-way ANOVA was performed to compare only the shot, pass, clear, unintentional deflection, and head-to-ground contact categories. Small sample numbers in the remaining categories did not allow for comparisons. **Results:** 731 total head impacts were recorded during the season. Only accelerations above a 20g threshold were used in calculating average values. Across all impacts, the average head acceleration was 39.72g ± 16.75. There was a significant (F = 7.204; p = .001) difference between head accelerations across impact type. Unintentional deflections (55.39g ± 26.46) and clears (44.59g ± 17.23) resulted in the highest average acceleration, followed by head-to-ground (43.69g ± 23.33), shot (39.90g ± 24.62), and pass (33.19g ± 10.39). Game-Howell post hoc comparisons revealed a significant (p = .001) difference between the pass and clear impact categories (11.4g difference). **Conclusions:** These results indicate that there is a difference in head acceleration across the various categories of impacts in our cohort of female soccer players. Athletic trainers should be especially aware of athletes who unexpectedly encounter unintentional impacts from errant balls during matches. Not surprisingly, clearing headers produce higher head acceleration than other types of headers. From a clinical standpoint, soccer athletes who are likely to encounter these types of headers during a match, along with those with previous history of concussion should be cautioned that these strategic headers have the highest head accelerations.

The Effects of Cervical Muscle Strength and Head Impact Location on Impact Biomechanics in Youth Ice Hockey Players

Campbell KR, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Research has shown that stronger cervical muscles do not provide a protective mechanism to reduce head impact severity sustained by athletes. Studies have not isolated this phenomenon based on the muscle-location interaction (e.g. anterior neck flexors' ability to mitigate impacts to the front of the head). Weaker cervical muscles may be unable to protect the athlete from injurious head impacts sustained at a given location. **Objective:** To investigate how cervical muscle strength and head impact location affects head impact biomechanics. **Design:** Quasi-experimental. **Setting:** Field setting. **Patients or Other Participants:** A convenience sample of 32 male ice hockey players (age = 15.0 ± 1.0 years; height = 173.4 ± 5.5 cm; mass = 67.6 ± 7.8 kg). **Interventions:** Isometric cervical muscle strength was measured for the anterior and anterolateral neck flexors, cervical rotators, posterolateral neck extensors, and upper trapezius. Head impact biomechanics (impact magnitude and location) were collected for all players for one season by using helmets customized to accommodate the Head Impact Telemetry (HIT) System. Our independent variables included: 1) relative neck strength (high, low) and 2) head impact location (back, front, side, top). **Main Outcome Measures:** Dependent variables included head linear acceleration (measured in terms of gravity, g), and head rotational acceleration (rad/s^2). Strength measures were normalized to body mass and then categorized as high (>median) or low (≤median). We controlled for repeated head impacts at the player level by employing separate random intercepts general mixed linear models across each dependent variable for relative neck muscle strength by head impact location interaction. **Results:** We did not observe any muscle group by head impact location interaction effects for linear acceleration ($P > 0.124$ for all) or rotational acceleration ($P > 0.053$ for all). We did not observe any differences in head impact biomechanics between relatively strong and weak players ($P>0.280$ for each muscle group). Main effects of head impact location drove our findings. Regardless of muscle group, impacts to the front (16.9g; 95%CI: 16.6,17.3) and side (16.8g; 95%CI: 16.5,17.2) resulted in significantly lower linear acceleration than those sustained to the back (19.0g; 95%CI: 18.3,19.8) or top (19.4g; 95%CI: 18.6,20.3) of the head ($F_{3,93} = 23.98$; $P < 0.001$). Impacts to the side (1766.2 rad/s^2; 95%CI: 1682.2,1854.6) resulted in greater rotational acceleration than impacts to the back (1517.4 rad/s^2; 95%CI: 1443.6,1595.0), front (1569.2 rad/s^2; 95%CI: 1485.7,1657.5), and top (994.9 rad/s^2; 95%CI: 910.7,1086.8) of the head ($F_{3,93} = 66.19$; $P < 0.001$). **Conclusions:** Head impact location, but not relative cervical muscle strength, affected head impact severity in youth ice hockey players. It is possible that our sample of players lacked the heterogeneity in strength measures that would be necessary to identify such an interaction effect. Future work should explore differences in relative cervical strength in non-elite and non-youth (e.g. college) samples to explore the role cervical muscle strength may have on concussion prevention.

Free Communications, Oral Presentations: Documentation Practices of Athletic Trainers

Friday, June 26, 2015, 9:15AM-10:15AM, Room 131; Moderator: Jessica Kirby, MSEd, ATC

Reasons for and Mechanics of Documenting Patient Care Among Athletic Trainers: A Report From the Athletic Training Practice-Based Research Network

Nottingham SL, Lam KC, Kasamatsu TM, Eppelheimer BL, Welch CE: Chapman University, Orange, CA; A.T. Still University, Mesa, AZ; University of La Verne, La Verne, CA

Context: Documentation of patient care is an important responsibility of Athletic Trainers (ATs). However, little is known about ATs' reasons for documenting patient care and strategies for completing documentation tasks. Understanding current opinions and practices of athletic training documentation is important to ensure that ATs are documenting appropriately, in addition to developing strategies for improving patient care documentation. **Objective:** To understand ATs' perceptions regarding reasons for and mechanics of patient care documentation. **Design:** Qualitative interviews using the consensual qualitative research tradition. **Setting:** Individual telephone interviews with Athletic-Training Practice-Based Research Network (AT-PBRN) members. **Patients or Other Participants:** Ten ATs employed in the secondary school setting (7.1 ± 7.8 years of athletic training experience) were recruited using a purposeful sampling technique. Participants were members of the AT-PBRN and practicing in 6 states. **Data Collection and Analysis:** One investigator conducted individual telephone interviews with each participant. Data collection was complete after the research team determined that data saturation was reached. Interviews were transcribed verbatim and independently analyzed by 4 research team members following the process of open, axial, and selective coding. After independently categorizing interview responses into categories and themes, the research team developed a consensus codebook, re-analyzed all interviews, and made a final agreement of the findings. Trustworthiness was established through multiple-analyst triangulation and member checking. **Results:** Participants identified three reasons for documenting patient care: improving communication, guiding patient care, and legal protection. Participants believed that documentation helps improve patient care by helping them monitor patient progress, treatment effectiveness, and communication between clinicians. Four sub-categories emerged from the mechanics of documentation theme, including criteria, location, time spent, and when documentation occurred. ATs described different criteria for documenting patient care situations, ranging from documenting every injury in the same manner to documenting time-loss and follow-up injuries differently. Most participants described documenting for 1-3 hours per day, some completing this throughout the day and others at the end of each day. Participants described that having a consistent schedule for documentation and completing it as soon as possible were the most effective methods for completing documentation tasks. While most participants described documenting in their office or athletic training facility, some described documenting from home or on mobile devices. **Conclusions:** ATs believe that documentation positively influences patient care in multiple ways, in addition to protecting themselves legally. However, ATs also describe a lack of consistent criteria for determining what and when patient care should be documented, leaving some patient care encounters documented insufficiently or not at all. Although ATs recognize individual mechanisms that enable them to document patient care, ATs may need more guidance on the appropriate criteria for documenting various patient care encounters in addition to strategies that may help them document more effectively.

Perceptions of and Barriers Toward Patient Care Documentation Among Athletic Trainers Employed in the Secondary School Setting: A Report from the Athletic Training Practice-Based Research Network

Eppelheimer BL, Nottingham SL, Kasamatsu TM, Lam KC, Welch CE: A.T. Still University, Mesa, AZ; Chapman University, Orange, CA; University of La Verne, La Verne, CA

Context: Patient care documentation is a vital component of comprehensive healthcare, yet little is known about the documentation behaviors of athletic trainers (ATs). Additionally, it is unclear what perceptions ATs may have about patient care documentation or the potential barriers they may encounter when ensuring high-quality patient care documentation. Without an adequate understanding of the issues ATs may face in regards to routine and complete patient care documentation, it is difficult to identify any valuable strategies for improvement. **Objective:** To explore ATs' perceptions of and barriers toward patient care documentation in the secondary school setting. **Design:** Qualitative investigation using the consensual qualitative research approach. **Setting:** Individual phone interviews were conducted with each participant. **Patients or Other Participants:** Ten ATs (4 males, 6 females, 7.1 ± 7.8 years of athletic training experience) employed in the secondary school setting were purposefully recruited and interviewed. Participants were members of the Athletic Training Practice-Based Research Network, practicing in six states. **Data Collection and Analysis:** Each participant interview was transcribed verbatim. Data were collected until the research team determined that data saturation was reached. Transcripts were individually analyzed by four research team members and coded into

common themes and categories. The research team developed a consensus codebook, re-analyzed the interviews, and discussed the findings until agreement was made. Triangulation and trustworthiness of the data occurred via the use of multiple researchers, internal and external auditors, and participant member checking to confirm accuracy of the findings. **Results:** Participants identified five main perceptions of patient care documentation: quality, expectations and accountability, priority, incentive, and culture of the patient population. Participants perceived the quality of documentation was occasionally lacking and that patient care documentation expectations and accountability were minimal. However, participants discussed that ATs must make patient care documentation a priority even though incentive may be lacking and the culture of the secondary school patient population may complicate documentation practices. Participants also identified four barriers that make patient care documentation difficult, including lack of time, an uncertainty of what to document, inadequate facility resources, and a lack of personnel. Along with general concerns about time, participants specifically discussed how the volume of patients was also a challenge in the secondary school setting. **Conclusions:** While ATs believe patient care documentation should be a priority in clinical practice, the barriers identified in this study represent practical difficulties ATs may face when attempting to document their patient care in the secondary school setting. In order to determine effective strategies to address these barriers, further research is needed to gain insight on how these barriers may affect the quality of patient care documentation. The athletic training profession can benefit from making a concerted effort to identify ways to improve patient care documentation habits.

Factors Associated With Athletic Trainers' Practices Regarding the Reporting of Overuse Injuries to Injury Surveillance Systems

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Context: Overuse injuries are hard to define due to their gradual onset, making them difficult to classify within injury surveillance systems. There is no standardized definition of overuse used in any injury surveillance system, creating potential for misclassification. **Objective:** To describe the variability among Athletic trainers (ATs) in defining and reporting overuse injury to surveillance systems. **Design:** Cross-sectional online survey. **Setting:** Population-based. **Patients or Other Participants:** Eligible participants were ATs contributing to the National Collegiate Athletics Associations' Injury Surveillance Program (ISP) in October 2014. All 293 ATs meeting this criteria were contacted, 113 (38.6% response rate) started the survey and 74 completed it (25.3% completion rate). Only completed surveys were analyzed. **Interventions:** The survey presented six hypothetical injury scenarios involving a variety of overuse injuries and was developed by the authors and 5 AT volunteers. In-depth, qualitative interviews were conducted with 5 additional ATs. The survey was pilot tested by 8 graduate students. ATs were emailed survey invitations and links on October 1, 2014 followed by 2 reminders. **Main Outcome Measures:** ATs were asked to estimate: percentage of treated injuries that were overuse, and percentage of overuse injuries reported to surveillance. Next, ATs were asked: what role overuse mechanisms played in each scenario (primary contributor, partial contributor, not related, not enough information), probability of reporting each injury as overuse to surveillance (0-100%) and open-ended questions regarding their individual processes for making these decisions. Scenarios were analyzed individually. Descriptive statistics included frequency, percentages, means, standard deviations and ranges. Percent agreement for the role of overuse for each scenario was calculated. Content analysis was used for open-ended questions. **Results:** ATs reported a mean of 48.8% (SD: 19.2%) of total treated injuries are overuse, and of those, they report 62.4% (SD: 35%) to injury surveillance, indicating approximately 30.5% of total injuries that ATs treat are not reported to injury surveillance. Responses regarding the role of overuse in each scenario were not equally distributed. Two scenarios (softball player with history of tendinosis; baseball pitcher with elbow pain >1 month) had the highest agreement (68.9% and 85.1% respectively). The gymnast learning a new skill scenario had the lowest agreement (46.0%). The probability of ascribing an overuse mechanism to each scenario ranged from 25.2%-85.1%, reflecting ATs' responses regarding the role of overuse in each scenario. Factors influencing decisions regarding overuse from open-ended questions were the progression of the injury, duration of symptoms, presence/absence of contact with an object/person during injury, and individual ATs' personal experiences with similar injuries. **Conclusions:** Overuse injuries are underreported to injury surveillance. The variable agreement among respondents indicates that developing a standardized definition of overuse injury based on the progression of injury and duration of symptoms may improve consistency within injury surveillance systems.

The Impact of the Use of an Electronic Medical Record on Professional Athletic Training Students' Perceived Abilities to Implement the Healthcare Competencies in Clinical Practice

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Context: Electronic Medical Record (EMR) documentation is increasing within athletic training clinical practice and athletic training (AT) student usage is instrumental in developing clinical competence. Utilization of real-time electronic data may assist with students' clinical decision making. **Objective:** To compare the influence of having an EMR on final-term professional AT students' perceived abilities to implement the healthcare competencies into clinical practice. **Design:** Cross-sectional. **Setting:** Self-reported paper survey. **Patients or Other Participants**: 1501 participants (929 EMR: age = 22.6 ± 2.4yrs, 377 males, 551 females; 1 missing; 355 no-EMR: age = 22.6 ± 2.6yrs, 120 males, 235 females; 181 unsure-EMR: age = 22.8 ± 2.8yrs, 77 males, 104 females) from a convenience sample of 1783 final-term athletic training students (84.2% response rate) enrolled in 167 participating AT programs. **Interventions:** The survey consisted of one section for each identified healthcare 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 section included concept statements (range:8-18) that directly relate to each competency. Participants rated their ability to incorporate concepts of each competency within clinical practice on a 4-point Likert scale of strongly disagree (1), disagree (2), agree (3), strongly agree (4). Reliability of the abilities scale was established prior to data collection (α = .955). The independent variable included availability of an EMR (EMR, no-EMR, unsure-EMR). **Main Outcome Measures:** The dependent variables were participants' responses to the survey items. Composite ability scores were achieved by tabulating all values and then averaging the score back to the Likert scale. Higher scores indicated participants perceived themselves to have greater ability implementing the competencies in clinical practice. Kruskal-Wallis H tests ($P < .05$) with post-hoc, Bonferroni-adjusted Mann-Whitney U tests ($P < .017$) were used to assess group differences. **Results:** There were significant group differences for HCI ($\chi2 = 28.06$, $P < .001$), EBP ($\chi2 = 23.56$, $P < .001$), PCC ($\chi2 = 10,11$,$P = .006$). Students had higher competency scores for HCI and EBP when they identified that their clinical site utilized an EMR compared to non-EMR use (HCI, EMR = 3.09/4, non-EMR + 2.99/4, U = 143058.00, P = .001; EBP, EMR = 3.39/4, non-EMR = 3.33.4, U = 146899.00, P = .014). Students also had higher competency scores for HCI, EBP and PCC when they reported that their clinical site did not use an EMR versus not knowing if the site had an EMR (HCI, U = 27782.00, P = .032; EBP, U = 27460.50, P = .015; PCC, U = 26714.00, P = .005), and also had higher competency scores if the clinical site used an EMR compared to not knowing if an EMR was used (HCI, U = 64095.00, P < .001; EBP, U = 64160.50, P < .001; PCC, U = 69164.00, P = .002). **Conclusions:** Utilization of an EMR within a professional program is related to increases in perceived competence within HCI, EBP and PCC. Professional programs should utilize EMRs to monitor clinical outcomes. Further research is warranted as to how EMRs are used to enhance clinical competencies. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Education Evidence-Based Forum: Beyond Simulation - Using Standardized Patient Encounters to Supplement Clinical Education

Friday, June 26, 2015, 10:30AM-11:30AM; Moderator: Kristen Schellhase, EdD, ATC, LAT
Discussants: Kirk Armstrong, EdD, ATC; Amanda Jarriel, PhD, ATC, LAT

Exploring the Professional Socialization of Senior Athletic Training Students: Perceptions of Burnout and Work Life Balance

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Context: The professional socialization process enables athletic training students (ATSs) to gain insights into the behaviors, values and attitudes that characterize their chosen profession. This socialization is often focused on skill development rather than professional issues such as burnout and work-life balance. During their education, ATSs may be exposed to such concepts, which may impact their professional perceptions. **Objective:** Examine the cumulative impact of the professional socialization process on the ATS regarding perceptions of burnout and work-life balance. **Design:** Qualitative research **Setting:** Semi-structured interviews conducted with 6 individuals and 4 small focus groups. **Patients or Other Participants:** 23 ATSs participated (9 male, 14 female, age = 22 ± 0.6). ATSs were enrolled in their final semester of academic studies in CAATE accredited programs at five different universities. **Data Collection and Analysis:** Data collection occurred from two different cohorts over a two-year period. Participants either participated in a focus group session or individual interviews following the same interview guide. All interview sessions were semi-structured and transcribed verbatim. A general inductive analysis was used to evaluate the data. Themes were enumerated by counting the frequency a particular viewpoint was mentioned within the interview, not all students answered each question Member checks and a peer review were used to establish data credibility. **Results:** Three major themes emerged: students reported experiencing symptoms of burnout, recognized signs of burnout in their preceptors, and realize that work life balance may be a challenge for them in the future. 88% of the ATSs described experiencing feelings they attributed to burnout during their undergraduate education. Of those who experienced such signs, 33% recognized similar signs in classmates and 67% recognized them in preceptors or professors. Many students (75%) acknowledged having a family could be difficult in the future. Despite these seemingly negative findings, this group of ATSs was not influenced to leave the profession. Observing their preceptors employ strategies and positive behaviors gave the ATSs hope for the future. 57% responded they feel prepared to succeed in athletic training with 61% having confirmed plans and 30% hoping to continue in athletic training post-graduation, only 2 indicated they were leaving the profession. **Conclusions:** Upon graduating, ATSs perceived that they had experienced burnout, had seen burnout in professionals they interact with and acknowledge possible difficulties in raising a family while working as an athletic trainer. Though cognizant of the challenges they may face ATSs do not see them as barriers to continue in the athletic training profession because they know successful strategies to cope with such challenges. Professionals must understand the importance of appropriate socialization when students are exposed to potentially negative situations so that students remain optimistic about entering the field.

The Role of Personality in Work-Family Conflict Among Collegiate Athletic Trainers

Eason CM, Mazerolle SM: University of Connecticut, Storrs, CT

Context: When the demands of balancing work and non-work roles become overwhelming, often due to a lack of time, conflicts can arise, thus the emergence of the term work-family conflict. While evidence shows that organizational factors may lead to work-family conflict, some researchers speculate that other individual mitigating factors, such as personality may stimulate conflict. **Objective:** Determine if a relationship exists between work-family conflict and personality among collegiate athletic trainers **Design:** A cross-sectional design was utilized to gain information regarding work-family conflict and the relationship to personality. **Setting:** Collegiate institutions. **Patients or Other Participants:** Participants were recruited using the National Athletic Trainers' Association email database. We excluded any athletic trainer who worked outside of the collegiate setting. A total of 202 athletic trainers participated; 68 (33.7%) males and 134 (66.3%) females, representing a response rate of 20.2%. Our participants were certified for 5 ± 3 years, worked on average 57 ± 16 hours per week and traveled 7 ± 7 days per month during in-season sport seasons, and provided medical coverage to 120 ± 104 student-athletes. **Interventions:** Data was collected using a web based survey instrument consisting of three distinct sections: 1) Demographics, 2) Work-Family Conflict Survey, and 3) Big Five Personality Inventory. **Main Outcome Measures:** Likert responses for each work-family conflict scale were summed to provide a score for each participant, ranging from 5-35. A Mann-Whitney U test was run to determine if there were any gender differences between the work-family conflict scores of males and females. To test

the correlation of work-family conflict scores and personality Spearman's correlation coefficient test was run. **Results:** For work-family conflict scale 1 the mean score overall was 25.03 + 7.6. For work-family conflict scale 2 the mean score overall was 9.72 + 4.6. The Mann-Whitney U test revealed that there was no gender difference among work-family conflict scale 1 ($p = 0.619$) or work-family conflict scale 2 ($p = .746$). Spearman's correlation found that agreeableness was negatively correlated ($p = .002$) to the work family conflict score of scale 2. **Conclusions:** Our results indicate that athletic trainers employed in the collegiate setting are experiencing work-family conflict and no differences between exist between males and females, indicating that both sexes are struggling with work-family balance. Additionally we found that athletic trainers, who exhibited higher levels of agreeableness exhibited lower work-family conflict. Fundamentally, agreeable people want harmony and value getting along with others. Research within other professions has found that more agreeable people are more likely to have success at work and receive more emotional support from co-workers, which is a key contributor in balancing work and personal lives.

Exploring Longevity in Athletic Training: Factors Influencing Persistence in the Division I Setting

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Context: Within the athletic training profession, there is a growing concern regarding career longevity. The departure of athletic trainers from the National Collegiate Athletic Association (NCAA) Division I collegiate setting has been documented for various reasons, thus it is rare to find an athletic trainer with more than 15 years at this setting. **Objective:** Investigate the factors that have supported persistence among athletic trainers working in the NCAA Division I setting. **Design:** Semi-structured phone interviews. **Setting:** NCAA Division I universities. **Patients or Other Participants:** 14 athletic trainers (11 males, 3 females; age = 54 ± 6) from 11 NCAA Division I institutions who have been working in this setting for greater than fifteen years (experience: 30 years ± 5). Participants had an average staff size of 15 people ± 5, including intern and graduate assistant athletic trainers. **Data Collection and Analysis:** Semi-structured phone interviews were completed by all participants, which were digitally recorded and transcribed verbatim. Follow-up interviews were completed with 4 participants to complete the member check process. Data analysis was completed using a general inductive approach. Multiple data triangulation and peer reviews were also completed to establish credibility. Data saturation was secured at 14 participants. **Results:** Four main themes were identified regarding the persistence of athletic trainers in the NCAA Division I setting: 1) having a passion for the role and job, 2) an acceptance of the athletics lifestyle, 3) having a support system, and 4) family integration and acceptance of parenting roles. Participants shared their passion for their role as an athletic trainer, which was developed by working daily with the student-athletes. Athletic training in the Division I setting was described as a lifestyle; something that encompasses ever-changing work schedules and long hours, however accepting it as such and adapting to it helped perseverance. Our participants credit their families, friends, and co-workers for providing support and helping their continued success. The support, in part, helped the athletic trainers navigate work-life balance and personal rejuvenation. Many of our participants have found ways to get their families involved in their work, often through workplace integration and family planning. We found, however, only a few female athletic trainers who were still working in the setting after 15 years. **Conclusions:** Career longevity in the NCAA Division I setting may not be commonplace in athletic training, however it appears that its stimulation can be multifactorial. Our study suggests that the athletic trainer needs to have a strong support network in place as well as have a love for their role within the setting. Mentoring and life planning may provide some insights to promotion of career longevity, and as such more research is needed with those who are able to persist.

Burnout in Undergraduate and Graduate Athletic Training Students Over the Course of an Academic Year

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Context: College coursework produces various levels of stress for students. Athletic training programs add in the variable of clinical sites potentially compounding the stress or burnout levels experienced during college. Knowledge of burnout levels throughout the course of an academic year in Athletic Training (AT) students can aid educators in optimizing the timing of clinical site report and end dates, as well as the timing of assignments and exams. **Design:** A cross sectional web-based survey design determined the levels of burnout of AT undergraduate (UG) and graduate (Grad) students during the beginning of a semester versus the end of a semester and over an entire academic year. **Patients or Other Participants:** A convenience sample of AT students from a Division I athletics school athletic training program participated in this study over the course of 3 academic years. A total of 256 responses (Grad = 146; UG = 119) were collected at 4 different time points each year [Fall begin of semester (Fall 1) = 66 responses; Fall end of semester (Fall 2) = 70 responses; Spring begin of semester (Spring 1) = 84 responses; Spring end of semester (Spring 2) = 45 responses]. Response rate was 49.6%. **Interventions:** Subjects completed demographic questions and the 19-item Copenhagen Burnout Inventory (CBI) through an online survey. The CBI is a valid and reliable tool (Kristenson 2005). **Main Outcome Measures:** Burnout scores were calculated from the 3 subsections [work (WBO), personal (PBO), client (CBO)] of the CBI and as a total burnout score (Total BO). A CBI burnout score of greater than 50 is considered high burnout. Outcome measured were analyzed with a 4(Time of Year) × 2(Student level) ANOVA. **Results:** Average scores across the entire year for each subsection and total score were the following: Total BO = 30.5 ± 13.3, WBO = 31.6 ± 16.2, PBO = 41.3 ± 17.3, CBO = 18.8 ± 15.4. The ANOVA showed a significant increase in Total BO from Fall 1 (27.7 ± 12.6) to Fall 2 (34.1 ± 13.1), $p = .047$. Also, graduate students reported significantly higher CBO across all time points compared to undergraduate students (Grad = 24.7 ± 16.7 vs. UG = 14.3 ± 12.3), $p < .001$. No differences were found for either PBO or WBO (p's $> .05$). However, 37% of responses by UG AT students and 33% of responses by Grad AT students indicated high PBO. **Conclusions:** These results suggest that burnout in AT students is increasing from the beginning of fall to end of fall semester. Also, graduate AT students may be more susceptible to client-related burnout compared to undergraduate students. Alarmingly, a significant proportion of students are reporting high personal burnout during the academic year. High burnout in AT students has the potential to influence academic performance, clinical site performance, and the likelihood of students continuing in the profession.

Development of a Survey to Assess High School Parent Knowledge of Athletic Trainer's Roles and Responsibilities

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Context: Insufficient knowledge of individuals involved in the healthcare of patients, such as parents, can impact the professional socialization of an athletic trainer (AT). This can lead to the AT leaving the setting, the profession, and potentially negatively impacting patient care. It is important to study the knowledge of those involved with the delivery of healthcare in the high school (HS) setting, specifically parents as they interact with the student-athletes every day. **Objective:** To develop and assess the reliability and validity of a survey instrument designed to measure parent knowledge of the AT's roles and responsibilities in the HS setting. **Design:** Multiple observational study designs were utilized. We employed a qualitative design for development of the instrument and a reliability design to determine the reliability of the instrument. **Setting:** Semi-structured interviews and electronic survey. **Patients or Other Participants:** Convenience sampling was used to identify HS ATs (n=9, 8±6 years in HS setting) to participate in semi-structured interviews. A random sample of 232 parents of HS student-athletes from a large public high school was contacted to complete the survey to determine reliability. Twenty-three participants (10%) responded to the initial survey and nine (39%) responded to the follow-up. **Interventions:** Semi-structured interviews were conducted to identify the roles and responsibilities of HS ATs. Common themes were derived through an inductive approach and summarized to create a 12-item survey instrument to identify gaps in the knowledge of parents of HS student-athletes. Validity was determined by an expert panel of ATs. To determine reliability, the web-based survey was distributed electronically using Qualtrics to parents of HS student-athletes at two different time-points, approximately two weeks apart. **Main Outcome Measures:** The responses of the surveys were coded and entered into Microsoft EXCEL. Descriptive statistics were calculated for all 12 items. Cronbach's α was employed to establish internal consistency. Percentage of agreement was employed to determine the test-retest reliability. The dependent variables were the survey responses and the independent variable was time. **Results:** Cronbach's α indicated the internal consistency of the instrument was (α=0.644). Percent agreement for each question ranged from 44%-100%. A total of 11 items had over 50% agreement. **Conclusions:** Our results indicate this survey is a valid and reliable assessment that should be utilized to identify gaps in the knowledge of parents of HS student-athletes regarding the HS ATs roles and responsibilities. If gaps in the knowledge are identified, a focused educational intervention aimed at improving the parent's knowledge of the roles and responsibilities of ATs in the HS setting should be developed and administered. Improving the knowledge of parents of HS student-athletes will increase the utilization of HS AT services, thus improving patient care as well as professional socialization of HS ATs.

The Current State of Athletic Training Facilities in Collegiate Athletics

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Context: The past decade has seen many colleges and universities focus on improving their athletic facilities to improve services provided to current student athletes and attract potential recruits. These facility investments have been documented, but no research has specifically assessed Athletic Training Facilities (ATF). **Objective:** The study sought to examine collegiate ATFs to better define their size and scope as well as determine differences based upon school classification. **Design:** Cross-sectional study. **Setting:** Web-based survey. **Patients or Other Participants:** A sampling pool, consisting of all Head Athletic Trainers/ Directors of Sports Medicine at NCAA Division I, II, III, and NAIA levels, resulted in 531 participants (age = 42.45 ± 9.9 years, AT experience = 18.48 ± 9.4 years, gender = 67.5% male and 32.5% female). The total survey response rate was 43.0% from the 1235 contacted with valid email addresses and included 29.6% DI, 22.2% DII, 33.5% DIII, and 14.6% NAIA schools. **Interventions:** A 50-question survey was designed by an expert in facilities management and an experienced certified athletic trainer and was reviewed for face and content validity by a panel of three athletic trainers (2 head athletic trainers, 1 educator). This Qualtrics software-hosted survey asked respondents to provide the various aspects of their ATF (e.g. total square footage, office space, storage space). After initial contact of potential participants, two follow-up emails were sent to increase response. **Main Outcome Measures:** The dependent variables were total size in square feet for the central ATF, satellite ATFs, and game day only facilities. We also examined storage, office, and physician examination facilities available. These outcomes were

assessed using the independent variable of school classification via ANOVA analyses with Tukey's post hoc testing. **Results:** Total sample mean for the central ATF size was 3214 + 5099 square feet. Component ATF space means included: 995 + 1504 square feet in satellite ATFs, 1239 + 1324 square feet in game day ATFs, 385 + 569 square feet in AT offices, 391 + 719 square feet in storage space, and 205 + 252 square feet in physician exam space. Division I schools had significantly greater facility resources than the other classifications in multiple categories including: central ATF size, $F(3,469) = 22.36$, $p < .001$; satellite ATF size, $F(3,219) = 7.51$, $p < .001$; storage space size, $F(3,403) = 17.55$, $p < .001$; and office size, $F(3,388) = 13.60$, $p < .001$. Game day ATFs ($p = .089$) and physician's exam rooms ($p = .112$) showed no significant facility size differences across classifications. **Conclusions:** With the lack of prior quantitative research of ATFs, this study provides benchmark descriptive data on ATF size and scope and illustrates the differences in facility resources at Division I level compared to the other NCAA and NAIA classifications. Additional studies of AT services from an equipment, staffing, or budgeting perspective based upon classification or student-athlete numbers would be warranted.

Assessment of Staffing Levels at National Collegiate Athletic Association Football Bowl Subdivision-Level Institutions

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Context: Increasing demands on sports medicine programs create concerns about adequate staffing, athletic trainers' (ATs) wellbeing, and the consistency of quality medical care. The Appropriate Medical Coverage for Intercollegiate Athletics (AMCIA) document assesses personnel requirements to ensure adequate AT staffing; however, little is known about compliance of current staffing practices with those recommended by the AMCIA. **Objective:** To determine the degree to which Football Bowl Subdivision (FBS) institutions meet the AMCIA full-time equivalent (FTE) recommendation for football. **Design:** Cross-sectional. **Setting:** Web-based survey. **Patients or Other Participants:** 104 of 123 ATs (84.6% response rate; age = 47.6 ± 8.2 years, AT experience = 25.5 ± 7.8 years) who had knowledge of budget and staffing at their FBS institution accessed the survey; 76 respondents completed all necessary items to calculate the AMCIA recommended number of FTEs. **Interventions:** Participants were solicited via email to complete the Assessment of Staffing Levels at National Collegiate Athletic Association FBS-level Institutions survey. This survey was developed by the research team and consisted of six sections; however, only the AMCIA variables (9 multi-part questions) and AMCIA utilization (3 multi-part questions) sections were assessed in this inquiry. **Main Outcome Measure(s):** The dependent variables were participants' responses to the survey questions. Descriptive analyses (mean ± SD, frequencies, percentages) were utilized to describe institutional characteristics and assess discrepancies between actual and recommended staffing levels. **Results:** One-third of respondents (34.2%, n = 26/76) met the recommended number of FTEs for football, two-thirds of the respondents (65.7%, n = 50/76) failed to meet the recommendation, and 26.0% (n = 27/104) were missing data, preventing FTE calculation. Of those that did not meet the recommended FTEs (n = 50), 38.0% (n = 19) were within 1 FTE of compliance, 26.0% (n = 13) were within 2 FTEs, and 24.0% (n = 12) were within 3 FTEs. More than one-third of respondents (35.6%, n = 37/104) reported they did not use the AMCIA, due to lack of funding (21.6%, n = 8/37), lack of administrative support (21.6%, n = 8/37), lack of understanding about the AMCIA (8.1%, n = 3/37), lack of time to complete the AMCIA (8.1%, n = 8/37) or other reasons (37.8%, n = 14/37). **Conclusions:** The majority of FBS institutions do not have the AMCIA-recommended FTEs allotted to the sport of football. For most institutions that failed to meet their AMCIA recommendation, 1-3 additional FTEs would make them compliant. The AMCIA is used inconsistently because ATs feel resistance from financial or administrative constraints; however, the majority of FBS institutions that used the AMCIA were able to provide justification for staffing. Increasing FTE quantities is one component of addressing AT workload/personnel imbalances. To have adequate staffing and manageable workloads within collegiate athletics, there must be a realistic valuation of the time and effort required to provide AT services, as well as a structured assessment and allocation of FTEs, including a standardized definition of the term full-time equivalent.

Athletic Trainers' Perspectives on Summer Medical Coverage in the NCAA Division I Setting

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Context: Over the last two decades, coverage and care during the summer months for National Collegiate Athletics Association (NCAA) Division I student-athletes have increased. Recent rule changes have allowed basketball coaches even more access to student-athletes for summer conditioning and skill sessions. To date, little is known regarding the impact of these changes on the athletic trainer, or how athletic training staffs are providing summer medical coverage. **Objective:** Investigate how athletic training departments manage summer medical coverage in the NCAA Division I setting, and examine athletic trainers' perspectives on the impact of increased summer medical coverage duties. **Design:** Asynchronous mixed-methods study utilizing qualitative and survey methods. **Setting:** NCAA Division I athletic training departments. **Patients or Other Participants:** Criterion sampling was used to select participants and data saturation guided the final pool. A total of 22 full-time athletic trainers (13 male, 9 female; age 35 ± 8; years of experience 12 ± 7) participated in our study. Participants worked, on average, 67 ± 10 in-season, 53 ± 10 non-traditional season and 40 ± 10 summer hours per week. **Data Collection and Analysis:** Data were collected via an online instrument, which contained closed-ended, Likert-scale items and open-ended, asynchronous, in-depth interview items. Descriptive statistics and frequency distributions were performed on demographic and 5-point Likert items. A general inductive analysis was used to evaluate the qualitative data. Data credibility was established with peer review, data source triangulation and multiple analyst triangulation. **Results:** Three mechanisms were used to provide medical coverage for summer activities: 1) individual coverage (athletic trainer provides medical coverage to assigned teams only), 2) shared coverage (athletic trainers rotate medical coverage for all sports), or 3) a combination of the two previously described. Our participants were, overall, moderately satisfied with how their department managed summer medical coverage (3.27 ± 1.03), and with the flexibility of their summer work schedule (2.96 ± 1.21). Two themes emerged from the perceptions on the impact of the NCAA rule changes and current summer medical coverage duties: 1) the impact on the athletic trainer and 2) the impact on the student-athlete. Summer hours are now beginning to mimick non-traditional season hours worked, which concerned our participants as it limits time for rejuvenation. Our participants were also concerned for the student-athletes and the lack of a true off-season for their physical and mental recovery, which, in turn, further increases the athletic trainer's workload. **Conclusions:** The evolution of summer conditioning and skill activities at the NCAA Division I level have increased the workload for athletic trainers, and is affecting both athletic trainers' and student-athletes' time for personal rejuvenation and recovery. Options such as job sharing and utilizing one centralized athletic training room should be considered to reduce the summer workload.

Perceptions Regarding Hiring Criteria of Collegiate Entry-Level Athletic Trainers

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Context: Hiring is one of the most important aspects of institutional maintenance and growth. Hiring in athletic training is difficult to understand. Athletic training is an allied healthcare profession with a variety of different work practice settings, but the traditional work setting of collegiate athletics still is very popular with entry-level athletic trainers. There is a lack of research on what employers believe are the most important qualities that entry-level athletic trainers have when making hiring decisions. Not knowing these qualities is problematic for multiple reasons including: 1) hiring institutions do not have a guide in which to compare their process, 2) candidates do not know how to prepare themselves when seeking employment, and 3) athletic training educators who do not know the best practices on advising athletic training students in preparing for employment. **Objective:** To determine the perceived importance of specific hiring criteria in of entry-level athletic trainers in the collegiate setting. **Design:** Cross-sectional. **Setting:** Web-based population survey. **Patients and Other Participants:** Athletic Directors, Head Athletic Trainers, and Athletic Training Education Program Directors were surveyed from 400 randomly selected institutions with various levels of athletic programs. Overall 408 of 787 (51.8%) participants responded (110 DI, 107 DII, 91 DIII, 100 NAIA) (121 Athletic Directors, 221 Head Athletic Trainers, 55 ATEP Directors, 11 Other). **Interventions:** A researcher-developed survey was sent using Survey Monkey to the athletic director, head athletic trainer, and athletic training education program director as applicable, and respondents had four weeks to respond. Expert and criterion validity testing was conducted prior to survey distribution. **Main Outcome Measures:** Results from a 7-point Likert scale ranging from 1= very nonessential to 4 neither

nonessential nor essential (neutral) to 7 very essential. Criteria were categorized into three categories: Academic and Additional Experiences, Personality Traits, and Similarity of Experiences. **Results:** Overall, the top five criteria identified were: Work Ethic (6.70 ± 0.50), Communication Skills (6.43 ± 0.58), Motivation/Enthusiasm (6.32 ± 0.66), Interpersonal Skill (6.25 ± 0.7), and Initiative (6.25 ± 0.71). The bottom five criteria identified were: NCAA Division I Clinical Experience (3.5 ± 1.46), Research/Thesis Experience (3.4 ± 1.32), Strength Coach Certification (3.39 ± 1.33), Undergraduate/Graduate Double Major or Minor (3.28 ± 1.28), and Played College/Amateur Athletics (3.12 ± 1.38). The highest rated academic experience was the eight ranked criteria, Recommendations (5.99 ± 0.91) and highest rated similarity measure was the twentieth criteria, Sport-Specific Experiences To Job Duties (5.11 ± 1.09). **Conclusions:** Of the criteria evaluated, personality traits were rated as the most important category with the majority of personality traits rating as somewhat essential to essential. Similarity of experiences criteria were rated the lowest with all being rated as neutral or below. Athletic training educators and potential employers should understand and advise students to select experiences that will assist them in developing personality traits opposed to settings that are similar to their dream job.

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

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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 49 high schools participating across four states over 4 competitive seasons. **Interventions:** 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 Measures:** 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, elective imaging and surgical procedures, injury severity, head, shoulder, and lower extremity trauma, cleat design, turf age, and environmental factors using univariate analyses. **Results:** Of the 1,163 high school games documented, 402 games (34.6%) were played on infill (A), 321 (27.6%) on infill (B), 292 (25.1%) on infill (C), and 148 (12.7%) on infill (D). A total of 2,826 injuries were documented, with significantly lower total injury incidence rates (IIR), [19.1 (95% CI, 18.7-19.3) vs 23.5 (22.8-24.0) vs 33.0 (32.2-33.6) and 23.0 (22.2-23.8)], substantial IIRs [3.5 (95% CI, 3.0-3.9) vs 5.2 (4.7-5.8), 8.5 (8.1-8.9) and 6.3 (5.5-7.0)], trauma from player-to-player collisions [8.9 (95% CI, 8.6-9.4) vs 10.8 (10.4-11.2), 16.4 (15.7-16.9) and 10.5 (10.1-10.9)], surface impact trauma [2.6 (95% CI, 2.2-3.0) vs 4.4 (3.9-4.9), 5.7 (5.1-6.2) and 4.1 (3.4-5.0)], and less lower extremity trauma [10.0 (95% CI, 9.8-10.0) vs 11.3 (10.9-11.7), 14.1 (13.4-14.6) and 11.4 (10.8-12.0)], 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 incidence ($P < .05$) was also observed across injury category and grade, muscle-tendon overload, time loss, skill positions, injury mechanism and situation, elective imaging and surgeries, 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, further investigation is warranted.

Epidemiology of National Collegiate Athletic Association Men's and Women's Cross Country Injuries, 2009/10-2013/14

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Context: Nearly 30,000 U.S. college students at more than 1000 institutions compete on National Collegiate Athletic Association (NCAA) cross country running teams every year. However, recent injury surveillance data for collegiate-level cross country is limited. **Objective:** To describe the epidemiology of NCAA men's and women's cross country during the 2009/10-2013/14 academic years. **Design:** Descriptive Epidemiology. **Setting:** Aggregate injury and exposure data collected from 25 men's cross country programs providing 47 seasons of data, and 22 women's cross country programs providing 43 seasons of data. **Patients or Other Participants:** Collegiate student-athletes participating in men's and women's cross country during the 2009/10-2013/14 academic years. **Interventions:** Men's and women's cross country data from the NCAA Injury Surveillance Program (ISP) during the 2009/10-2013/14 academic years were analyzed. **Main Outcome Measures:** Injury rates, injury rate ratios, injury proportions by body site and diagnosis, and injury proportion ratios (IPR) were reported with 95% confidence intervals (CI). **Results:** The ISP captured 216 injuries from men's cross country and 260 injuries from women's cross country, leading to injury rates of 4.66/1,000 athlete-exposures (AEs) for men (95% CI 4.39, 5.02) and 5.85/1,000 AEs for women (95% CI: 5.53, 6.25). The injury rate in women's cross country was 1.25 times that of men's cross country (95% CI: 1.05, 1.50; P = 0.02).

Common injured body sites included the lower leg (Men: 35.2%; Women: 23.5%), foot (Men: 15.7%; Women: 15.4%), thigh (Men: 12.5%; Women: 14.6%), and knee (Men: 10.7%; Women: 12.3%). Compared to men, women sustained a larger proportion of injuries to the hip/groin (11.2% vs. 3.2%; IPR = 3.44; 95% CI: 1.54, 7.70; P = 0.001). Compared to women, men sustained a larger proportion of injuries to the lower leg (35.2% vs. 23.5%; IPR = 1.50; 95% CI: 1.13, 1.99; P=0.006) and ankle (13.0% vs. 5.0%; IPR = 2.59; 95% CI: 1.38, 4.88; P = 0.003). The majority of injuries were classified as overuse (Men: 57.6%; Women: 53.3%). **Conclusions:** Findings indicated a lower injury burden in men's and women's cross country than reported in a similar study conducted one decade earlier. Consistent with prior research, there was a relatively higher burden of reported injury among females compared to males. To mitigate the frequency of overuse injuries, cross country programs may benefit from training guidelines that limit the number of miles or running per week, and encourage other nonimpact cross training activities.

Fatalities Associated With Exertional Rhabdomyolysis and Sickle Cell Trait: A Review of 99 Fatal Cases

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Context: Exertional rhabdomyolysis (ER) ranges from an asymptomatic illness with myalgia, myoglobinuria, and elevation in creatine kinase (CK) to a life-threatening condition associated with acute compartment syndrome (ACS), acute renal failure (ARF), and death. The primary cause of ER typically involves un- or under-trained individuals performing strenuous exercises to which they are unaccustomed and can be exacerbated by heat stress, dehydration, and sickle cell trait (SCT). Although ER is rare in physically active individuals, it can occur when people are prompted to go beyond their capabilities by a coach or authoritative figure. **Objective:** To identify trends and common characteristics of fatal cases of ER reported in the medical literature during the period of 1968-2014. **Data Sources:** A PubMed search of cases reported in the peer-reviewed literature. **Study Selection:** Inclusion criteria were: history of strenuous exercise, CK >500 IU/L, or a reported diagnosis of ER. **Data Extraction:** Cases were entered into a spreadsheet and descriptive statistics were calculated. Cases were examined for the presence of myoglobinuria, SCT, ACS, ARF, and death. Chi square analysis was performed to determine the risk estimate of fatal cases related to SCT. **Data Synthesis:** Cases reviewed from the medical literature revealed 572 cases of which 17% (99/572) were fatalities. Of the fatal cases, 86% (85/99) those with SCT (often tested post-mortem) were significantly $p < .001$ ($X2 = 368$, Odds Ratio = 27, 95% Confidence Interval = 16, 46) more likely to die of their condition. The fatal cases were young adult men (mean age = 25 ± 10yr, range = 6-47 yr), except for 7% (7/99) women. Reported CK levels for the fatal cases were mean ± SD = 175,014 ± 280,718 IU/L, range = 425-941,000 IU/L and 21% (21/99) had myoglobinuria. Additionally, 24% (24/99) were associated with heat stress or dehydration and 4% (4/99) occurred at high-altitude. Serious complications included 10% (10/99) developed ARF and 3% (3/99) developed ACS. All of the fatal cases involved strenuous activity with 31% (31/99) football/athletes, 43% (43/99) military/service (firefighters/police) personnel/trainees, 14% (14/99) children/adolescents, 8% (8/99) recreational athletes, or 4% (4/99) other/not described. **Conclusions:** Fatalities are considerably more likely to occur in those with SCT and to a lesser extent when exacerbated by heat stress, dehydration, and altitude. Combined with the lack of preparation through physical training, excessive exercise can be the major precipitating cause of ER especially for those with SCT. High CK responses were common; however, ACS and ARF occurred less often. The greatest risk is to those with SCT who participate on team sports or group training. Individuals with SCT should be provided with counseling and educational materials on the potential danger of excessive exercise with this condition. Additionally, coaches and those directing exercise should use good judgment with universal precautions for the health and welfare of all individuals on the team.

Medical Injuries and Illnesses at an Ironman Triathlon Competition

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Context: Extreme endurance events, such as an Ironman triathlon, expose athletes to a variety of physiological stressors. Medical injuries for such events are not well described or quantified. **Objective:** The purpose of this study was to describe the type and severity of medical encounters during an Ironman triathlon competition. **Design:** Data was collected from race entrants seeking medical attention during an Ironman triathlon competition. **Setting:** 2014 Lake Placid Ironman Race, Lake Placid, NY (Mean WBGT = 20.0°C, Range = 14.4-28.3°C). **Patients or Other Participants:** A sample of 163 participants (Mean ± SD; age: 41 ± 10y; post race weight: 72.9 ± 12.9kg: 106 males, 55 females, 2 unknown) who sought medical care was analyzed. **Interventions:** No intervention occurred. **Main Outcome Measures:** Descriptive statistics were performed. Percent body mass loss (%BML), blood glucose (Glu), sodium (Na), and potassium (K) were included when available. Groups based on final diagnosis were created for comparison via independent t-tests. An a priori alpha level of 0.05 was set. **Results:** The most frequent finishing time was 11:00-11:29h (n = 20). The majority of participants (51%; n = 83) finished under 12:59h, while 79% (n = 129) finished within the mandated 17:00h cut-off time, and 21% (n = 34) either did not either finish within this allotted time or dropped out. The most common diagnosis was dehydration (DHY; n = 60, 38%; 2.51 ± 3.12%BML, Na = 140 ± 3mEq/L, K = 4.1 ± 0.55mmol/L, Glu = 105 ± 33mg/dl), followed by exhaustion (EXH; n = 59, 36%; 1.73 ± 3.23%BML, Na = 137 ± 4mEq/L, K = 3.8 ± 0.46mmol/L, Glu = 97 ± 16mg/dl), nausea (n = 18, 11%; 1.40 ± 3.21%BML), cramps (n = 18, 11%; 2.70 ± 4.20%BML, Na = 139 ± 5mEq/L, K = 4.3 ± 0.80mol/L, Glu = 86 ± 22mg/dl), abrasions (n = 16, 10%), dizziness (n = 16, 10%), hyponatremia (EAH; n = 8, 5%; 1.80 ± 3.20% body mass gain, Na = 132 ± 2mEq/L, K = 3.8 ± 0.04mol/L, Glu = 101 ± 13mg/dl), hypothermia (n = 12, 7%), and other (n = 17, 10%). Some participants, however, had multiple final diagnoses. The highest co-morbidities for DHY were EXH (n = 16, 26%) and cramps (n = 10, 16%). Consequently, EXH cases presented most often in conjunction with DHY (n = 16, 27%), followed by cramps (n = 8, 14%). The highest co-morbidities for Nausea were Dizziness (n = 8, 44%) and DHY (n = 4, 22%). Additionally, the highest co-morbidities for Cramps were DHY (n = 10, 56%) and EXH (n = 8, 44%), while EAH commonly occurred with EXH (n = 4, 50%) and cramps (n = 1, 13%). %BML and Na values were significantly different between DHY and EAH ($p = 0.004$, $p < 0.001$ respectively), while finish time was not significantly different ($p > 0.05$). Finish time, treatment time, and Na values for DHY and EXH were significantly different ($p = 0.017$, $p < 0.001$, $p = 0.013$, respectively). EAH and cramps had significantly different values for %BML ($p = 0.028$), finish time ($p = 0.006$) and Na ($p < 0.001$). **Conclusions:** Dehydration and exhaustion were the most frequent illnesses, while both had the common co-morbidity of cramps. EAH had significantly lower Na and %BML compared to cramps. While a spectrum of illnesses related to blood volume and blood composition existed within this sample, DHY, EXH were more prevalent and required greater treatment time from the medical staff.

Sex Differences in the Incidence of Anterior Cruciate Ligament Injuries in National Collegiate Athletic Association and High School Basketball and Soccer, 2009/10 – 2013/14

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Context: Previous research has noted sex differences in the rate of anterior cruciate ligament (ACL) injuries in young athletes. However, updated injury surveillance data for collegiate and high school student-athletes is limited. The most recent report looking at this population and injury was published in 2007. Additionally, over the last 10 years there has been the introduction of ACL injury prevention programs along with increased youth sport specialization, which may have impacted injury rates. **Objectives:** To describe the epidemiology of ACL injuries among males and females in National Collegiate Athletic Association (NCAA) and high school (HS) basketball and soccer. **Design:** Descriptive epidemiology. **Setting:** Aggregate injury and exposure data collected from men's and women's NCAA and HS basketball and soccer programs (average 25 and 41 team-seasons per academic year, respectively). **Patients or Other Participants:** Collegiate and high school student-athletes participating in basketball and soccer. **Interventions:** College and HS basketball and soccer injury data from the NCAA Injury Surveillance Program (ISP; 2009/10-2013/14 academic years) and the National Athletic Treatment, Injury and Outcomes Network (NATION; 2011/12-2013/14 academic years) were analyzed. **Main Outcome Measures:** Injury counts, injury rates, and injury rate ratios (RR) were reported with 95% confidence intervals (CI). **Results:** The NCAA ISP captured 118 ACL injuries [38 in women's basketball, Rate = 2.0/10000 athlete-exposures (AE); 15 in men's basketball, Rate = 0.7/10000AE; 55 in women's soccer,

Rate = 2.6/10000AE; 10 in men's soccer, Rate = 0.6/10000AE]. NATION captured 88 ACL injuries (27 in girls' basketball, Rate = 1.3/10000AE; 10 in boys' basketball, Rate = 0.2/10000AE; 31 in girls' soccer, Rate = 1.6/10000AE; 20 in boys' soccer, Rate = 0.9/10000AE). ACL rates were higher among females than males at all levels in both basketball and soccer. In basketball, the NCAA women's ACL rate was 2.8 times that of men (95% CI: 1.5, 5.1, $p < 0.001$); the HS girls' ACL rate was 5.2 times that of men (95% CI: 2.5, 10.7, $p < .001$). In soccer, the NCAA women's ACL rate was 4.1 times that of men (95% CI: 2.1, 8.0, $p < 0.001$); the HS girls' ACL rate was 1.8 times that of men (95% CI: 1.0, 3.2, $p = 0.05$). **Conclusions:** These findings are consistent with earlier reports of a sex disparity toward women sustaining ACL injuries at a higher rate than men during NCAA and HS basketball and soccer. Compared to previous findings, our reported RRs are larger in soccer and smaller in basketball. The sex disparity is also present at the HS level, but with a higher RR in basketball versus soccer. Though injury prevention programs have targeted female athletes, there still appears to be a higher propensity for ACL injury in females in level 1 sports like basketball and soccer, warranting continued efforts to develop strategies to identify and minimize injury risk factors in these populations.

The Effects of 6-Week Open and Closed Chain Resistance Tubing Programs on Shoulder Torque and Power

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Context: The efficacy of various upper extremity open kinetic chain (OKC) and closed kinetic chain (CKC) exercises have been reported in the literature. It remains unclear if the OKC or CKC position provides an advantage over the other when incorporated into a neuromuscular training program for the shoulder. **Objective:** To compare peak torque and average power of shoulder rotation after 6-weeks of resistance tubing exercise in the OKC and CKC position. **Design:** Randomized controlled trial. **Setting:** Controlled laboratory. **Patients or Other Participants:** Thirty volunteers with no history of shoulder injury (12 males: age = 21.0 ± 1.9 yrs, height = 177.3 ± 4.3 cm, mass = 86.9 ± 18.6 kg; 18 females: age = 22.1 ± 2.7 yrs, height = 165.0 ± 4.8 cm, mass = 70.0 ± 17.1 cm). **Interventions:** Pretest internal rotation (IR) and external rotation (ER) were performed concentrically at 60º/second and 180º/second on the throwing dominant arm with an isokinetic dynamometer. Participants performed five consecutive repetitions in the seated modified neutral position at 60º/second and 10 consecutive repetitions at 180º/second using maximal effort and the order of testing speed was randomized. Peak torque and average power were recorded. Participants were randomly assigned to one of three groups: OKC, CKC and control group. The OKC group performed glenohumeral IR and ER against resistance tubing in the standing position. The CKC group performed glenohumeral IR and ER against resistance tubing in a push-up position on the Standing Firm device. Exercises were performed 3 days/week for 6-weeks and repetitions, velocity and resistance progression were the same for both groups. Control group participants were not enrolled in an exercise program. All participants refrained from upper body resistance exercises and overhead activities outside the scope of the study. Posttest isokinetic testing was performed within 48 hours of completing the 6-week period. The independent variables were group (OKC, CKC and control) and time (pretest and posttest). **Main Outcome Measures:** Dependent variables were peak torque and average power for IR and ER at 60º/second and 180º/second. For each dependent variable, a 2x2 factorial ANOVA was performed ($p<0.05$). **Results:** For peak torque, there was a main effect for time with IR at 180º/second ($F1,27 = 7.69$, $p = 0.01$) in which the posttest (36.6 ± 17.4Nm) was greater than the pretest (34.2 ± 17.1Nm). For average power, there were main effects for time. For IR at 60º/second ($F1,27 = 5.83$, $p = 0.023$), the posttest (30.66 ± 15.62W) was greater than the pretest (27.54 ± 15.28W). For ER at 180º/second ($F1,27 = 4.42$, $p = 0.045$), the posttest (40.17 ± 18.84W) was greater than the pretest (38.04 ± 18.75W). For IR at 180º/second ($F1,27 = 8.20$, $p = 0.008$), the posttest (57.38 ± 36.06W) was greater than the pretest (50.79 ± 35.4W). There were no other main effects or interactions. **Conclusions:** Peak torque and average power increased following the 6-week period, however, the three groups responded similarly. Participants in the current study were free of injury. Future research efforts should focus on patients that warrant strengthening of the rotator cuff.

The Correlation Between Upper Extremity Blood Flow and Grip Strength in Baseball Players

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Context: Baseball players, specifically pitchers, often experience upper extremity symptomatic neurovascular occlusion initially resulting in arm fatigue. This sensation has been termed "dead arm syndrome". As the compression continues complaints may manifest into pain, paresthesia, and decreased strength within the affected upper extremity. Unfortunately, no research has investigated the correlation between upper extremity blood flow and strength. **Objective:** To determine if correlations exist between upper extremity blood flow in different arm positions and grip strength among baseball players. **Design:** Cross-sectional. **Setting:** Athletic training room. **Patients or Other Participants:** Sixty-six asymptomatic professional baseball pitchers (age = 21.6 ± 2.0 years; height = 186.9 ± 5.7 cm; mass = 91.3 ± 10.9 kg) and 24 position players (age = 20.9 ± 2.6 years; height = 181.7 ± 4.8 cm; mass = 87.7 ± 9.3 kg) participated. **Interventions:** We used diagnostic ultrasound to measure blood flow of the throwing arm brachial artery in two different shoulder positions. The first position was conducted with the test arm resting at the participant's side. For the second position, we palpated the test arm radial pulse while the arm was abducted, horizontally abducted, and externally rotated until we felt maximum diminution of the pulse. We measured grip strength with participants seated and their throwing arm elbow flexed to 90° with neutral forearm rotation. We used Pearson product-moment correlation coefficients to determine the strength of the relationships between blood flow in the two arm

positions and grip strength ($p<0.05$). **Main Outcome Measures:** The dependent variable was grip strength of the throwing arm. **Results:** The pitchers' blood flow in the resting and provocative shoulder positions were 27.0 ± 11.2 and 20.0 ± 8.5 ml/min, respectively, while grip strength was 129.5 ± 19.3 lbs. The position players' blood flow in the resting and provocative shoulder positions were 26.6 ± 11.6 and 16.0 ± 5.9 ml/min, respectively, while grip strength was 121.5 ± 16.5 lbs. A strong positive correlation was found among the pitchers indicating that as blood flow tested in the provocative shoulder position decreased, so did grip strength ($r = .66$, $p = .001$). No significant relationship was reported in pitchers between blood flow in the resting position and grip strength ($r = .01$, $p = .95$). Position players did not present with any significant relationships between grip strength and blood flow while in either the resting ($r = .17$, $p = .43$) or provocative positions ($r = .07$, $p = .74$). **Conclusions:** We found a strong positive relationship in pitchers demonstrating that as upper extremity blood flow while in the provocative shoulder position decreases, so does grip strength. Such was not the case in the evaluation of the position players. These findings suggest that diminished grip strength may be considered a partial predictor of upper extremity neurovascular occlusion amongst pitchers and may be precursor to an increased risk of clinically significant thoracic outlet syndrome or "dead arm syndrome. We suggest that both tests, done in conjunction, may be useful preseason screening tools in the prevention of potential long term health and performance issues.

Comparison of Exercises Activating Latissimus Dorsi Over Axioscapular Muscles

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Context: Previous researchers have examined activation and co-activation ratios of axioscapular or scapulohumeral muscles during exercises, but often exclude the axiohumeral muscles. Further research is needed to determine if axiohumeral muscles are overtly recruited when performing exercises aimed at targeting axioscapular muscles. **Objective:** The purpose of the study is to investigate activity levels of latissimus dorsi (LD) relative to axioscapular (serratus anterior, SA; upper trapezius, UT; lower trapezius, LT) in subjects with shoulder pain compared to subjects without shoulder pain. **Design:** Cross-sectional study. **Setting:** Clinical Laboratory. **Patients or Other Participants:** 17 subjects with no shoulder pain (age = 32 (12, Penn shoulder score = 99(3) and 16 subjects with shoulder pain (age = 34(14, Penn shoulder score = 75(11) clinically evaluated by a Certified Athletic Trainer as having rotator cuff tendinopathy (n = 7), glenohumeral instability (n = 7), or biceps tendonsis (n = 2) were recruited from a sample of convenience. **Interventions:** The independent variables were groups (shoulder pain versus no pain) and the 7 exercises: knee push-up plus, wall push-up plus, incline push-up plus, wall slide, ball roll with depression (BR), inferior glide (IG), and active forward elevation (AFE). Surface EMG signal was obtained from the LD, UT, LT, and SA using previously established electrode placements was the dependent measure. Three maximal voluntary isometric contractions (MVIC) were performed using standard manual muscle test positions. The peak 500 msec of each trial was averaged together to represent 100% MVIC. Subjects then completed the seven exercises in a randomized order. Muscle activity was recorded during each exercise and was normalized to the MVIC value. **Main Outcome Measures:** The LD/UT, LD/LT, LD/SA amplitude ratios were determined for each exercise from the normalized data. Twenty-one separate Mann-Whitney U pairwise comparisons were performed. **Results:** Sixteen comparisons between shoulder pain and no pain revealed no significant differences ($P > 0.052$). The IG ratios were greater in the no pain versus the shoulder pain, respectively: (LD/SA 7 ± 9 vs. 3 ± 1, $P = 0.04$); (LD/UT 44 ± 32 vs. 13 ± 10, $P < 0.001$); (LD/LT 7 ± 6 vs. 3 ± 4, $P = .013$). The BR ratio was greater in the no pain group (22 ± 24) compared to shoulder pain group (5 ± 4, $P = 0.003$).The AFE ratio was greater in the no pain group (0.5 ± 0.3) compared to shoulder pain group (0.2 ± 0.1, $P = 0.04$). **Conclusions:** High activation ratios during IG and BR exercises indicate that LD is highly activated and may be substituting for the targeted axioscapular muscles when prescribing these exercises. These exercises are prescribed at the onset of shoulder rehabilitation to activate axioscapular and scapulohumeral muscles. These findings indicate that axiohumeral muscles may be playing a larger role than expected when performing these exercises. The SA is 5 times more active than the LD during AFE in the shoulder pain group. Therefore, if targeting the SA active elevation exercises should be encouraged if tolerated by patient.

Effects of Sustained Muscle Contraction on Shoulder Muscle Endurance

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Context: The Advanced Throwers Ten Exercise Program incorporates sustained isometric contractions in conjunction with dynamic shoulder movements. It has been suggested that incorporating isometric holds may facilitate greater increases in muscular endurance. However, no empirical evidence exists to support this claim. **Objective:** We hypothesize that utilizing a sustained isometric hold during a shoulder scaption exercise from the Advanced Throwers Ten will produce greater increases in shoulder muscular endurance as compared to a Traditional Training Program. **Design:** Randomized Clinical Trial. **Setting:** Clinical Laboratory. **Patients or Other Participants:** Forty-three healthy participants were enrolled in this study, of which 23 were randomized into the Traditional Training group (age:25 ± 7,height: 173 ± 9cm, weight: 74 ± 14kg, Marx Activity Scale: 11 ± 4) and 20 were randomized to the Advanced Throwers Ten group (age: 26 ± 6, height: 175 ± 10cm, weight: 76 ± 17kg, Marx Activity Scale: 12 ± 5). No pre-intervention differences existed between the groups ($p > 0.05$). **Interventions:** Endurance data were collected using a load cell (BTE Evaluator, Hanover, MD). During pre and post-testing participants were instructed to maximally abduct against isometric resistance at 90° abduction in the scapular plane. This was repeated twice with 4 minutes rest between two trials. Following pre-intervention testing, participants were randomly assigned one of the programs to be completed 4 times a week for 6 weeks at home. All volunteers started at 15% of their baseline maximum force and increased resistance by 25% per week. Traditional Training consisted of 3 sets of 15 repetitions of bilateral scaption performed twice at one setting for a total of 90 repetitions. The Advanced Throwers Ten group performed 3 sets of exercises twice at one setting. The first set included included 10 repetitions of bilateral scaption. The second set included 10 repetitions of scaption while holding the opposite arm at 90° abduction, and repeating with opposite arm. The third set included 20 repetitions of alternating arm lifts while holding the opposite arm at 90° abduction for a total of 100 repetitions. **Main Outcome Measures:** Average angular impulse change score from post to pre-test was used in an Independent T-test. Average angular impulse from the two trials for the dominant arm was the summation of torque x time for the entire 30 seconds to represent endurance. **Results:** There were no difference in the pre to post change scores evaluating endurance between the Traditional (123.87 ± 144.03Nm*sec) and Advanced Throwers Ten (75.77 ± 169.03Nm*sec) groups ($p = 0.32$). **Conclusions:** Incorporating isometric contractions into training does not appear to be more effective at increasing endurance than traditional training regimes; however, these findings do support that either set of exercises can be used to improve shoulder endurance. Both sets of exercises are time efficient in that they only take five minutes to perform. The Advanced Throwers Ten provides variation to a commonly prescribed scaption exercise that may reduce boredom while training.

Sex Differences and Practice Effects in Balance Using the Sway Balance™ Application in Secondary School Athletes

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Context: Mobile applications have improved the ability to assess balance in a cost effective and convenient manner. Serial assessments of balance require an understanding of learning effects, noted with other balance assessments. Gender differences have also been noted in other assessments. **Objective:** To assess for sex differences and learning effects on the Sway Balance. **Design:** Repeated measures. **Setting:** Athletic facilities. **Patients or Other Participants:** Male (n = 336, age = 16.2 ± 1.2 years) and female (n = 78, age = 15.8 ± 1.1 years) adolescent athletes. **Interventions:** The independent variables were trial and condition. All participants completed three trials (T1, T2, T3) of the Sway Balance™. Each trial consisted of five 10-second balance tests with eyes closed: double-leg (DL), tandem right (TR) and tandem left (TL), single-leg right (SLR), and single-leg left (SLL). Each trial was separated by a 2-minute seated rest period. **Main Outcome Measures:** The dependent variable was sway score (0-100), with higher values indicating better balance. A total sway score and separate scores were recorded for each of the five conditions. Data were analyzed using a generalized estimating equations approach, with a gamma, log link and auto-regressive (1) working correlation matrix. Sequential Bonferroni adjustments were used for pairwise comparisons ($P < .05$). Data are presented as means (95% confidence interval). **Results:** For total sway score, the trial by sex interaction was not significant ($p = .057$), nor was the main effect for sex ($p = .101$). The main effect for trial was significant ($p < .001$) with total sway score for T2 [78.9, 95% CI:75.2,82.8)] and T3 [79.0, 95% CI:74.8,83.5)] higher than T1[74.6, 95% CI:771.2,78.3)]. For the DL condition, there was a significant interaction ($p = .007$), but the main effects for sex ($p = .068$) and trial ($p = .525$) were not significant. Post hoc analyses showed a practice effect from T1 [93.0 (95% CI:90.1,96.0)] to T2 [97.6 (95% CI:96.8,98.4)] for males, but no other significant differences. There was no significant interaction ($p = .379$) or main effect for sex ($p = .237$) or trial ($p = .249$) for the TR condition. A significant interaction ($p = .049$) was noted for TL, but the main effects for sex ($p = .060$) and trial $p = .152$) were not significant. No pairwise differences were found. For SLR, there was no significant interaction ($p = .351$) or main effect for sex ($p = .082$), however the main effect for trial was significant ($p = .034$) with T2 [66.6 (95% CI:60.4,73.3)] and T3 [67.1 (95% CI:60.3,74.5) higher than T1 [59.0 (95% CI:52.5,66.3)]. No significant interaction ($p = .098$) or main effect for sex ($p = .186$) were noted for SLL, but there was a significant main effect for trial ($p = .009$) with T2 [66.7 (95% CI:52.2,66.9)] and T3 [68.7 (95% CI:61.1,72.8)] higher than T1 [59.1 (95% CI:52.2,66.9)]. **Conclusions:** Males and females performed similarly on all conditions of the Sway Balance™. A practice effect was noted for the total sway score and the condition scores for both single-leg trials, suggesting the importance of including a practice trial and following the recommendations to complete three full trials during a baseline assessment.

The Efficacy of Four Different Replacement Treatments on Fluid and Electrolyte Balance After Exercise Induced Dehydration

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Context: Fluid and electrolyte balance is necessary for optimal physiological function and athletic performance. Identifying the most effective methods of fluid and electrolyte replacement is important. **Objective:** To compare the efficacy of intravenous fluids (IV), a meal and water (Soup), an electrolyte beverage (Pedialyte®), and Water alone in the rehydration of subjects after exercise-induced dehydration. **Design:** Randomized crossover study. **Setting:** Research laboratory. **Patients or Other Participants:** Active females (6) and males (3) volunteered, age = 21 ± .5y, weight = 67.1 ± 10kg, height = 173 ± 11cm, %body fat = 19.3 ± 8%. **Interventions:** Participants completed 4 bouts of moderate exercise in 35˚C, 60% relative humidity until a deficit of 2.5% bodyweight was reached (107 ± 19min). Rehydration occurred over a 30-min period with 1.5 L 0.45% saline infusion, .5L chicken noodle soup and 1L water, 1.5L Pedialyte®, or 1.5L of Water only. Blood samples were taken pre-dehydration, post-dehydration, and post-rehydration at 0, 15, 30, 45, 60, 120, and 180 min. Ad lib fluids were consumed between minutes 180-195. **Main Outcome Measures:** Serum and urine electrolytes (sodium, potassium, chloride) and osmolality, percent change plasma volume (%ΔPV), thirst rating, urine volume produced and ad lib fluid consumed. **Results:** Serum sodium was lower in IV (132.8 ± 2.8 mmol·L-1) versus Soup (139.1 ± 2.1 mmol·L-1), Pedialyte® (138.6 ± 1.7 mmol·L-1), and Water (137.8 ± 1.6 mmol·L-1) at 0 Post-Rehy ($P = .000$).

At 60Post-Rehy, serum sodium was lower in Water (135.0 ± 0.9 mmol·L-1) versus all other trials (P = .001). Serum potassium in Pedialyte® (5.10 ± 0.51 mmol·L-1) was higher than IV (4.49 ± 0.33 mmol·L-1) at 0 Post-Rehy (P = .049), and higher than all other trials at 30 Post-Rehy (5.09 ± 0.51 mmol·L-1), (P < .001). %ΔPV was higher in IV (18.5 ± 15.9%) versus all trials from Post-Dehy to 0 Post-Rehy (P < .001). From 0 Post-Dehy to 15 Post-Rehy %ΔPV was higher in IV (15.6 ± 13.7%) than Water (-1.2 ± 9.2%), (P = .013). Thirst rating was higher in IV (4.0 ± 1.1) versus Pedialyte® (1.9 ± 1.3) and Water (1.8 ± 2.2) at 0 Post-Rehy (P = .023), and higher than Water (1.8 ± 1.6) at 15 Post-Rehy (P = .025). IV consumed more ad lib fluid (534 ± 197 ml) compared to Water (278 ± 122ml), (P = .026). Water (649 ± 215 ml) produced more urine compared to IV (298 ± 83 ml), Soup (427 ± 149 ml) and Pedialyte® (401 ± 166 ml), (P = .001). Water retained a lower percentage of fluid (57 ± 14%) compared to IV (80 ± 5.5%), Soup (72 ± 10.0%), and Pedialyte® (73 ± 11%), (P = .001). Urine sodium excretion was higher in Soup (1,089.0 ± 560.6mg) versus Water (278 ± 182mg), (P = .001). **Conclusions:** IV fluids did not present a clear benefit over Soup or Pedialyte® at 3hr post-rehydration. Pedialyte® produced significant and clinically elevated serum potassium (>5.0 mmol·L-1) compared to all other treatments at 30 min post rehydration raising concern for athletes at risk for rhabdomyolysis. Lower ad lib fluid consumption, larger urine volume, lower percentage of fluid retained (only 57%), and negative sodium balance suggest that water alone is not optimal for rehydration compared to IV fluids, or oral consumption of fluids or soup that contain moderate to high concentrations of electrolytes.

The Impact of Concussion on Specific Measures of Health-Related Quality of Life in Secondary School Student-Athletes

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Context: Headache and fatigue are two common symptoms experienced by patients following a concussion. These are often evaluated using a graded symptom scale, which measures symptom severity or duration. However, little is known about the impact of headache and fatigue on a concussed patient's health status. **Objective:** To determine whether concussion recovery length influences symptom-specific health-related quality of life (HRQOL) in student-athletes. **Design:** Repeated measures. **Setting:** Athletic training facilities. **Patients or Other Participants:** 122 secondary school student-athletes (102 males, 20 females, age = 15.8 ± 1.1 years, grade = 10.1 ± 1.0) with a concussion. **Interventions:** Participants completed the Pediatric Quality of Life Inventory Multidimensional Fatigue Scale (MFS) and Headache Impact Test (HIT-6) during a preseason baseline and on days 3 (D3), 10 (D10) and 30 (D30) post-concussion. Independent variables were group [based on length of time until return-to-play: Short (0-7 days, n = 46), Moderate (8-13 days, n = 38) and Prolonged (≥14 days, n = 38)] and post-injury assessment day. **Main Outcome Measures:** Dependent variables included MFS subscales [general fatigue (GF), cognitive fatigue (CF), sleep fatigue (SLF)] and HIT-6 total scores. Lower MFS and higher HIT-6 scores indicate decreased HRQOL. Analyses were conducted using generalized estimating equations with a gamma distribution and auto-regressive (1) working correlation matrix. Bonferroni adjustment was used for pairwise comparisons (Alpha = .05, two-tailed). Baseline scores, age and sex were covaried. Descriptive statistics are reported as mean: 95%confidence intervals (CI). **Results:** Significant group by time interactions (P < .01) were noted for all dependent variables. Pairwise comparisons for the GF subscale found Prolonged [D3:59.5 (95%CI: 51.7-68.5)], had significantly lower scores compared to Short [D3:89.5 (95% CI: 85.9-93.2)] and Moderate [D3:79.1 (95% CI: 72.5-86.2)] on D3 and lower scores than Short, but not Moderate, on D10 [Prolonged: 85.2 (95% CI: 79.3-91.5), Short: 96.7 (95% CI: 94.5-99.0), Moderate: 93.9 (95% CI: 90.5-97.5)]. Scores for CF on D3 were significantly lower in Prolonged [D3:63.8 (95% CI: 56.6-71.9)] and Moderate [D3:71.9 (95% CI: 64.7-79.9),] compared to Short [D3:88.8 (95% CI: 84.7-93.1)]. On D10, CF scores remained significantly lower in Prolonged [77.9 (95% CI: 71.6-84.7)] compared to both Short [95.1 (95% CI: 91.8-98.5)] and Moderate [91.4 (95% CI: 87.1-96.0)], with Moderate also being significantly lower than Short. The Prolonged group [D3:58.7 (95% CI: 50.9-67.7), D10:81.3 (95% CI: 76.3-87.7)] also scored significantly lower than both the Short [D3:81.6 (95% CI:76.5-87.0), D10:92.8(95% CI: 89.0-96.7)] and Moderate [D3:73.2 (95% CI: 65.8-81.5), D10:88.4 (95% CI: 83.7-93.4)] on D3 and D10 for SLF, with no differences between Short and Moderate. HIT-6 scores were significantly higher in Prolonged [D3:53.8 (95% CI: 50.7-57.0), D10:51.6 (95% CI: 48.7-54.6)] on both D3 and D10 compared to Short [D3:46.4 (95% CI: 44.2-48.7), D10:42.9 (95% CI: 41.0-44.8)] and on D10 compared to Moderate [D3:50.3 (95% CI: 47.5-53.3), D10:43.8 (95% CI: 41.3-46.4)], with no differences between Short and Moderate. **Conclusions:** Patients with a prolonged recovery noted more HRQOL deficits on the MFS and HIT-6 through the first 10 days post-concussion than those with shorter recovery periods. Notably, CF was affected more in both moderate and prolonged recovery groups,

suggesting a perceived impact of cognitive fatigue that could influence academic performance. Clinicians cannot discount the importance of integrating symptom specific patient-reported measures into their post-concussion assessments to assess the various dimensions of HRQOL impairment following concussion. Funded from a grant from the National Operating Committee on Standards for Athletic Equipment.

Single Nucleotide Polymorphism Within VGLUT1 and Its Association Between Concussion Duration and Severity

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Context: Sport-related concussion is a resultant of a mechanical insult which alters neuronal structure and chemical balance, modifying how the brain transmits neurological responses. Genetic variations [i.e., single nucleotide polymorphism (SNP)] within the promoter region disrupt the amount of protein produced, which could affect an individual's susceptibility to neuronal injury and alter the healing response post head impact. **Objective:** To determine the association of a promoter SNP within VGLUT1 (i.e., rs74174284) to concussion duration and severity. **Design:** A between subjects design. **Setting:** Athletes were diagnosed at Temple University Sport Concussion and Athletic Neurotrauma Center (Philadelphia, PA), and genetic analysis took place at Jayne Haines Center for Pharmacogenomics Drug and Safety Center of Temple University School of Pharmacy (Philadelphia, PA). **Patients or Other Participants:** Forty participants (29 males and 11 females, mean age 19.96 + 6.28 yrs.) who sustained a head impact via a concussion mechanism. **Interventions:** Athletes diagnosed with a concussion were genotyped for the VGLUT1 SNP, and followed prospectively to full return to play. A Hardy-Weinberg Equilibrium to ensure observed genotype frequencies were consistent with the general population genotypes. A 2x2 chi-square assessed the allele frequency of the VGLUT1 SNP and concussion duration. Fisher's exact tests examined genotype frequency and concussion duration. Six independent t-tests and 3 ANOVAs analyzed Vestibular-Ocular Reflex (VOR), BESS, and ImPACT scores and concussion duration. Univariate and multivariate regression analyzed genotype association with concussion duration and severity. **Main Outcome Measure(s):** Dependent variables were concussion duration and severity, which were reported through the concussion center evaluation forms. **Results:** An association was found between the dominant genetic model (CC versus GG + GC; $p = 0.0179$) and recovery, where prolonged recovery was 5.60 times greater for those carrying the dominant allele. An association was also found between age and recovery, where prolonged recovery was 4.70 times greater for adult (19.96 + 6.28 yrs.) athletes. An association was identified for ImPACT test motor speed scores in the dominant (CC = 33.38 + 10.15, GG + GC = 41.59 + 7.39, $p = 0.01$) and codominant (CC = 33.82 + 10.00, GG = 40.25 + 5.18, CG = 42.46 + 8.82, $p = 0.03$) genetic models, where those carrying the CC had worse scores at initial assessment. **Conclusions:** This study was the first to investigate an association between rs7417284 SNP within VGLUT1 and concussion severity and duration. Due to the association found within the common genotype, regulation of glutamate may be at maximum capacity and during a concussive event, the overload of glutamate may overtake the amount of glutamate VGLUT1 vesicles can package. Based upon these findings, rs74174284 maybe a predictive genetic marker for identifying athletes who a more susceptible for altered recovery times and more severe symptoms. Key Words: genetics, SLC17A7, rs74174284, prolonged recovery, head impact.

Current Physical Fitness Level is a Predictor of Health-Related Quality of Life in Former Division I Athletes

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Context: Research has shown that current physical activity is more important than prior athletic participation for disease prevention. However, there is limited information on the transitioning athlete; from regimented college athletics to the general population and how the shift impacts their future health-related quality of life (HRQoL). **Objective:** Determine what measures of physical fitness can predict two components of HRQoL (physical and mental) in former Division I athletes. **Design:** Cohort study **Setting:** Research laboratory **Patients or Other Participants:** A total of 100 individuals between the ages of 40-65 (60 Males, 40 Females, 53.1 ± 7.4 years, 87.41 ± 19.13 kg, 178.54 ± 10.13 cm) volunteered to participate in this study. Participants were recruited from a University Alumni Database. To be included in the study, participants had to be between 40-65 years old and be a former NCAA Division I athlete. **Interventions:** Participants completed a demographic questionnaire (height, weight, age, sex, sport participation, and injury history in college athletics), the SF-36v2, and a physical fitness assessment. The SF36v2 is a patient-reported survey of HRQoL, and has two component summary scores: physical (PCS) and mental (MCS). Each component is transformed to a 0-100 scale; a lower score indicates more disability. The physical fitness assessment included: a one-mile walk (minutes), sit to stand (repetitions), push-up (repetitions), sit and reach test (cm), back scratch test (cm), percent body fat (%BF), and balance (Balance Error Scoring System Total Errors). The order of the physical fitness test was chosen at random for each subject. Two linear regressions were conducted to determine if the PCS and MCS (dependent variables) could be predicted from age, and the eight physical fitness measures (independent variables). **Main Outcome Measures:** PCS and MCS score **Results:** For the PCS linear regression, the model explained 77.6% of the variance using adjusted R^2 ($F(9,90) = 39.16$, $p < 0.001$). After controlling for the other variables in the model, %BF, mile time and balance had significant regression weights. The weights were negative, indicating former athletes with higher (slower) mile times ($b = –3.93$, $\bar{x} = 13.16 \pm 1.52$ minutes), higher %BF ($b = –.35$, $\bar{x} = 23.72 \pm 6.39$), and more errors on the BESS ($b = –0.51$, $\bar{x} = 14.71 \pm 5.56$) are expected to have lower PCS HRQoL ($\bar{x} = 50.10 \pm 9.91$). For the MCS linear regression the model explained 32.1% of the variance using adjusted R^2 ($F(9,90) = 6.21$, $p = 0.01$). After controlling for the other variables in the model, mile time had a significant negative regression weight, indicating that the former athletes with higher (slower) mile times ($b = –1.91$, $\bar{x} = 13.16 \pm 1.52$ minutes) are expected to have lower MCS HRQoL ($\bar{x} = 51.97 \pm 6.89$). **Conclusions:** By maintaining physical fitness it will not only increase an individual's physical HRQoL but could also positively impact their mental HRQoL. It is important to emphasize continued general physical fitness rather than highly competitive athletics after participation in collegiate sports.

Cerebral Control of Jump Landing in Anterior Cruciate Ligament Reconstructed Individuals

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Context: The anterior cruciate ligament (ACL) is vital to mechanical knee stability and maintaining neuromuscular control. ACL injury may cause cortical remodeling due to disrupted mechanoreceptors and/or compensations in neuromuscular control. These alterations are not completely understood and may not be addressed in rehabilitation. Assessing brain function more directly after ACL injury using functional magnetic resonance imaging (fMRI) may help address this knowledge gap, but requires patients to remain still, limiting measurement of complex actions (walking; jumping). To assess brain activation during jump landing we developed a novel, action observation paradigm involving mirror neurons and mental imagery to provide an assay of jump landing neuromotor control. **Objective:** To investigate brain activation differences during an action observation jump landing task in those with ACL reconstruction (ACLR) versus matched healthy controls. **Design:** Descriptive laboratory study. **Setting:** Academic medical neuroimaging center. **Patients or Other Participants:** Participants were matched on height, mass, extremity dominance, and physical activity level. Four left ACLR participants (23.7 ± 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 four 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). **Interventions:** fMRI was collected while participants watched a video of a 1st person perspective of jump landing while lying supine in a Siemens 3T MRI scanner. Data were collected in 30 second epochs with 90 whole brain

gradient-echo scans at a 3 second temporal resolution and voxel dimension of 2.5 mm for 55 transverse slices. **Main Outcome Measures:** Subject specific analysis was completed on the contrast of landing – baseline (1st person video of standing) to get the brain activation pattern of landing for each subject. The two groups were compared with a general linear model second-level fixed-effects paired analysis a priori threshold at $p < .01$ corrected. **Results:** Results are reported as z-score (relative activation to matched control) for the peak voxel in the respective brain regions that demonstrated significantly higher or lower activation in the ACLR cohort. Patients with ACLR exhibited increased activation in the superior parietal region ($z = 9.32 \pm 2.7$ $p < .001$) and dorsal visual processing regions ($z = 13.5 \pm 3.7$ $p < .001$) and diminished activation in fusiform ventral visual processing areas ($z = 12.65 \pm 2.9$, $p < .001$) compared to matched controls. **Conclusions:** ACLR and rehabilitation may alter brain activation to control jump landing. The higher parietal activation indicates greater sensory integration, possibly due to the altered afferent input from the ACLR. The increased dorsal visual processing may indicate greater reliance on vision to guide the motor imagery and internally program motion. The decrease in ventral activation may be associated with greater recognition of object details by the control subjects. Alternatively, the ACLR individuals increase in dorsal visual motor programming may relatively suppress the ventral system, inhibiting visual integration of environmental cues.

Preoperative Neural Excitability is Associated With Postoperative Neural Excitability in Anterior Cruciate Ligament Reconstructed Patients

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Context: Alterations in spinal-reflexive and corticospinal excitability of the quadriceps muscle have been identified following anterior cruciate ligament reconstruction (ACLr). Given that neural excitability can influence quadriceps strength, and that greater preoperative quadriceps strength and activation have been shown to facilitate quadriceps strength and activation gains following surgery, it is important to understand the impact that preoperative neural excitability measures have on postoperative neural excitability. These data will provide valuable information regarding preoperative interventions used to target neural excitability in ACLr populations. **Objective:** Investigate the association between preoperative quadriceps spinal-reflexive and corticospinal excitability on postoperative spinal-reflexive and corticospinal excitability in ACLr patients. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants**: Twenty ACL injured patients scheduled to undergo surgical reconstruction (11 females/9 males; 20.9 ± 4.4yrs; 1.72 ± 0.07m; 75.9 ± 12.2kg) volunteered. **Interventions:** Quadriceps spinal-reflexive and corticospinal excitability were tested pre-surgery (37.1 ± 15.3 days post-injury) and when patients were cleared for full physical activity (28.3 ± 2.9 weeks post-surgery). All measures were collected bilaterally. **Main Outcome Measures:** 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) and motor evoked potentials (MEP) elicited through transcranial magnetic stimulation (TMS). Participants performed knee extensions at 5% of their maximal isometric contraction while TMS was applied over the motor cortex. AMT was defined as the lowest TMS intensity that elicited a measurable MEP (>100μV) in 5/10 consecutive trials. The average amplitude of five MEPs elicited at 120% of AMT was normalized to M-responses for analysis. Higher H:M ratios and MEPs denoted increased spinal-reflexive and corticospinal excitability, respectively, while higher AMTs indicated decreased corticospinal excitability. Pearson product moment correlations were performed to determine the association between preoperative and postoperative neural excitability measures. Alpha level was set at $P \leq 0.05$. **Results:** Significant, positive strong correlations were detected between preoperative and postoperative H:M ratios for both the injured ($r = 0.73$, $P < 0.001$) and uninjured limbs ($r = 0.84$, $P < 0.001$). A significant, positive moderate correlation was also observed between preoperative and postoperative AMT for the injured limb ($r = 0.69$, $P = 0.001$) and a significant, strong correlation for the uninjured limb ($r = 0.84$, $P < 0.001$). Lastly, significant, positive strong correlations were detected between preoperative and postoperative MEP for both the injured ($r = 0.97$, $P < 0.001$) and uninjured limbs ($r = 0.96$, $P < 0.001$). **Conclusions:** ACLr patients with better preoperative quadriceps spinal-reflexive excitability demonstrated greater postoperative spinal-reflexive excitability. Similarly, patients with better preoperative quadriceps corticospinal excitability demonstrated greater postoperative corticospinal excitability. Based on these results, it is possible that postoperative quadriceps excitability can be maximized through preoperative interventions used to target neural excitability.

Time to Plasma Sodium Accumulation of 2 Beverages and 1 Gel Supplement During Exercise

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Context: Sodium depletion decreases performance and may contribute to exercise associated muscle cramps and hyponatremia. Sodium supplementation before and during exercise is often achieved through carbohydrate electrolyte beverages (CEB) or carbohydrate gel supplements (CGS). Current sodium recommendations are to consume modest amounts (0.3 to 0.7g/L) to offset sodium loss and prevent a drop in P[Na+]. However, there is limited research on the effectiveness of electrolyte supplements on maintaining P[Na+]. **Objective:** To compare time to plasma sodium accumulation following consumption of 2 beverages or 1 gel supplement in exercising, sodium depleted individuals. **Design:** Randomized crossover design to determine effects of water (W), CEB, and a CGS on P[Na+] and hydration measures. **Setting:** An environmental chamber in an exercise physiology laboratory. **Patients or Other Participants:** Seven endurance trained individuals (5 male, 2 female; mean age = 22.9 ± 2.9 years, weight = 75.8 ± 17.4kg, height = 177.6 ± 10.1cm, VO2max = 46.5 + 8.2 ml/kg/min). **Interventions:** Participants began a sodium depletion protocol 2 days prior to data collection that included instructions on how to decrease dietary sodium intake and increase water intake. Upon reporting to the laboratory, participants ingested 2ml/kg of body weight of W, CEB, or W and one CGS packet. Participants ingested the same amount of the assigned beverage at 15 min intervals over a 90 min treadmill run at 70% max hear rate. After exercise, participants rested in a seated position for 60 min. **Main Outcome Measures:** P[Na+], plasma osmolality (Posm), and fluid differential (total amount consumed – total urine volume). Repeated measures ANOVAs were used to determine differences over time points for all dependent variables within and between experimental groups. **Results:** Overall mean P[Na+] loss was 2.14% (131.0 + 1.5 mmol/L to 128.2 + 2.2 mmol/L). Compared to pre-exercise (128.2 ± 0.5mmol/L), overall P[Na+] was significantly higher at 45 min (130.6 ± 0.4 mmol/L, P = 0.024) and reached baseline levels at 90 min (130.8 ± 0.3 mmol/L, P = 0.008). While there were no significant differences between beverage groups at any time point, at 15 min CEB resulted in a sharper rise in P[Na+] then plateaued compared to a delayed increase with W and CGS. There was significant increase in P[Na+] from 30 to 90 min in CGS (128.3 ± 0.7 mmol/L to 131.8 ± 0.4 mmol/L, P = 0.032). We found a significant main effect for Posm over time (P = 0.01; overall mean = 304.5mosm/L), but no significant differences at any time point or between groups. Fluid differential was not significantly different between groups (overall mean = 544.2 + 475 ml). **Conclusions:** We found no significant differences between beverages on P[Na+] in sodium depleted individuals completing a 90 min run. Interestingly, W did not decrease P[Na+] as hypothesized and neither CEB or CGS was more effective in increasing P[Na+]. Additional research on different electrolyte supplements and in individuals with lower P[Na+] is warranted.

Lacrosse Helmet Removal Versus Helmet Facemask Removal: A Comparison of Time and Head/Neck Movement

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Context: Cervical spine injuries are potentially life threatening events that may occur in collision sports, including lacrosse. Following a catastrophic injury, standard procedures to access the airway in a timely manner are essential to facilitate patient and spine stabilization. There are no established standards and limited objective data in lacrosse to support the removal of the facemask or helmet. **Objective:** To determine the time and movement of the head/neck during helmet and facemask removal in 3 commercially available lacrosse helmets. **Design:** Crossover study. **Setting:** Motion analysis lab. **Patients or Other Participants:** Twenty-four Certified Athletic Trainers (AT) (10 males, 14 females; age = 35.08 ± 8.41 years; AT experience = 12.21 ± 7.50 years). **Interventions:** Participants were randomly assigned to 1 helmet type (Warrior Regulator, Cascade Pro7, Cascade R) and performed 3 trials of each of the two different removal methods [i.e., helmet removal (HR); facemask removal (FMR)]. During each trial, a single human model wore shoulder pads and one of the properly fitted helmets. During HR, participants placed their hands just outside the earholes of the helmet while a second rescuer assisted with head/neck stabilization. During FMR, participants used an electric screwdriver to remove the screws that held the facemask in place while the second rescuer assisted with head/neck stabilization. Separate 2x3 ANOVAs were used to evaluate main and interaction effects of removal method and helmet type on time and head/neck movement in three planes (i.e., frontal, sagittal, transverse). Post-hoc t-tests or one-way ANOVA were used to determine mean differences between removal method and helmet type on time and head/neck movement. **Main Outcome Measures:** The dependent variables were time (s) and maximal head/neck movement (°) in relationship to the trunk measured in three planes. **Results:** Significant main and interactive effects for helmet type ($P < 0.001$) and removal method ($P < 0.001$) were present for time. On average, FMR (45.86s ± 18.83s) took longer than HR (22.31s ± 5.03s). With regard to helmets, the Regulator (23.41s ± 7.37s) was removed significantly faster ($p = 0.007$) than the Pro7 (43.10s ± 23.66s) but was not significantly faster than the R (34.34s ± 13.50s). Sagittal plane movement was significantly greater ($P < 0.001$) during HR (9.69° ± 3.99°) compared to FMR (4.33° ± 2.30°). Transverse plane movement was significantly affected ($p = 0.004$) by helmet type (Pro7 = 4.23° ± 1.45°, Regulator = 4.63° ± 1.96°, R = 5.93°±0.09°). **Conclusions:** These data demonstrate that lacrosse HR is faster than FMR, but is associated with more sagittal plane movement, which may further compromise the cervical spine following injury. Although slower, FMR may be the more prudent approach to access the airway following catastrophic on-field injuries. Lacrosse helmet design appears to have a marked influence on time and movement during FMR, so industry should consider designs to make FMR more efficient.

Head Acceleration Caused by Chinstrap Removal During Emergency Management of Football Equipment

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Context: When emergency removal of a football helmet in a potentially-spine-injured athlete is necessary, it is recommended that the chinstrap be cut off for removal rather than unsnapped. There is a lack of data to support this recommendation. Further, some speculate that removing the facemask facilitates helmet removal. Because facemask removal might be a first step in emergency procedures, it is important to understand the effect of the chinstrap removal method with the facemask on and off. **Objective:** To determine the amount of head acceleration caused by cutting and unsnapping a chinstrap with and without the facemask in place. **Design:** Repeated measures. **Setting:** Controlled laboratory. **Patients or Other Participants:** A power analysis, using pilot data, indicated a sample size of 15 pairs was required to achieve a power of 0.80. Thirty-four certified athletic trainers volunteered for the study (male = 17, age = 29.35 ± 8.57 years, weight = 85.33 ± 14.88 kg, height = 180.19 ± 5.51 cm, experience = 6.91 ± 8.58 years; female = 17, age = 26.18 ± 3.11 years, weight = 74.63 ± 16.48 kg, height = 163.64 ± 6.83 cm, experience = 2.80 ± 2.42 years). **Interventions:** A healthy male model, wearing a properly-fitted Riddell 360 helmet and Riddell Power CPX shoulder pads, lay supine on the floor. An accelerometer was mounted on the model's goggles to capture head acceleration. The output range of the accelerometers was 6g with an accuracy of 0.5% at 1g. A new pair of scissors was issued to each pair.

Participants worked in pairs to stabilize the head and remove the chinstrap by cutting or unsnapping with and without the facemask in place. Each pair member performed either stabilization or chinstrap removal duties as randomly assigned. Two trials of each condition were performed in random order. **Main Outcome Measures:** The dependent variable, peak acceleration, was measured in three planes (sagittal, frontal and transverse). One-way analyses of variance were conducted to compare peak acceleration during cutting and unsnapping trials. **Results:** In the sagittal plane ($F_{3,48} = 13.344$; $p < 0.001$), unsnapping with the facemask on (4.91 ± 1.41 m/s²) and the facemask off (5.62 ± 1.98 m/s²) produced less acceleration than cutting with the facemask on (9.4 ± 4.2 m/s²) and the facemask off (9.91 ± 3.61 m/s²). In the frontal plane ($F_{3,48} = 5.449$; $p = 0.003$), there was less acceleration during cutting with the facemask off (5.99 ± 1.7 m/s²) than with the facemask on (8.94 ± 3.87 m/s²). In the transverse plane ($F_{3,48} = 6.405$; $p = 0.001$), there was less acceleration during cutting with the facemask off (4.12 ± 1.09m/s²) than cutting with the facemask on (5.92 ± 1.82 m/s²) and unsnapping with the facemask on (5.67 ± 1.14 m/s²). **Conclusions:** Acceleration was not consistently lower in one condition than others. Lower accelerations were associated with unsnapping in some planes; cutting was lower in others. Therefore, it is unclear whether cutting or unsnapping is safer. If the clinician decides to remove the chinstrap by cutting, it appears best to do this after facemask removal. How much acceleration would cause further injury in a spine-injured patient is unknown. We are assuming that less acceleration at the head is safer.

A Comparison of Chinstrap Removal Techniques for an American Football Athlete With a Suspected Cervical Spine Injury

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Context: Current recommendations for emergency management of cervical injuries in American football suggest that helmet removal is sometimes necessary. To remove the helmet, the chinstrap must be removed. The current recommendation is to cut the chinstrap rather than unsnap it, but no data exists to support this. Some experts suggest helmet removal may be facilitated by first removing the facemask. Therefore, chinstrap removal in both scenarios should be investigated. **Objective:** Compare head motion during chinstrap removal by cutting and unsnapping, with and without the facemask in place. **Design:** Repeated measures. **Setting:** Controlled laboratory. **Patients or Other Participants:** Pilot data indicated a sample size of 15 pairs was needed to achieve a power of 0.80. Thirty-four certified athletic trainers volunteered (males = 17; age = 29.35 ± 8.57 yrs, height = 180.19 ± 5.51 cm, weight = 85.33 ± 14.88 kg, experience = 6.91 ± 8.58 years), (females = 17; age = 26.18 ± 3.11 years, height = 163.64 ± 6.83 cm, weight = 74.63 ± 16.48 kg, experience = 2.80 ± 2.42 years). **Interventions:** A properly-fitted Riddell 360 helmet and Power CPX shoulder pads were worn by a healthy, supine, male model. Each participant pair cut off or unsnapped the chinstrap with and without the facemask in place, in random order, for 2 trials each. While one partner performed the removal, the other stabilized the head. A new pair of scissors was used for each group. A 2-dimensional inclinometer mounted onto the model's goggles captured head motion (transverse and sagittal planes). **Main Outcome Measures:** The independent variables were facemask (on and off) and chinstrap removal technique (cut and unsnap). The dependent variables were the integrated head motion in the transverse and sagittal planes. For each dependent variable, a two-way analysis of variance was performed ($p < 0.05$). **Results:** There was an interaction for the transverse plane ($F_{1,16} = 43.059$; $p < 0.001$). Unsnapping the chinstrap with the facemask on (6.83 ± 3.03°) created significantly less integrated motion than cutting with the facemask on (26.49 ± 12.69°) and cutting with the facemask off (15.02 ± 6.56°). Unsnapping with the facemask off (9.4 ± 3.9°) and cutting with the facemask off created less motion than cutting with the facemask on. For the transverse plane, main effects existed for facemask ($F_{1,16} = 9.074$; $p = 0.008$) and chinstrap ($F_{1,16} = 29.522$; $p < 0.001$). The facemask off (12.21 ± 6.03º) was less than the facemask on (16.66 ± 13.49º).Unsnapping (8.12 ± 3.68º) was less than cutting (20.76 ± 11.52º). There was an interaction in the sagittal plane ($F_{1,16} = 11.041$; $p = 0.004$). Unsnapping with the facemask on (6.58 ± 2.66°) and unsnapping with the facemask off (12.34 ± 8.61°) created less motion than cutting with the facemask on (32.27° ± 9.64) and cutting with the facemask off (26.66 ± 12.97°). There was a main effect for chinstrap ($F_{1,16} = 58.204$; $p < 0.001$). There was less motion with unsnapping the chinstrap (9.45 ± 6.92º) compared to cutting the chinstrap (29.46 ± 11.61º). **Conclusions:** Although a motion threshold for injury exacerbation is unknown, these results suggest unsnapping the chinstrap generates less head motion than cutting, and chinstrap removal with facemask off generates less head motion than with facemask on. This first finding is contrary to current recommendations.

The Difference in Head and Helmet Motion During an Emergency Management Maneuver: Does the Helmet Immobilize the Head?

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Context: In a supine football player, the helmet and shoulder pads maintain neutral cervical alignment. Current guidelines for managing a potential spine injury recommend leaving the helmet in place, assuming that stabilizing the helmet will also immobilize the head. Guidelines further recommend facemask removal to allow access to the airway. New research suggests that the chinstrap's chin cup prohibits proper mask seal, interfering with ventilation, suggesting the chinstrap may need to be removed. The current recommendation for chinstrap removal calls for cutting the chinstrap off. There is no evidence regarding whether the head is immobilized during this emergency management approach. **Objective:** To determine the difference between helmet and head motion during chinstrap removal. **Design:** Repeated Measures. **Setting:** Controlled laboratory. **Patients or Other Participants:** Thirty-four certified athletic trainers (males = 17; age = 29.35 ± 8.57 yrs, height = 180.19 ± 5.51 cm, weight = 85.33 ± 14.88 kg, experience = 6.91 ± 8.58 yrs), (females = 17; age = 26.18 ± 3.11 yrs, height = 163.64 ± 6.83 cm, weight = 74.63 ± 16.48 kg, experience = 2.80 ± 2.42 yrs). **Interventions:** A healthy male model was positioned supine wearing a properly-fitted Riddell 360 helmet with the facemask removed and Riddell Power CPX shoulder pads. Two biaxial (transverse (x), sagittal (y)) inclinometers were used. One was secured to the model's goggles. The other was secured to the helmet. Participants worked in pairs; one stabilized the head, while the other cut the chinstrap off. Trials were complete when the cut portion of the chinstrap was placed on the floor. A new pair of 7.5" scissors was issued to each pair. Each participant performed one trial in each role (stabilization and removal) in random order. Helmet and head motion data were integrated over each trial to allow comparison of the motion over the length of the trial. Paired samples t-tests were used to compare helmet and head motion in each plane. **Main Outcome Measures:** The dependent variables were the integrated motion of the helmet and head in the transverse and sagittal planes. The independent variable was the chinstrap removal perturbation. **Results:** The mean time per trial was 39.5 ± 9.7 seconds. In the sagittal plane, the head experienced significantly more motion (26.7 ± 13.0°) than the helmet (12.7 ± 5.3°, $t(16) = 5.5$, $p < 0.001$). In the transverse plane, there was no difference between head (15.02 ± 5.6°) and helmet motion (14.9 ± 6.9°, $t(16) = .234$, $p = 0.818$). The 95% confidence interval (CI) for the difference between head and helmet motion was -1.4–1.7 in the transverse plane and 8.6–19.3 in the sagittal plane. **Conclusions:** Despite a rescuer's manual stabilization of the helmet, the head experienced sagittal movement inside the helmet during the trials. These results call into question the assumption that stabilizing the helmet immobilizes the head. This work should be repeated studying other helmet types, different perturbations and multiple models. If confirmed, guidelines may require updating to allow manual stabilization of the head instead of the helmet.

Minimizing Motion in the Injured Spine During Spine Boarding With 90° Rotation: Comparison of Three Techniques

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Context: Patients with suspected spinal cord injury (SCI) are immobilized on a spine board and are transported to a hospital. While the current recommendation is to use the 6+ person lift to move and position an injured person, many programs and paramedics continue to use the log roll maneuver. During transportation to the hospital, patients may become ill resulting in the need to rotate the patient to clear their airway to prevent aspiration. The processes of spine boarding and rolling a patient, while necessary, may have the potential to cause excess motion if not executed properly, resulting in secondary injury to the spinal cord. **Objective:** The purpose of this investigation was to quantify segmental motion in the lower cervical spine with a global instability during spinal immobilization and rotation to 90° for airway clearance. **Design:** Repeated measures design was utilized. **Setting:** All trials were conducted in a controlled laboratory environment. **Patients or Other Participants:** Five male fresh, whole body cadavers (age 68.4 ± 9.0 years) were used to allow for a worst-case scenario (global instability) injury to be created in the lower cervical spine. Six paramedics, one spine surgeon, and one athletic trainer completed all trials. **Interventions:** An electromagnetic motion tracking system quantified dynamic angulation and translation of the unstable segment throughout the process of immobilizing and rotating the cadavers. Spine motion was compared using three different immobilization devices; 1) log roll and strap to rigid spine board (LRSB), 2) scoop on and strap to orange vacuum mattress (OVM), and 3) scoop on and strap to green vacuum mattress (GVM). **Main Outcome Measures:** Six key variables were captured during

each trial, flexion-extension, lateral bending, axial rotation, anterior-posterior translation, medial-lateral translation, and axial translation. Separate ANOVAs with appropriate post-hoc pairwise comparisons were completed to assess for differences between the three immobilization devices. **Results:** LRSB (6.04° ± 1.25°) produced significantly more axial rotation than GVM (3.52° ± 1.80°, $p = 0.011$). LRSB also produced significantly more axial translation than GVM (9.25 mm ± 3.84 mm, 5.50 mm ± 2.47 mm respectively, $p = 0.027$). OVM produced significantly less anterior/posterior translation than LRSB (2.77 mm ± 1.39 mm, 5.38 mm ± 2.53mm respectively, $p = 0.026$). No significant differences existed between immobilization devices for rotation to 90°. **Conclusions:** When immobilizing a patient with an unstable cervical spine, log rolling onto a spine board resulted in greater motion than the use of a scoop stretcher onto a vacuum mattress. Additionally, the type of immobilization device does not appear to impact the amount of motion generated in the injured c-spine when the device and cadaver are rotated 90°. Therefore, based on this data our research team recommends use of the scoop stretcher over the log roll technique for spine boarding and that appropriate training be completed to ensure the patient is securely restrained when using any immobilization device.

The Test-Retest Reliability of the SCAT3

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Context: The Sport Concussion Assessment Tool (SCAT3) is a commonly used sideline measure of sport concussion (SC). Despite its common use for the identification and management of SC, the SCAT3 possesses limited to no psychometric evidence to support its clinical use. Specifically, no evidence of test-retest reliability exists for the SCAT3. **Objective:** To assess the test-retest reliability of the SCAT3 in healthy college students. **Design:** Repeated measures. **Setting:** Research Laboratory. **Patients or Other Participants:** Participants consisted of 67 healthy college students (males = 32, females = 35) who were 23.1 + 4.16 years of age with 14.5 + 2.00 years of education. Subjects reported no prior history of concussion, vestibular/neurological impairment, or lower extremity injury within six month prior to or throughout study participation. **Interventions:** The current study consisted of three time points (Days 1, 7, and 14). At Day 1, subjects completed a health history questionnaire, the revised Head Injury Scale (HIS-r), and then were administered the SCAT3 using the first word and digit lists of the Standardized Assessment of Concussion (SAC). On Days 7 and 14 participants were administered the HIS-r and SCAT3 using the second and third alternate word and digit lists of the SAC, respectively. **Main Outcome Measures:** Intraclass correlation coefficients (ICC) were calculated using a one way randomized model between time points for the SCAT3's Total Symptom (TSS), SAC, Balance Error Scoring System (BESS), and Tandem Gait (TG) composite scores. Acceptable reliability for clinical utility was defined as ICC values > 0.75. Performance across time for each measure was assessed using a repeated measure analysis of variance (ANOVA). Greenhouse-Geisser corrections were performed to account for violations of sphericity. All analyses were conducted with $\alpha = 0.05$. **Results:** No significant differences across time were observed for any component of the SCAT3 ($p > 0.05$). Test-retest reliability values for the TSS, SAC, BESS, and TG composite scores ranged from strong to weak (0.97 to 0.32) with only the SAC and TG meeting the necessary criteria for clinical utility. The TSS possessed the lowest ICC value (0.32) between Days 1 and 14. The highest ICC value (0.97) was observed for the TG between Days 1 and 7. **Conclusion:** Overall, the SAC and TG components of the SCAT3 possessed acceptable reliability for clinical utility using one week test-retest intervals. The remaining SCAT3 components assessed in the current study were observed to have suboptimal reliability. Clinicians must be aware of the limitations of the SCAT3 when used for SC management. Further research is needed to address the reliability of the SCAT3 using a larger sample size to support our findings.

Does Having a Neuropsychological Baseline Test Influence the Number of Days to Return to Premorbid Neuropsychological Function: A Pilot Study

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Context: Neuropsychological Assessment (NP) has been considered an important component of concussion evaluation. Though not solely used to determine return to play, NP provides clinically valuable information on cognitive function, which has been correlated to concussion symptom resolution. Clinicians observe that baselines may not be necessary when age appropriate norms are available, and regularly interpret the NP test without baselines. Athletic Trainers (AT) question the value of a baseline given the amount of time needed to obtain baseline testing. It has been suggested that the value of baseline testing for evaluating NP should not be overlooked, however, there is insufficient evidence to determine the importance of baseline testing. **Objective:** To investigate the effect of NP baseline testing on the number of days to return to premorbid neuropsychological function (PMNPF). **Design:** Retrospective case review of football concussions reported during 2013 Fall sporting season. **Setting:**. High school **Patients or Other Participants:** De-identified data from concussed high school student athletes participated in football. **Interventions:** The State of Hawai`i has implemented a comprehensive concussion management program (CMP) which monitors and tracks Immediate Post Assessment and Cognitive Test (ImPact) test results of concussed student athletes in 67 high schools. Each school's AT administered post-concussion ImPact tests. All post-test NP results were evaluated by

a single Neuropsychologist who determined the return to PMNPF using baseline or age appropriate norms when baseline was not available. Of the 219 NP post-tests data reported to CMP as return to PMNPF, 26 (age: 15 ± 1.2 y/o) did not have a baseline on record. From the remaining cases, all with baseline NP test, 26 were randomly selected (age: 15 ± 1 y/o) to match the non-baseline group. **Main Outcome Measures:** Total days from concussion onset to return to PMNPF were calculated for baseline (mean = 18.6 days, SD = 15.6) and non-baseline groups (mean = 14.2 days, SD = 14.6). A two-sample t-test was used to compare the group difference. **Results:** There were no significant difference in days to return to PMNPF between baseline and non-baseline groups ($p = 0.26$). **Conclusions:** Our result indicated that the presence of a baseline NP did not significantly influence the number of days to return to PMNPF, suggesting age appropriate norm might be adequate in determining the return to PMNPF. Future investigation should include both genders and different sports with larger sample size.

Repetitive Sub-Concussive Impacts from Soccer Heading Effect Ocular Near Point of Convergence

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Context: Sub-concussion is an under recognized phenomenon resulting from low level head impacts that has the potential to cause neurological dysfunction. Soccer heading provides a safe and unique human model to study controlled head impacts. Measuring ocular near point of convergence (NPC) is an emerging sport concussion ocular motor assessment defined as the closest point in space an individual can see one target with binocular vision. **Objective:** To investigate the effect of sub-concussive impacts from soccer heading on NPC. We hypothesized that sub-concussive impacts from headers would not influence NPC scores. **Design:** Multifactorial repeated measures. Setting: Sport concussion laboratory. **Patients or Other Participants:** Twenty healthy young adult soccer players with at least 5 years of soccer heading experience were randomly assigned to either an experimental group (8 male; 2 female; age = 21 + 1.2 yrs; height = 70.2 + 3.6 in; weight = 164 + 20.9 lbs; soccer experience = 14.9 + 2.2yrs) or control group (7 male; 3 female; age = 19 + 1.1 yrs; height = 69.2 + 2.1 in; weight = 163.4 + 12.4 lbs; soccer experience = 11.4 + 4.2 yrs). They participated after signing an IRB approved consent form. **Interventions:** The independent variables were group (control vs. experimental) and assessment time (pre- vs. 0-2 hr post- vs. 24 hr post-heading). At the beginning of the second test session (0-2 hr post-test) subjects in the experimental group performed 10 standing frontal headers over 10 minutes. Soccer balls were projected from a JUGS machine at a speed of 25 mph. Control subjects did not perform soccer heading. During the NPC assessment participants were seated and a visual target was moved towards the participant's face at 1cm/sec using an accommodative ruler. The participant signaled when they experienced diplopia (double vision) and the distance was recorded in centimeters. Inter-rater reliability was a Pearson $r = .90$. Data were analyzed using a multivariate repeated measures ANOVA and appropriate follow-up tests using IBM SPSS Statistics Version 20 ($p < .05$). **Main Outcome Measure:** The dependent variable was NPC. **Results:** There was a statistically significant interaction effect, $F(2,36) = 5.93$; $p = .006$. Follow-up one-way ANOVAs within each group over time indicated a significant main effect for the experimental group only, $F(2,18) = 10.06$; $p = .001$. Conversely, control group showed no difference in NPC scores over time, pretest (7.7 + 1.9 cm), 0-2 hr (7.6 + 1.8 cm) and 24 h (8.0 + 2.1 cm) post-test scores, $F(2,18) = 0.347$; $p = .711$. Post-hoc paired samples t-tests indicated experimental group pretest NPC scores (8.3 + 2.5 cm) were significantly lower (better) than 0-2 hr (10.6 + 1.5 cm; $p = .017$) and 24 hr (11.3 + 2.4 cm; $p = .008$) post-test scores. **Conclusions:** This is the first study to assess the effect of controlled head impacts on ocular NPC. Our findings suggest that mild frontal head impacts affect ocular motor function for up to 24 hours.

The Relationship Between ImPACT Neurocognitive Testing Scores and Total Brain Volumes in Collegiate Football Athletes

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Context: Immediate Post Concussion Assessment and Cognitive Testing (ImPACT) is utilized in the athletic training setting to assess neurocognitive function in athletes. Little is known however regarding the relationship between total brain volumes as measured by magnetic resonance imaging (MRI) and neurocognitive function in athletes. **Objective:** The aim of this study was to assess the relationship between ImPACT neurocognitive testing scores and total brain volumes in collegiate football athletes. **Design:** Observational study design. **Setting:** Athletic Training room and Neuroimaging Lab. **Patients or Other Participants:** Thirty members of an NCAA Division 1 Football team were recruited to participate. Players were identified first by position (offense or defense) and then as high or low risk for concussion based on criteria established by Broglio and colleagues (2013) who used the frequency and severity of head impacts by position to group players into one of two risk groups: High (linemen, running backs, linebackers and tight ends) or Low (quarterbacks, wide receivers, cornerbacks and safeties). **Interventions:** Pre-season athletes completed a baseline ImPACT neurocognitive test and then underwent 3 Tesla MRI scanning of the brain. The FreeSurfer software package was used to quantify white and gray brain matter volume. Correlational analyses between ImPACT scores and imaging measures were carried out. **Main Outcome Measures:** ImPACT testing scores, total white and gray matter volume. **Results:** The ImPACT testing total symptom score was significantly positively correlated with total brain gray matter volume($r = .348$ $p = .064$). Reaction time was also significantly positively correlated with total brain gray matter volume ($r = .376$ $p = .044$). However, total white brain matter was negatively correlated with both the ImPACT testing total symptom score ($r = -.438$, $p = .018$) and reaction time ($r = -.370$, $p = .048$). Further, the findings appear to be driven by offensive position as the offensive players revealed significant correlations between ImPACT Total Symptom Score and total brain white matter ($r = -.504$, $p = .023$) as well as total brain gray matter ($r = .554$ $p = .011$) whereas the defensive players did not show significant correlations. **Conclusions:** These findings suggest that performance on the ImPACT, particularly the Reaction time subtest, is associated with brain tissue volume in collegiate football players. Previous reports have indicated that in adults, increased gray matter volume is associated with better cognitive function (Haier, et al. 2004; Luders, et al, 2009). However, our data suggests that athletes who had greater gray matter volume and less white matter volume demonstrated slower reaction times on the ImPACT test. Additional studies are needed to determine whether these correlations observed are influenced by specific brain developmental patterns and/or history of injury.

Free Communications, Oral Presentations: Prospective Risk Factors for Lateral Ankle Sprain

Thursday, June 25, 2015, 8:00AM-9:15AM, Room 132; Moderator: Masafumi Terada, PhD, ATC

A Novel Approach for Prediction of Lateral Ankle Sprains in Football Players Using Functional Test Performance

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Context: With the high prevalence of lateral ankle sprains (LAS) among the physically active, especially in football players, risk identification using functional tests is becoming increasingly important in the development of prevention programs. Previously, the Star Excursion Balance Test (SEBT) and the Functional Movement Screen (FMS) have been utilized in prediction of lower extremity injury, but definitive models of prediction specifically for LAS in football players do not exist. **Objective:** Explore novel models of prediction for LAS risk in football players. **Design:** Prospective cohort. **Setting:** Athletic Training facilities. **Patients or Other Participants:** Five hundred thirty-nine football players from high school (n = 330; 15.79 ± 1.15 yrs; 176.76 ± 8.09 cm; 79.43 ± 16.98 kg) and NCAA Division I teams (n = 209; 19.74 ± 1.34 yrs; 186.61 ± 7.04 cm; 103.57 ± 18.82 kg) volunteered. All players were cleared for full participation at the time of the study. This was part of a larger database and only players that sustained a LAS during the season or remained free of any lower extremity injury were included. **Interventions:** The SEBT and FMS were used to screen football players bilaterally prior to the beginning of the competitive season. Athletic Trainers recorded LAS incidence daily. **Main Outcomes:** The anterior (SEBT-A), posteriormedial (SEBT-PM) and posteriorlateral (SEBT-PL) directions of the SEBT were performed 3 times on each limb and the means were normalized to stance leg length (%). Additionally, the mean of the three directions created a composite score (SEBT-Comp). The deep squat, in-line lunge, hurdle step, and straight-leg raise tests of the FMS were performed 3 times each to produce a modified FMS score (#/12). As group data were not normally distributed, separate Mann-Whitney U comparisons between groups were performed for each dependent variable. A Bonferroni correction was applied resulting in a statistical significance level of $P < 0.01$. For dependent measures that associated with significant group differences, receiver operator characteristic curves (ROC) were performed to examine group prediction using the area under the curve (AUC) for each dependent variable. Finally, cut-off scores that produced sensitivity >0.70 were identified, to focus on identification of true positives. **Results:** The LAS group (n = 54) performed worse on the SEBT-A (65.51 ± 7.90%) compared to the Injury-free group (n = 485; 69.67 ± 7.60%; $P < 0.001$). No other significant group-differences existed ($P > 0.05$). The AUC from the ROC analysis for the SEBT-A was 0.646. A normalized SEBT-A score of 69.03% had an associated sensitivity of 0.704, while the associated specificity was 0.522. **Conclusions:** Pre-season performance on the SEBT-A was significantly worse in the LAS group of football players. A SEBT-A score of <69.03% may lead to better identification of true positive cases for LAS. Continued work is needed to perfect a prediction model for LAS from functional tests that can identify true positives and true negatives.

Examining Relative Risk Ratios Between Measures of Dynamic Stability and Ankle Sprain in a Collegiate Athletic Population

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Context: Those with previous ankle sprains (LAS) have impaired dynamic postural stability (DPS). However, it is unknown whether the impaired DPS resulted from damage to the ankle or if the impairment leads to an increased risk of LAS. **Objective:** To examine the relative risk (RR) for an LAS using measures of DPS. **Design:** Longitudinal study. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** 177 collegiate athletes (77 Females, 100 Males; age = 19.1 ± 1.7 years; height = 178.4 ± 11.1 cm; mass = 78.7 ± 17.1 kg) involved in sports that require jumping/cutting motions and free from injury at the time of testing were recruited for the study. **Interventions:** DPS was measured by jumping barefooted over a small hurdle, landing single-legged onto a force plate from the forward, backward, medial, and lateral directions. DPS was quantified by the time (secs) for the sequential averaged (SA) ground reaction force (GRF) to fall under 25% of the overall standard deviation and by a stability index (SI) calculated by the mean squared deviations around a zero point rather than an overall mean (unit-less). These baseline data were saved while participants continued with their sport participation and injuries involving LAS were tracked throughout their collegiate athletic career. **Main Outcome Measures:** Data were analyzed using logistic regression analyses to determine the RR of injury by examining the DPS measures to subsequent LAS using the two calculating methods and four jump-landing directions. **Results:** Of the 354 ankles included in this analysis, 100 sustained a LAS while the

remaining 254 did not. The associations between the anteroposterior GRF (from both SA and SI methods) during the forward jump-landing and LAS were significant where the RR of an LAS was 4.64 (P = 0.027) and 13.51 (P = 0.009), respectively. The means ± SD of the forward jump for the injured vs. non-injured ankles were: SA (2.9 ± 0.10s vs. 2.7 ± 0.09s) and SI (0.40 ± 0.19 vs. 0.37 ± 0.19). An additional association between the mediolateral GRF during the backward jump-landing and LAS was significant where the RR of an LAS was 2.54 (P = 0.047) using the SI method. The mean±SD for the injured vs. non-injured were (0.05 ± 0.03 vs. 0.06 ± 0.04). No significant associations in RR for LAS were found in the medial or lateral jumps for any orthogonal direction of the GRFs. **Conclusions:** Landing from a jump is the most common mechanism for a LAS. These results indicate that individuals who cannot control the momentum of the body when jumping in the forward direction are 4 to 13 times more likely to sprain their ankle. Additionally, those who cannot control the backward jump-landing are twice as likely to experience a LAS. Perhaps this jump-landing protocol can be used as a pre-season screening tool to identify those at risk for an injury to prevent time loss from a LAS.

Examining Relative Risk Ratios Between Measures of Lower Leg Strength and Ankle Sprain in a Collegiate Athletic Population

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Context: Lateral ankle sprains are the most common injuries in sport with eccentric loading of the muscles being linked to injury. Identifying those at risk for an ankle sprain can improve current preventative strengthening protocols. **Objective:** To examine the relative risk for an ankle sprain using measures of lower-leg strength. **Design:** Longitudinal study. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** 161 NCAA Division-I collegiate athletes (66 females, 95 males; age = 18.4 ± 1.6 years; height = 178.6 ± 11.5 cm; mass = 80.7 ± 20.7 kg) involved in sports that require jumping/cutting motions. **Interventions:** Using an isokinetic dynamometer, average torque (AT) and peak torque (PT) were measured eccentrically at 30 degrees/sec in the direction of plantar flexion (PF), dorsiflexion (DF), inversion (INV) and eversion (EV) in a randomized order. These baseline strength measures were then normalized to the participant's lean body mass. Participants continued with their sport participation and injuries involving ankle sprains were tracked throughout their collegiate athletic career. **Main Outcome Measures:** Data were analyzed using logistic regression analyses to determine the relative risk of injury by examining the strength measures to subsequent ankle sprains. **Results:** Of the 322 ankles tested, 65 ankles were sprained. The association between AT PF strength and ankle sprain was significant where the relative risk of an ankle sprain was 10.76 (P = 0.023) with a standard error of ± 0.65. AT PF strength for the injured vs. non-injured group was 2.25 ± 0.71 Nm/kg and 2.39 ± 0.64 Nm/kg, respectively. The association between PT INV strength and ankle sprain was also significant where the relative risk of an ankle sprain was 4.40 (P = 0.032) with a standard error of ± 0.14. PT INV strength for the injured vs. non-injured group was 0.41 ± 0.14 Nm/kg and 0.44 ± 0.12 Nm/kg, respectively. Additional means (±SD) for other the other strength measures (Nm/kg) include the following for the injured vs. non-injured athletes respectively: PT PF (3.39 ± 1.04 vs. 3.68 ± 0.95), PT DF (1.00 ± 0.35 vs. 0.97 ± 0.31), AT DF (0.94 ± 0.15 vs. 0.89 ± 0.15), AT INV (0.29 ± 0.08 vs. 0.29 ± 0.08), PT EV (0.42 ± 0.14 vs. 0.42 ± 0.13) and AT EV (0.32 ± 0.08 vs. 0.32 ± 0.08). No significant associations in relative risk were found in the DF and EV strength measures as compared to ankle sprain events. **Conclusions:** Both PT and AT measurements provide clinicians with good indicators of overall strength, especially in muscles of the lower leg where forces tend to be lower than in other body regions. Those with lower eccentric PF (10.8 times risk) and INV (4.4 times risk) isokinetic strength normalized to lean body mass are at increased risk for an ankle sprain. Since lateral ankle sprains occur frequently when landing from a jump, our outcomes demonstrate that strength losses effecting eccentric loading of the ankle in the plantar flexed and inverted position results in an increased risk of an ankle sprain.

Are Baseline Measures of Balance and Functional Movement Associated With Incidence of Ankle Sprains?

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Context: The star excursion balance test (SEBT), weight-bearing lunge test (WBLT), and balance error scoring system (BESS) may be used to detect limitations in functional movement and balance deficits. The SEBT measures dynamic balance where the BESS measures static balance. The WBLT assesses functional dorsiflexion range of motion. Although it is theorized that poor performance on these tests may identify individuals at greater risk for ankle sprains, there is limited research in this area. **Objective:** To determine if SEBT, WBLT, or BESS performance is associated with incident ankle sprain. **Design:** Prospective cohort. **Setting:** Field setting. **Patients or Other Participants:** Five-hundred and forty-four collegiate athletes (164 females, 380 males,age = 19.74 ± 1.73 yrs, height = 174.04 ± 9.59 cm, mass = 78.30 ± 27.86 kg) volunteered to participate. **Interventions:** Participants completed a baseline injury questionnaire prior to testing. Individuals with a previous ankle injury were excluded from data analysis. The SEBT (three trials), WBLT (three trials), and BESS (one trial) were performed on each limb. For the SEBT, participants were instructed to maintain balance while maximally reaching with the opposite limb into the anterior(A), posteromedial(PM), and posterolateral(PL) directions. Maximum reach distance (cm) was recorded for each direction. For the WBLT, participants performed a lunge allowing the knee to make contact with wall. The foot was progressively moved backwards until maximum dorsiflexion was reached while the knee maintained contact with the wall and the heel remained planted on the floor. The distance from the great toe to the wall was recorded and measured in cm. The BESS test was performed in a single limb stance on a stable surface with eyes closed. Participants were instructed to maintain balance for 20 seconds and errors were recorded. Participants were followed for up to 1.5 years to determine those who sustained an ankle sprain. **Main Outcome Measures:** The SEBT (normalized to limb length) and WBLT trials were averaged for each limb. Separate logistic regression analyses were performed to determine if there was an association between the WBLT, SEBT and BESS and incident ankle sprain ($\alpha \leq 0.05$). **Results:** Two-hundred eighty-nine participants did not have a history of ankle injury and were included in the analysis. Twenty-one of these individuals sustained an ankle sprain during the follow-up period. There were no significant associations between incident ankle sprain and performance on the WBLT (right: 8.73 ± 3.47 cm [uninjured (UN)] vs. 8.89 ± 3.18 cm [injured (INJ)], Odds ratio (OR): 1.01, P = 0.84; left: 8.82 ± 3.56 cm (UN) vs. 9.05 ± 3.13 cm (INJ), OR: 1.02, P = 0.77), each direction of the SEBT (A-right: 57.23 ± 14.30 cm (UN) vs. 57.35 ± 8.71 cm (INJ), OR: 1.00, P = 0.97; A-left: 57.63 ± 14.21 cm (UN) vs. 57.09 ± 8.79 cm (INJ), OR: 1.00, P = 0.86; PM-right: 101.04 ± 24.14 cm (UN) vs. 103.78 ± 9.5 cm (INJ), OR: 1.01, P = 0.61, PM-left: 101.08 ± 24 cm (UN) vs. 104.02 ± 10.69 cm (INJ), OR: 1.01, P = 0.58; PL-right: 96.81 ± 23.6 cm (UN) vs. 99.05 ± 10.48 cm (INJ), OR: 1.01, P = 0.67; PL-left: 95.82 ± 23.53 cm (UN) vs. 99.22 ± 10.05 cm (INJ), OR: 1.01, P = 0.51), and the BESS (BESS-right: 4.12 ± 4.46 (UN) vs. 5.05 ± 5.60 (INJ), OR: 1.04, P = 0.41; BESS-left: 3.92 ± 4.33 (UN) vs. 4.50 ± 4.11 (INJ), OR: 1.03, P = 0.56). **Conclusions:** Performance on the SEBT, WBLT, and BESS were not associated with incident ankle sprain. Additional research needs to be performed to determine if other measures of balance or functional movements are associated with incident ankle sprains.

The Utility of a Modified Balance Error Scoring System for Identifying Athletes at Increased Risk of Ankle Sprain

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Context: The Balance Error Scoring System (BESS) is a widely-accessible clinical alternative to expensive laboratory tests for assessing postural stability. While it has been used to assess post-injury recovery and make return-to-play decisions following concussion, it is not clear if the BESS can be used to identify individuals at increased risk for incident ankle sprain injuries. **Objective:** To determine if a modified version of the BESS (mBESS) is associated with increased risk for ankle sprain injuries. **Design:** Prospective cohort study. **Setting:** US Service Academy. **Patients or Other Participants:** 470 (207 women) military cadets (age = 18.8 ± 0.8 years, height = 68.6 ± 6.2 inches, weight = 157.1 ± 28.9 pounds, BMI = 23.4 ± 2.9) who were deemed healthy and fit for military service were assessed upon entry to the Academy and followed for four years while engaged in a rigorous program of required physical education courses, competitive sports, and military training. **Interventions:** The mBESS was administered to all participants upon entry to the academy. Because the outcome of interest was ankle sprain, subjects performed the single-leg stance on both limbs on both the firm and foam surfaces and the tandem stance on both surfaces, for a total of six conditions. Lower-extremity injury data were collected for all participants over four years using the institution's injury surveillance system. The military's closed healthcare system makes it unlikely that any injuries were not captured. **Main Outcome Measures:** The primary outcome of interest in the current study was incident ankle sprain during the four year follow-up period. Univariate and multivariable logistic regression models were used to analyze the data. Odds ratios (OR), and 95%

confidence intervals (95% CI) were calculated for all models, and receiver operating characteristic curves and area under the curve were calculated for multivariable models. **Results:** The cumulative incidence of ankle sprains over the entire study period was 31.1% (95% CI: 26.9%-35.5%). In univariate analyses single leg stance on the left leg (OR = 1.10, 95% CI: 1.00-1.21) and tandem stance (OR = 1.09, 95% CI: 1.00-1.19) on foam, as well as total item scores for the three foam conditions combined (OR = 1.05, 95% CI: 1.01-1.09) were associated with the likelihood of ankle sprain during the four year follow-up period. In multivariable models controlling for history of ankle sprain, sex, and BMI at baseline, those who scored above the median for the tandem stance foam condition were 56% more likely to sustain an ankle sprain during follow-up. Similarly, those who scored above the median for the three foam items combined were 70% (95% CI: 1.13-2.56) more likely to sustain an ankle sprain during follow-up after controlling for injury history, sex, and BMI. Estimates of area under the curve for these multivariable models were 0.638 and 0.642, respectively. **Conclusions:** The foam condition items for the mBESS at baseline appear to be associated with the likelihood of incident ankle sprain injuries during follow-up.

Free Communications, Oral Presentations: Knowledge and Policy in Emergency Management

Thursday, June 25, 2015, 9:30AM-10:30AM, Room 132; Moderator: Scott Unruh, EdD, ATC

Knowledge of Athletic Trainers and Emergency Personnel Regarding Management of the Spine-Injured Athlete

Neil ER, Eberman LE, Games KE, Kahanov L, Edler JR: Indiana State University, Terre Haute, IN, and Misericordia University, Dallas, PA

Context: Although many spine-boarding techniques exist, current practice appears inconsistent with the literature. Moreover the evidence expands faster than it can be disseminated to necessary personnel. **Objective:** To compare athletic trainers (ATs, certified), emergency personnel (paramedics and emergency medical technicians [EMTs]), dual credentialed personnel, and students (AT, paramedic, and EMT) knowledge regarding management of the spine injured athlete. **Design:** Cross-sectional design. **Setting:** Web-based knowledge assessment. **Patients or Other Participants:** We recruited ATs (n1 = 726), emergency personnel (n2; paramedics = 17, EMTs = 13), dual credentialed (n3; AT/paramedic = 3, AT/EMT = 26) and students (n4; AT = 22, paramedic = 1, EMT = 0) from the NATA, Facebook® and Twitter®. We posted five Facebook® posts and 100 tweets in social media. A majority of respondents (age = 35.5 ± 11.19, men = 388, 49.7% female = 393, 50.3% of 781 reporting, years of experience = 12.4 ± 10.0 y) completed the entire survey (n = 808/1374, 55.8%). **Interventions:** We measured actual knowledge among all participants and compared the separate sub-groups (ATs, paramedics and EMTs, dual credentialed AT/paramedic or EMT, and students). **Main Outcome Measure:** Participants completed 9 actual knowledge questions, organized into retrieval (n = 3), comprehension (n = 3), and utilization (n = 3) items. We analyzed the data using descriptive statistics. We compared the subgroups using a non-parametric one-way analysis of variance (Kruskal-Wallis) and separate non-parametric t-tests (Mann Whitney U). Significance was established α-priori ($p < 0.05$) and partial data were included in the analysis. **Results:** Participants performed poorly on the actual knowledge assessment (5.5 ± 1.2, 60.7 ± 13.5%). We identified statistical differences ($df = 3$, $\chi 2 = 8.150$, $p = 0.043$) between the subgroups on actual knowledge total scores. Dual credential professionals (5.7 ± 0.2) significantly outperformed both emergency personnel (mean = 5.1 ± 0.2; Mann Whitney U = 306.0, n2 = 30, n3 = 29, p = 0.042) and students (mean = 5.1 ± 0.3; Mann Whitney U = 209, n3 = 29, n4 = 23, p = 0.017). ATs (5.5 ± 0.1) also significantly outperformed (Mann Whitney U = 6344.0, n1 = 726, n4 = 23, p = 0.042) students (5.1 ± 0.3). No other pairwise comparisons revealed statistical significance. **Conclusions:** Dual credentialed clinicians (holding credentials in both AT and paramedic or EMT) performed best, but overall participants performed poorly on the actual knowledge assessment. Diverse training and increased exposure to spine boarding likely contributed to higher performance. Dual credentialing may be optimal, but cannot be expected for all clinicians. As such, interprofessional education, or integrated training sessions where clinicians can learn from with and about each other, could prove valuable and may improve cognitive knowledge and behavioral skill. A lack of actual knowledge, particularly regarding life-preserving skills for spine injury management has potentially serious consequences for patients. With a constant influx of new evidence, clinicians have a professional responsibility to inform themselves, share with colleagues, and practice new skills to provide evidence-based care. Future research should identify what mechanisms to disseminate new knowledge are failing to update clinicians.

Emergency Action Plans in High Schools With and Without Athletic Trainers

Johnson ST, Norcross MF, Chang E, Bigam JT, Hoffman MA: Oregon State University, Corvallis, OR

Context: It is the position of the NATA that institutions or organizations that sponsor athletic activities have a written emergency action plan (EAP) specific to the activity venue. Failure to have EAPs may not only result in inefficient care with potential negative consequences for the athlete, but it may also put the institution and its employees at risk for litigation for negligence. However, the extent to which high schools have implemented this recommendation is not known. It is also unknown if the presence of an athletic trainer (AT) at the high school increases the likelihood for the school to have venue specific EAPs. **Objective:** 1) To describe the proportion of Oregon high schools that have implemented venue specific EAPs for all locations where athletic activities occur. 2) To determine whether availability of an AT is associated with an increased probability that high schools have venue specific EAPs. **Design:** Cross-sectional. **Setting:** Online survey. **Patients or Other Participants:** Athletic directors (AD) from all 292 Oregon School Activity Association schools were sent an invitation to complete the survey. The response rate was 36.9% (108/292). **Interventions:** An online survey instrument was developed based on recommendations from the NATA position statement on emergency planning in athletics. ADs were asked to identify whether their school had athletic venue specific EAPs for athletic emergency medical situations; and whether an AT was available at the school to provide care for athletic injuries and illnesses. **Main Outcome Measures:** School implementation of athletic venue specific EAPs for athletic emergency medical situations. A Chi-square test of association was used to

evaluate the influence of an AT on the dependent measure ($\alpha = 0.05$). **Results:** Only 38% (41/108) of high schools reported having venue specific EAPs for all locations where athletic activities occur. AT availability was associated with implementation of venue specific EAPs ($X2 = 7.706$, $P < 0.001$). Specifically, 51.9% (28/54) of schools with an AT versus 24.1% (13/54) of schools without an AT had implemented venue specific EAPs. **Conclusions:** While schools with an AT were twice as likely to implement venue specific EAPs; 48.1% of schools with an AT and 62% of schools overall reported not having venue specific EAPs despite the NATA position that they should. Institutions sponsoring athletic activities - as well as the ATs working for these institutions - have a duty to provide emergency care to athletes. The failure to develop and implement venue-specific EAPs may have a negative effect on the care provided to athletes during emergency situations, and could put the institution and AT at risk for litigation. Future work should determine how to increase the development and implementation of venue specific EAPs, irrespective of whether the institution employs an AT.

Using the 6+ Spine Board Technique Still Recommended: Evaluating EMS Protocols

Horodyski MB, Zdziarski LA, Coyne E, Vincent HK, Hill I, Chen C, Marschall R, Prasarn ML, Rechtine GR: University of Florida, Gainesville, FL

Context: Recent publications have suggested that immobilization may not be warranted in patients who are awake, alert, not intoxicated, without neck pain, do not have an abnormal motor or sensory examination, and do not have an associated mechanism of injury that may suggest a spinal injury is present. Recent recommendations to forgo the use of the spine board have brought to question what technique is appropriate to transport an injured athlete. **Objective:** The purpose of this study was to quantify the amount of segmental motion generated in the unstable cervical spine during six different spine boarding techniques currently utilized by emergency medical personnel. **Design:** Block randomized, repeated measures design was used. **Setting:** All trials were conducted in a controlled laboratory environment. **Patients or Other Participants:** Five male fresh cadavers (age 68.4 ± 9.0 years) were used. A lower cervical spine worst-case scenario injury (3-column instability) was created. Eight paramedics completed all trials. **Interventions:** An electromagnetic motion tracking system (Liberty Polhemus) quantified dynamic angulation and translation motions for each procedure. A rigid cervical collar was applied to the cadaver for every technique. The six immobilization techniques compared included: "Tech 1" (2 person lift to gurney), "Tech 2" (log roll onto spine board, lift to gurney, log roll off to gurney), "Tech 3" (scoop stretcher, lift onto gurney, scoop stretcher off onto gurney), "Tech 4" (6+ person lift onto spine board, lift board to gurney, 6+ person lift off board onto gurney), "Tech 5" (6+ person lift, strap to spine board, lift and secure to gurney), "Tech 6" (6+ person lift to gurney, secure to gurney). **Main Outcome Measures:** Six dependent variables: flexion-extension, lateral bending, axial rotation, anterior-posterior translation, medial-lateral translation, and axial translation. Separate ANOVAs with appropriate post-hoc pairwise comparisons were completed to assess for differences between the six techniques. **Results:** Significant differences were noted for all six dependent variables ($p \leq .01$; except medial-lateral translation, $p \leq .05$). Among numerous significant pairwise comparisons ($p \leq .05$), Tech 1 resulted in greater motion for all dependent variables, specifically significantly greater flexion-extension (mean ± SD; 40.87° ± 2.17°), axial rotation (13.93° ± 1.40°), axial (13.98 mm ± 1.33 mm) and anterior-posterior (24.33 mm ± 1.65 mm) translation motion. Tech 2 had the second greatest amount of motion for all six variables with significantly greater motion noted in five of six motions between the various techniques. Tech 3 and 4 resulted in similar axial and translational motions. Tech 5 resulted in the smallest amount of motion for four of the six motions, significantly less for flexion-extension (5.50° ± 0.65°), axial rotation (3.30° ± 0.06°), lateral bend (4.37° ± 0.39°), and axial translation (6.30 mm ± 0.07 mm). Tech 6 resulted in the smallest amount of motion for medial-lateral (4.0 mm ± 0.53 mm) and anterior-posterior translation (5.4 mm ± 0.33 mm). **Conclusions:** Based on these results our research team recommends the use of Tech 5 to appropriately immobilize a potentially spine injured athlete.

Emergency Care Training Requirements and AED Availability in Oregon High Schools

Chang E, Johnson ST, Bigam JT, Hoffman MA, Norcross MF: Oregon State University, Corvallis, OR

Context: The NATA encourages coaches to receive training in cardiopulmonary resuscitation (CPR), automated external defibrillator (AED) use, and first aid (FA) so they can provide emergency care (EC) for student-athletes until a medical professional arrives. AED availability at athletic venues is also essential as early defibrillation (<4 minutes) following sudden collapse is crucial. However, it is unknown whether these recommendations are being implemented in high schools. Further, while the presence of an athletic trainer (AT) is vital for improving EC, AT availability should not influence the degree to which coaches are prepared for emergency events or AED availability. **Objective:** Describe EC training requirements and AED availability in Oregon high schools and whether these are influenced by the presence of an AT. **Design:** Cross-sectional. **Setting:** Online survey. **Patients or Other Participants:** Athletic directors (ADs) from 108 of 292 OSAA schools (36.9%) responded to an email invitation to participate. **Interventions:** An online survey was developed to assess the implementation of NATA recommendations related to emergency preparedness. ADs were asked about EC training requirements, AED availability, and AT availability at their school. **Main Outcome Measures:** 1) Required coach training in CPR, AED, and/or FA. 2) Availability of an AED in <4 minutes at all, some, or no athletic venues. Summary statistics [Proportion (95% CI)] were calculated and tests of association used to evaluate the influence of an AT on the dependent measures ($\alpha = 0.05$). **Results:** CPR, AED, and FA training was required in 46.3% (36.9, 55.7), 30.6% (21.9, 39.3), and 50.0% (40.6, 59.4) of schools, respectively. Presence of an AT (n = 54) was not associated with required CPR ($X^2 = 1.341$, $P = 0.247$), AED ($X^2 = 0.393$, $P = 0.531$), or FA ($X^2 = 3.704$, $P = 0.054$) training. AEDs were available for use at all athletic venues in 56.5% (47.1, 65.9) of schools and at some venues in 37.0% (27.9, 46.1) of schools. An AED was not available in 6.5% (1.2, 11.8) of schools. Though schools with an AT were more likely to have an AED (Fisher's Exact $P = 0.013$), the presence of an AT did not influence whether an AED was available at all or some athletic venues ($X^2 = 3.201$, $P = 0.074$). **Conclusions:** Despite the NATA's position that coaches be prepared to provide EC until a medical professional arrives, less than half of Oregon high schools require coaches to have CPR, AED, or FA training. Schools without ATs were no more likely to require EC training than schools with ATs, even though coaches at these schools are likely the primary EC provider until EMS arrives. While most schools have an AED available, just 30.6% require AED training for coaches. Therefore, in emergency events at schools without an AT, or if the AT is not present, there may be no one trained to utilize the available life-saving equipment.

Free Communications, Oral Presentations: Movement Assessment and Functional Tests

Thursday, June 25, 2015, 10:45AM-11:30AM, Room 132; Moderator: Sarah de la Motte, PhD, MPH, ATC

Validity of Real-Time Automated Measurement of Movement Errors During a Jump-Landing Task Using the Microsoft Kinect Sensor

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Context: The Landing Error Scoring System (LESS) is a valid field-assessment of lower-extremity biomechanics and has been shown to predict those at risk for musculoskeletal injury. A limitation of the LESS is that a trained rater visually identifies movement errors from video replay, which is a time consuming process that requires offline expert analysis. The Microsoft Kinect sensor is a potentially low-cost and real-time solution for objective and reliable clinical identification of movement errors. **Objective:** To determine the accuracy of an automated software solution using the Kinect in identifying movement errors during the LESS compared to the validated expert rater method. **Design:** Correlational. **Setting:** Field laboratory. **Patients or Other Participants:** A total of 38 healthy, physically active individuals volunteered to participate in this study (males = 34; females = 4; age = 18.6 ± 0.6 yrs, ht = 174.5 ± 6.7 cm, wt = 75.9 ± 9.2 kg). **Interventions:** Participants performed a jump-landing task (3-trials) by jumping from a 30-cm high box, landing a distance equivalent to 50% of the participants' height, followed by an immediate vertical jump. Standard video cameras recorded frontal and sagittal views of the jump-landings. An expert rater scored the videos using the LESS, which is a standardized rating system to evaluate movement patterns using a binary system (0 = no error, 1 = error). A single Kinect sensor simultaneously recorded the participants' movement patterns from the frontal view. Data from the Kinect sensor were analyzed using PhysiHome software to evaluate movement patterns using the same LESS rubric used by the expert rater. **Main Outcome Measures:** Participants were identified as demonstrating either a negative or positive error for each individual LESS item based on their score for at least two of three trials. LESS scores were determined by both the expert rater from video replay and the PhysiHome software analyzing the Kinect data. Separate Kappa coefficients (κ) were calculated for each LESS item to determine the agreement between the expert rater and the Kinect based LESS scores. **Results:** The average total LESS score was 6.08 ± 1.99 for the expert rater and 4.82 ± 2.36 for the PhyisHome software using Kinect. The following LESS items demonstrated significant associations between the expert rater and Kinect: hip flexion at initial contact (IC) ($\kappa = 1.00$, $P < 0.001$), asymmetric foot contact ($\kappa = 1.00$, $P < 0.001$), heel-toe landing ($\kappa = 1.00$, $P < 0.001$), wide stance-width ($\kappa = 1.00$, $P < 0.001$), foot internal rotation ($\kappa = 1.00$, $P < 0.001$), trunk flexion displacement ($\kappa = 0.89$, $P < 0.001$), knee flexion displacement ($\kappa = 0.79$, $P < 0.001$), trunk flexion at initial contact ($\kappa = 0.72$, $P < 0.001$), foot external rotation ($\kappa = 0.58$, $P < 0.001$), knee flexion at IC ($\kappa = 0.36$, $P = 0.02$), knee valgus at IC ($\kappa = 0.37$, $P = 0.02$), and narrow stance width ($\kappa = 0.36$, $P = 0.01$). **Conclusions:** The comparison of LESS items demonstrated an average of almost perfect agreement between the expert rater and the Kinect sensor using PhysiHome software. These findings suggest that automated real-time analytic software using the 3D video sensor has potential for accurate movement assessment.

Landing Kinetics Can Be Predicted With Lower Extremity Functional Tests

Cacolice PA, Carcia CR, Scibek JS: Duquesne University, Pittsburgh, PA

Context: Female collegiate athletes continue to incur injuries to the Anterior Cruciate Ligament (ACL) at reportedly increasing rates. Prediction of ACL injury risk is possible through evaluation of landing kinetics. This process however requires equipment or expertise that prohibits implementation on a large scale. The utilization of field-based tests to predict ground reaction force (GRF) at landing would create a practical and cost-effective risk identification method. **Objective:** To develop predictive models for GRF from the results of several lower extremity (LE) functional tests. We hypothesized linear regression models would explain a substantial amount of the variance associated with landing kinetics. **Design:** Descriptive laboratory study. **Setting:** University 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. **Interventions:** Participants performed five unilateral LE landings with their dominant LE from a 35cm (13.78in) platform onto a force plate (Bertec Corporation; Columbus, OH). LE kinetics during the landing trials were interfaced with motion analysis software (Innovative Sports Training; Chicago, IL). Using a randomized order, participants then performed three trials of three standardized field-based tests of LE function: single-limb triple hop (SLTH), countermovement vertical jump (CMVJ) and the Margaria-Kalamen (MK) test. The kinetic trials were signal averaged. Descriptive statistics were tabulated and two separate linear regression models were

created (SPSS, v22, IBM, Armonk, NY) to predict body mass normalized vertical GRF (nGRFz) and body mass normalized posterior GRF (nGRFy) from the LE functional test results. **Main Outcome Measures:** The multiple linear regression analysis produced two separate models to predict the dependent variables of nGRFz and nGRFy. Additionally, the coefficient of determination (r2) 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 nGRFz was 2.735 ± 0.404 (range 1.499 to 3.504) while mean nGRFy was 1.337 ± 0.200 (range 0.833 to 1.690). Mean values for the three functional tests were SLTH 536.98 ± 48.41cm, CMVJ 42.79 ± 5.08cm, and MK 1035.92 ± 193.26 Watts. The linear regression model to predict nGRFz was significant ($r^2 = .651$, $P < .001$) as was the model to predict nGRFy ($r^2 = .407$, $P < .001$). **Conclusions:** The results from our investigation show a significant amount of variance for nGRFz and nGRFy may be explained with the three functional tests using linear regression models. A large effect size is noted for each regression model. Additional study is necessary to establish validity and reliability of these models before they may be recommended for clinical use. If established, a cost-effective and practical method would exist to identify those with landing kinetics at risk for ACL injuries.

Relationship Between Weight-Bearing Ankle Dorsiflexion and Deep Squat Performance

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Context: The overhead deep squat is a component of the Functional Movement Screen (FMS) that is used to predict injury risk. Deep squat performance may be affected by mobility and stability, with one key mobility component being weight-bearing ankle dorsiflexion (DF) range of motion. It is unknown to what extent ankle DF range of motion impacts deep squat score. Understanding differences in ankle DF between deep squat risk categories may help clinicians determine intervention strategies to reduce functional movement deficits. **Objective:** To determine if there is a difference in weight-bearing ankle dorsiflexion range of motion between individuals who score above and below a 2 on the deep squat test. We hypothesize that individuals who score below a 2 on the deep squat will have less weight-bearing ankle dorsiflexion range of motion. **Design:** Cross-sectional study. **Setting:** Biomechanics research laboratory and collegiate athletic training facility. **Patients or Other Participants:** 173 NCAA Division I athletes (19.68 ± 1.24 years, 1.80 ± 0.11 m, 86.05 ± 21.76 kg) were recruited to participate in this study. **Intervention:** All participants performed the FMS deep squat test and bilateral ankle DF measurements in a weight-bearing position. **Main Outcome Measures:** Participants were divided into high-risk and low-risk groups based on deep squat scores; scoring a 0 or 1 on the deep squat was considered high-risk. Ankle DF range of motion was measured in centimeters using a weight-bearing lunge test. Independent samples t-tests were performed to determine if there were statistically significant differences in ankle DF range of motion between high-risk and low-risk deep squat groups. Alpha level was set a priori at $p < 0.05$. **Results:** Left and right mean ankle DF measurements were significantly different between high-risk and low-risk deep squat groups (Left: high-risk = 9.37 ± 3.55 cm, low-risk = 11.10 ± 2.86cm, $p < 0.001$; Right: high-risk = 9.33 ± 3.53cm, low-risk = 11.34 ± 2.93cm; $p < 0.001$). There was a mean DF difference of -1.73 cm (95% CI: -2.58,-0.88) between risk groups on the left ankle and a difference of -2.01 cm (95% CI: -2.88,-1.15) between groups on the right ankle. **Conclusions:** The results of this study indicate that performance on the FMS deep squat test may be affected by weight-bearing dorsiflexion range of motion. Specifically, individuals who score a 0 or 1 on the deep squat may have diminished weight-bearing ankle dorsiflexion range of motion. Clinicians should consider assessing ankle DF range of motion in individuals who are categorized as high-risk following deep squat testing.

Lower Extremity Muscle Activation Patterns During Walking Gait Between Individuals With and Without a Previous Hamstring Injury

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Context: Hamstring injuries are a primary concern for sports medicine professionals due to their high injury and re-injury rates in sport. Examining long-term alterations in lower extremity muscle activation patterns during activities such as walking gait has not been explored following hamstring strain and may provide insight into re-injury mechanisms. **Objective:** The purpose of this study was to investigate lower extremity muscle activation patterns during walking gait between individuals with and without a previous hamstring injury. **Design:** Case-Control. **Setting:** Laboratory. **Patients or Other Participants:** Eight recreationally active individuals with a history of hamstring strain (5 males, 3 females; age = 21.5 ± 1.19 years; height = 177.56 ± 6.11 cm; mass = 81.27 ± 8.98 kg; Hamstring Outcome Score = 88.59 ± 7.79%) were matched to 8 individuals with no history of hamstring strain (5 males, 3 females; age = 21.5 ± 0.92 years; height = 178.31 ± 8.24 cm; mass = 79.9 ± 11.6 kg; Hamstring Outcome Score = 95.94 ± 3.12%). All participants were physical activity ≥30 minutes, 3 times per week and had no lower extremity injury within 4 months. Participants in the hamstring group (HG) suffered a strain within 5 years that removed them from physical activity for ≥1 day, but were excluded if they reported lower extremity surgery or history of neurological complications. The involved limb was defined as the limb with a previous hamstring strain and the matched limb of the healthy participant. **Interventions:** Wireless EMG surface electrodes were placed bilaterally on the Gluteus Maximus, Gluteus Medius, Rectus Femoris, Vastus Medialis (VMO), Biceps Femoris, Medial Hamstrings (MH), and Lateral Gastrocnemius. Maximum Voluntary Isometric Contraction was performed in plantarflexion, knee flexion and extension, and hip extension and abduction. Participants performed three walking trials at a self-preferred pace landing with the involved foot on the center of a force plate. The gait cycle included the preparatory swing phase (0.2s prior to initial contact) and the absorption and propulsion phases, as determined by the anterior-posterior ground reaction force curve of each trial. **Main Outcome Measures:** Maximum normalized EMG(%EMGmax) and time of maximum (%Cycle out of 100%), were determined for all muscles. Between-group comparisons in %EMGmax and %Cycle for each muscle were examined with independent t-tests and effect sizes. The alpha level was set at $p < 0.05$. **Results:** There were no statistically significant differences between groups ($p > 0.05$). Although statistical significance was not reached, the largest differences in %EMGmax were in the VMO and MH (VMO: HG = 20.06 ± 11.96%, Healthy = 42.72 ± 35.00%, ES = 0.97; MH: HG = 23.53 ± 16.58%, Healthy = 40.58 ± 43.22%, ES = 0.57). **Conclusions:** The lack of significant differences in muscle activation patterns between individuals with and without a history of hamstring strain may indicate there are no long-term effects of the strain on the amount of muscle activation or time of peak activation during walking gait. However, the moderate to large effect sizes associated with the VMO and MH may indicate a clinically relevant reduction in muscle activation in those with a history of hamstring injury and should be further investigated.

Bilateral Differences in Muscle Activation Patterns During Walking Gait of Individuals With a Previous Hamstring Injury

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Context: After a hamstring injury, changes may occur to the physiological properties of the involved muscle, causing long-term alterations. To date, little research has investigated changes and adaptations in muscle activation patterns during walking gait as a result of a history of hamstring injury. **Objective:** To determine the bilateral differences in lower extremity muscle activation patterns during walking gait in individuals with a history of unilateral hamstring injury. **Design:** Cross-sectional **Setting:** Laboratory. **Patients or Other Participants:** Six physically active individuals (4 male, 2 female; age = 22 ± 1.4 years; height = 179.42 ± 5.43 cm; mass = 83.44 ± 19.83 kg; Hamstring Outcome Score: Involved = 89.37 ± 5.40%, Uninvolved = 98.33 ± 1.71%) with history of unilateral hamstring strain within five years participated. Participants were excluded if they suffered a grade 3 strain, any lower extremity joint surgery, a current hamstring strain or history of neurological complications. The limbs were labeled as involved, defined as the previously injured limb, and uninvolved, which had no history of hamstring injury. **Interventions:** Wireless EMG surface electrodes were placed bilaterally on Gluteus Medius (GMed), Rectus Femoris (RF), Vastus Medialis (VMO), Biceps Femoris (BF), Medial Hamstrings (MH), and lateral head of the Gastrocnemius (GAL). After a 5-minute warm-up, Maximum Voluntary Isometric Contraction testing was performed bilaterally using a portable fixed dynamometer in plantarflexion, knee flexion and extension, and hip extension and abduction. Each participant then performed three walking trials

for each limb at a self-preferred pace landing with the test foot in the center of a force plate. The gait cycle began 0.2s prior to initial contact with the force plate and ended at toe-off. Using the anterior-posterior ground reaction curve of each trial, the preparatory swing phase, absorption phase and propulsion phase were identified for each trial. **Main Outcome Measures:** Maximum normalized EMG (%EMGmax) and time of %EMGmax during the cycle (%Cycle out of 100%) were used to analyze bilateral muscle activation patterns of each muscle. Paired t-tests with an alpha level set at $p < 0.05$ and effect sizes (ES) were used to examine differences between limbs. **Results:** No statistically significant bilateral differences were found in %EMGmax or %Cycle ($p < 0.05$). Although statistical significance was not achieved, the %EMGmax of the BF and MH demonstrated the largest asymmetry between limbs (BF: Involved = 43.4 ± 18.8%, Uninvolved = 28.30 ± 4.2%, ES = 1.31; MH: Involved = 24.8 ± 17.8%, Uninvolved = 15.1 ± 6.0%, ES = 0.81). All other differences ranged from 0% (GAL) to 4.2% (GMed) with weak-to-moderate effect sizes (GAL = 0.0; GMed = 0.28; VMO = 0.34; RF = 0.56). **Conclusions:** The results suggest that physically active individuals, who have returned to full activity following unilateral hamstring strain, do not demonstrate statistically significant bilateral asymmetries in muscle activation patterns during gait. However, the large ES signify that the BF and MH may exhibit higher muscle activity in the involved limb during gait which may be clinically relevant. The higher muscle activation in the BF and MH may indicate a need for greater muscle recruitment after previous injury and should be further investigated.

The Effect of Ankle Orthoses and Taping on Lower Extremity Kinematics and Energy Expenditure During a 30-minute Continuous Run

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Context: External ankle orthoses and ankle taping are effective in restricting excessive ankle motion and preventing ankle injuries. Duration and extent of ROM restriction provided by ankle supports remain inconclusive, possibly due to differences in the activity and methodology. Restriction of an individual's natural ROM could potentially change gait kinematics and energy expenditure (EE). **Objective:** The purpose of the current study was to determine the effect of different types of ankle support on lower extremity (LE) kinematics and EE during continuous running activity. **Design:** Randomized repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** Thirteen (5 males, 8 females) physically active adults (Age:25.07±4.12, Body mass:70.81±9.59 kg, Height:1.72±0.08 m) that were free of LE injuries volunteered. **Interventions:** Participants completed four 30-minute treadmill run sessions at a standardized, self-selected pace in four different conditions; semi-ridged hinged (AA), lace-up (ASO), taping, and control. Three-dimensional kinematics (240Hz) and metabolic data were collected every 5-minutes. **Main Outcome Measures:** Repeated measures analysis of variance were used to examine the effect of ankle supports on LE kinematics and EE at each time period compared to controls. **Results:** There was a significant decrease in ankle inversion-eversion excursion in AA (at 30-minute: 19.35° ± 5.38°, $p = .006$) and tape (at 30-minute: 17.92° ± 6.35°, $p = .001$) at all time periods, and ASO became no longer significant at 25-minutes (at 25-minute: 18.12° ± 6.06°) compared to control (at 30-minute: 26.92° ± 8.91°). Inversion at maximal (at 30-minute, AA: 10.11° ± 5.36°; control: 15.85° ± 6.36°, $p = .008$,) and initial contact (at 30-minute, AA: 5.92° ± 7.17°; control: 10.37° ± 7.37°, $p = .01$) were significantly decreased in AA at all time periods. Maximal plantarflexion was significantly decreased in ASO (at 30-minute: 5.89° ± 3.19°, $p = .001$) and tape (at 30-minute: 6.02° ± 5.63°, $p = .001$) at all time periods compared to control (at 30-minute: 12.92° ± 8.67°). Ankle internal-external rotation excursion was significantly decreased in ASO and tape at all time period (at 30-minute, ASO: 17.36° ± 4.79°, $p = .028$; tape: 15.53° ± 3.14°, $p = .018$) compared to control (at 30-minute: 23.08° ± 8.83°). Maximal knee internal rotation was significantly decreased in tape and became no longer significant at 25-minutes (at 25-minute, tape: 13.03° ± 4.82°; control: 17.42° ± 6.25°). Hip adduction at initial contact was significantly increased in AA (at 30-minute: 6.59° ± 2.24°, $p = .007$) and ASO (at 30-minute: 5.94° ± 3.57°, $p = .023$) at all time periods and tape became no longer significant at 25-minutes (at 25-minute: 6.46° ± 2.99°) compared to control (at 30-minute: 4.56° ± 3.84°). AA significantly increased EE in four of six time periods (at 30-minute, AA: 10.28 ± 1.63kcal/min; control: 9.92 ± 1.68kcal/min, $p = .023$), while tape significantly increased EE initially (at 10-minute, tape: 10.26 ± 1.82kcal/min; control: 9.77 ± 1.65kcal/min, $p = .025$). **Conclusions:** All ankle supports were effective in limiting inversion during continuous running. The ASO and tape effectively restricted sagittal and transverse planes of motion, while AA allowed normal kinematics in these planes. Degradation of tape and ASO occurred after 25-minutes of running. We recommend ankle tape for multi-directional instability, AA for maximal inversion restriction, and a combination of AA and tape for maximal support; however, AA may increase metabolic cost.

Effect of Transcutaneous Electrical Nerve Stimulation on Gait Kinematics in Subjects With Anterior Knee Pain

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Context: Knee pain is 1 of 5 leading causes of disability among adults. Knee pain alters lower-extremity muscle function and gait mechanics. While transcutaneous electrical nerve stimulation (TENS) mitigates deficits of muscle activation due to pain, it is unclear whether TENS improves walking mechanics. **Objective:** To examine the effect of TENS on gait kinematics in subjects with anterior knee pain. **Design:** Crossover. **Setting:** Controlled laboratory. **Patients or other Participants**: Thirty university students participated: fifteen subjects (24 ± 3 yrs, 71 ± 12 kg, 178 ± 7 cm) were assigned to the TENS group, after which subjects were matched by gender, age, mass, height for the placebo TENS group (23 ± 2 yrs, 72 ± 14 kg, 177 ± 9 cm). **Interventions:** All subjects underwent 3 different experimental conditions (hypertonic, isotonic, control) in a counterbalanced order, separated by 48 hours. Hypertonic (5% NaCl) or isotonic (0.9% NaCl) saline was infused into the right infrapatellar fat pad for 50 min for the pain or sham condition. No infusion was administered to the control condition. Subjects and investigators were blinded regarding the saline solution which was being infused. A 20-min TENS or placebo TENS treatment was administered. The treatment was blinded to subjects. Gait kinematic data were collected using the high-speed video (240 Hz) and force-sending tandem treadmill (1200 Hz) at a self-selected walking speed for 30 sec at four times (baseline, infusion, treatment, post-treatment). Functional linear models ($\alpha = 0.05$) were used to evaluate difference between treatment groups (TENS, placebo) over time for lower-extremity joint kinematics. This analysis compared variables as polynomial functions rather than discrete values. Functions (mean curve) were compared between groups and conditions over times during stance (0% = heelstrike, 100% = toe-off). Pairwise comparison functions with 95% confidence interval (CI) bands were plotted to determine specific difference. If the function difference with 95% CI bands did not cross zero, then significant difference existed. **Main Outcome Measures:** Ankle angle (sagittal, frontal), knee angle (sagittal, frontal), and hip angle (sagittal, frontal). **Results:** The functional analyses revealed no group x time interaction for ankle, knee, and hip kinematic functions. Hypertonic saline infusion (pain) gave rise to an increase in: (1) ankle dorsiflexion at 38-75% of stance, (2) knee valgus at 20-40% of stance, (3) knee flexion at 40-90% of stance, (4) hip adduction at 72-100% of stance, and (5) hip flexion at 50-90% of stance. **Conclusions:** Our findings suggest knee pain acutely changed lower-extremity gait mechanics. Altered gait strategies may play a role in long-term compensation that could have consequences for the joint. TENS treatment, however, did not acutely reduce the deficits in aforementioned kinematic variables. Future research is needed to examine other therapeutic interventions that may reduce the deficits in altered gait mechanics due to pain.

Biomechanical Lower Extremity Asymmetry During Running Gait

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Context: Assumptions of symmetry between lower extremities are often made during the collection of gait measures in healthy populations, resulting in unilateral examination during gait analysis. However, preferences toward a single limb for stabilization or propulsion, resulting in bilateral biomechanical differences, have been noted previously in healthy individuals. Significant differences between limbs of individuals with previous lower extremity overuse injures (LEOI) have also been found. The extent to which asymmetry occurs naturally in human gait during physically demanding tasks is not well understood. **Objective:** To evaluate lower extremity asymmetry during running gait in both rested (RS) and fatigued states (FS). **Design:** Pretest-Posttest. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one cadets (7 females, Age: 21.09 ± 2.76 yrs, Height: 1.75 ± 0.1 m, Mass: 71.57 ± 13.46 kg, Body fat: 14.13 ± 8.86%), from the University's Army ROTC unit undergoing standardized physical fitness training volunteered to participate. Cadets who were medically limited from physical fitness training were excluded. **Interventions:** Three-dimensional lower-extremity kinematics (240Hz) and kinetics (960Hz) were collected for three trials, bilaterally while running at 4.0 m/s±10% in both RS and FS. Rested state gait trials were collected, followed immediately by an exhaustive treadmill protocol (graded exercise test, three-minute walking recovery, and run to voluntary exhaustion performed in succession) to elicit fatigue. Fatigued state gait trials were initiated within 6:09±1:41 minutes following the treadmill protocol. **Main Outcome Measures:** Variables previously associated with LEOI and stiffness were of primary interest. Separate paired t-tests comparing limbs at RS and FS were used to assess asymmetry. Symmetry angles (SA) were calculated as SA =

((45°- arctan (Xleft/Xright))/90°)•100% with a value of zero indicating perfect symmetry. A paired t-test was used to compare SA between RS and FS for all gait variables. **Results:** The left limb had significantly ($p < 0.05$) increased peak knee varus (L-RS:11.31 ± 6.36°, R-RS: 4.83 ± 3.51°, L-FS: 9.79 ± 5.37°, R-FS: 5.82 ± 4.11°), knee varus velocity (L-RS: 175.71 ± 78.54°•s^{-1}, R-RS: 108.60 ± 43.76°•s^{-1}, L-FS: 182.42 ± 77.39°•s^{-1}, R-FS: 128.74 ± 65.49°•s^{-1}), and peak knee internal rotation (L-RS: 31.15 ± 8.83°, R-RS: 19.33 ± 5.45°, L-FS: 33.84 ± 11.32°, R-FS: 20.18 ± 6.68°) at both RS and FS. Vertical stiffness (L: 58.51 ± 9.18 kN•m^{-1}, R: 53.88 ± 7.51 kN•m^{-1}) and maximal ground reaction force (L: 24.30 ± 1.36 N•kg-1, R: 23.80 ± 1.40 N•kg-1) were increased ($p < 0.05$) on the left limb at RS only. Free moment was significantly increased on the right limb ($p = 0.02$) at FS, and approached significance ($p = 0.06$) at RS. Symmetry angles were significantly increased ($p = 0.03$) at RS for vertical stiffness (RS: 4.55 ± 3.24%, FS: 2.96 ± 2.04%), free moment (RS: 10.26 ± 7.08%, FS: 7.07 ± 5.81%), and knee varus velocity (RS: 17.78 ± 9.90%, FS: 14.01 ± 37.50%). **Conclusions:** Based on the differences between limbs in the present study, symmetry should not be assumed and conclusions drawn from unilateral analysis should be viewed with caution. The magnitude of asymmetry between limbs when rested and fatigued remained similar in healthy subjects, suggesting that differences between limbs are naturally occurring apart from compensations associated with injury. Future research should evaluate if asymmetries predispose individuals to unilateral LEOI.

Implementation of an Electronic Injury Documentation System for Concussion Management

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Context: The National Athletic Trainers' Association released an update for Position Statement: Management of Sports Concussion (March 2014). This guideline emphasized the importance of documenting incident, symptoms and action taken associated with concussion. **Objective:** To enable Athletic Trainers operating at secondary schools to document details of concussive injuries for physician review using an electronic documentation format under the guidance of the Cleveland Clinic Concussion Center. **Setting:** ATs were provided an Apple iPad with custom-built Cleveland Clinic Concussion (C3) Application, which included an electronic Incident Report for use at their contracted school. The incident report collected 5 domains of information in electronic form: athlete demographics, red flags, injury demographics, major symptoms and actions taken. In addition to field use, ATs and medical staff in the Concussion Center utilized the incident report for athletes' initial visits in clinic. **Patients and Other Participants:** Population of athletes ranged from Kindergarten to Graduate School presenting in the field or clinically with an average age of 16.1 years. **Data Collection and Analysis:** From 8-1-14 to 11-14-14, 461 incidents were filed across 42 ATs; 246 (53%) filed clinically, 215 (47%) filed in the field. Time to complete all mandatory fields of the incident report was approximately five minutes. 338 (73%) incidents involved maleathletes. 259 (56%) football and 107 (23%) soccer incidents were reported. 247 incidents (54%) occurred during competition while 170 incidents (37%) occurred in practice and 44 (9%) occurred under other circumstances. Approximately 30% of the athletes reported having a previous concussion and nearly 4% of athletes experienced a loss of consciousness. **Results:** The C3 application incident report provided ATs and physicians at Cleveland Clinic the ability to rapidly collect and electronically store the most relevant information of mechanism, symptomology and actions taken for concussive injuries. Based on incident reports filed in the clinic, those populations (K-8th grade) in which an AT was not present were returned to play more frequently than athletes in which an AT was present. **Conclusions:** To date a unified electronic incident reporting structure for concussion has not been successfully deployed across anenterprise meeting the criteria outlined in the NATA position statement. The information gathered on actions taken can implicate areas to target for future education on concussion recognition and management with area teams and potentially makes an argument for an increased AT presence at exposures for younger athletic populations. A limiting factor however is direct exposure rates for these populations were not recorded. Future directions for incident reporting would be integration with an exposure and/or impact monitoring system.

Length of Recovery Following Sport-Related Concussion and the Impact on Generic Health-Related Quality of Life in Adolescent Athletes

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Context: Sport-related concussion can result in increased self-reported symptoms, impaired cognition and mood disturbances. These symptoms can potentially impact health-related quality of life (HRQOL). Identifying health domains affected by concussion may aid clinicians in recognizing athletes at risk for depressed HRQOL. **Objective:** To determine the relationship between concussion recovery length and generic HRQOL in adolescent athletes. **Design:** Repeated measures. **Setting:** Athletic facilities. **Patients or Other Participants:** 122 concussed adolescent athletes (102 males, 20 females, 15.8 ± 1.1 years, grade = 10.1 ± 1.0). **Interventions:** Participants completed the Pediatric Quality of Life Inventory (PedsQL) during a preseason baseline and on days 3 (D3), 10 (D10) and 30 (D30) post-concussion. Independent variables were group, based on return-to-play time [Short (0-7 days, n = 46), Moderate (8-13 days, n = 38) and Prolonged (>14 days, n = 38) Recovery] and day post-concussion. **Main Outcome Measures:** Dependent variables included PedsQL total (TS) and subscale scores [physical (PF), emotional (EF), social (SOF), psychosocial (PSF), and school (SCF) functioning], scored 0-100, with lower scores indicating lower HRQOL. Analyses were conducted using generalized estimating equations with a gamma distribution and auto-regressive (1) working correlation matrix. Bonferroni adjustment was used for pairwise comparisons (alpha = .05, two-tailed). Baseline scores, age and sex were covaried. Descriptive statistics are reported as mean: 95%confidence intervals (CI). **Results:** Significant

interactions ($p < .001$) were noted for TS, PF, EF, PSF, SCF, but not SOF ($p = .761$). Pairwise comparisons revealed significantly ($P < .05$) lower scores in Prolonged Recovery compared to Short Recovery for all significant subscales on D3, with no significant pairwise differences reported for D30. On D3 and D10, Prolonged Recovery scored significantly lower on TS [D3:78.2 (95% CI: 74.4-82.3), D10:87.8 (95% CI: 84.6-91.2)] than Short [D3:94.5 (95% CI: 92.6-96.4), D10: 98.7 (95% CI: 97.8-99.5)] and Moderate [D3:88.3 (95% CI: 84.6-92.3), D10: 95.9 (95% CI: 93.8-98.0)]. No differences were found between Short and Moderate. Prolonged Recovery scored significantly lower on PF [D3:63.1 (95% CI: 56.1-71.0), D10:84.9 (95% CI: 79.9-90.2)] compared to Short [D3: 91.4 (95% CI: 87.9-95.0), D10: 98.7 (95% CI: 97.7-99.7)] and Moderate [D3: 82.8 (95% CI: 76.9-89.2), D10: 95.1 (95% CI: 91.7-98.5)], who did not differ. Prolonged Recovery EF scores were significantly lower on D3 [85.4 (95% CI: 80.3-90.8)] compared to Short [95.9 (95% CI: 93.6-98.3)], with no differences between Prolonged and Moderate [89.9 (95% CI: 85.0-95.1)]. No between-group differences were found on D10. For PSF on D3, Prolonged Recovery [84.4 (95% CI: 81.3-87.7)] scored significantly lower than Short [95.7 (95% CI: 94.1-97.4)] with no difference compared to Moderate [90.5 (95% CI: 87.3-93.4)] On D10, the PSF scores were lower for Prolonged Recovery [89.0 (95% CI: 86.2-91.8)] compared to Short [98.7 (95% CI: 97.8-99.5)] and Moderate [96.3 (95% CI: 94.6-98.1)]. Lastly, SCF was found to be significantly lower on D3 and D10 in Prolonged Recovery [D3:65.0 (95% CI:59.7-70.9), D10:77.4 (95% CI: 72.6-82.5)] compared to Short [D3:90.8 (95% CI:87.6-94.2), D10:97.9 (95% CI: 96.5-99.4)] and Moderate [D3:80.7 (95% CI:75.9-85.9), D10:92.5 (95% CI: 89.0-96.2)], with Moderate demonstrating significantly lower scores than Short on D3. **Conclusions:** Concussed student-athletes with a prolonged recovery demonstrated lower generic HRQOL in the immediate days post-injury, particular in PF and SCF. Interestingly, length of recovery following a concussion most strongly impacted school functioning. These findings highlight the need for clinicians, administrators and teachers to consider the potentially negative academic consequences of concussion and the importance of obtaining the patients' perspective on their health status. Funded from a grant from the National Operating Committee on Standards for Athletic Equipment.

Concussed Athletes Report Less Pain, Greater Function, and Less Disability Compared to Athletes With Musculoskeletal Injury: A Report From the Athletic Training Practice-Based Research Network

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Context: Single item patient-rated outcome measures (SI-PROMs) provide quick, easy assessments of patient-perceived health from different perspectives including pain, function, disability, and global change. Research suggests that concussive and musculoskeletal injuries impact mental and physical health-related quality of life differently. Whether differences exist between injury types for perceived pain, function, disability, and global change as measured with SI-PROMs is unknown. **Objective:** To compare patient-rated recovery of pain, function, disability, and global change between athletes following concussion or musculoskeletal injury. **Design:** Repeated Measures. **Setting:** Athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** 1907 athletes who suffered either a concussion (n = 370 males, n = 211 females; age = 16.8 ± 1.7) or musculoskeletal sprain/strain (n = 703 males, n = 623 females; age = 17.9 ± 4.3) that was diagnosed and documented by an athletic trainer within the AT-PBRN were included. **Interventions:** Patients completed the numeric pain rating scale (NPRS; range = 0-10; 0 = no pain, 10 = extreme pain), global rating of function (GROF; range = 0-100%; 0% = no use, 100% = full use), global rating of disability (GROD; 7-point Likert; 1 = no difficulty, 7 = cannot perform daily activities), and global rating of change (GROC; 15-point Likert scale; 1 = a very great deal better; 15 = a very great deal worse) during treatment sessions at time 1 [(T1); range = 0-5 days post-injury] and time 2 [(T2); range = 10-15 days post-injury]. All patients were classified as "no participation" at T1 and grouped by injury [concussion (CON) or musculoskeletal (MSK)]. **Main Outcome Measures:** Dependent

variables included NPRS, GROF, GROD, and GROC scores. Generalized estimating equations, gamma with a log link response scale and unstructured working correlation matrices were used for analyses ($P < .05$). Data are reported as mean (95% CI). **Results:** A significant interaction between group and time was found for the NPRS ($P < .001$), with CON reporting less pain at T1 [2.8(2.5-3.0)] and T2 [0.9(0.7-1.1)] compared to MSK [T1 = 4.5(4.3-4.6); T2 = 2.7(2.6-2.9)]. There was no significant interaction for GROF ($P = .11$), but there were main effects for group ($P < .001$) with CON [81.8(80.1-83.6)] reporting better function than MSK [MSK = 69.1(67.9-70.3)] and time with scores at T2 [84.0(82.8-85.3)] better than at T1 [67.3(66.0-68.7)]. No significant interaction was found for GROD ($P = .336$), however there were main effects for group ($P < .001$) with CON [1.9(1.77-1.96] reporting less disability than MSK [2.5(2.41-2.54)] and time with scores at T2 = 1.7(1.6-1.8) better than at T1 [2.7(2.6-2.8)]. There was an interaction for GROC ($P < .001$), with CON reporting greater perceived change at T1 [CON = 5.1(4.8-5.4)] and T2 [CON = 2.7(2.5-3.2)] than MSK [T1 = 5.9(5.8-6.1); T2 = 4.6(4.5-4.8)]. **Conclusions:** Our findings suggest that athletes experience differing levels of perceived impact between CON and MSK injuries. Concussed athletes reported less pain, greater function, less disability, and greater perceived change than athletes who suffered sprain or strain injuries. However, regardless of group, scores for all variables improved over time. SI-PROMs are useful for efficiently evaluating patient-reported pain, function, disability, and change over time. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Concussion Increases Lower Extremity Musculoskeletal Injury Risk After Return-to-Play Among Collegiate Athletes

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Context: Current research is beginning to uncover the long lasting neurological effects of concussions. Some of these studies have found concussion's effects on cognition and emotions. However, few have investigated or found neuromuscular impairments that may lead to increased risk of debilitating musculoskeletal injuries. **Objective:** To determine if collegiate athletes are at increased risk of acute lower extremity musculoskeletal injury during the 90-day period following return-to-play from concussion. **Design:** Medical records review for concussion and lower extremity musculoskeletal injuries to create retrospective cohort study. **Setting:** Division one University athletics program. **Patients or Other Participants:** Records from 272 division one collegiate athletes (male = 208, female = 64, age = 19.9 years) participating during the years of 2011-2014 were reviewed. Each concussion incident was paired with up to three non-concussed subjects at the time of the concussion incident. The control subjects were matched with concussed subjects based on sport, gender, position and game play. **Interventions:** Concussion cases were reviewed for lower extremity musculoskeletal injuries during the time period between their return-to-play date and the 90-day period after the return-to-play date. Congruently, the non-concussed subjects paired with the concussion case were reviewed for lower extremity musculoskeletal injuries during the same time period. A lower extremity musculoskeletal injury was defined as an acute fracture, muscle strain or ligament sprain of the hip, groin, thigh, knee, shank, ankle and foot resulting in time loss of participation in team practices and or competition. **Main Outcome Measures:** The number of lower extremity musculoskeletal injuries sustained during the 90-day period after the concussion case's return-to-play date was recorded for each concussion case and their respective non-concussed matched controls. A conditional logistic regression was used to compare concussed subjects to their corresponding matched controls to assess the association between concussion and subsequent risk of acute lower extremity musculoskeletal injuries. **Results:** The odds of sustaining a lower extremity musculoskeletal injury were 2.66 times higher in concussed athletes than in their non-concussed counterparts (Odds ratio: 2.66; 95% confidence interval = 1.12, 6.28; p =.026). The incidence of lower extremity musculoskeletal injury during the 90-day period after the return-to-play date was higher in concussed athletes (15/87; 17%) as compared to matched controls (16/189; 8%). **Conclusions:** Concussed collegiate athletes were at a greater risk for lower extremity musculoskeletal injuries after being cleared to return-to-play than non-concussed collegiate athletes. These results support recent research that the effects of concussion last longer than clinical symptoms and signs illustrating that more research is needed on proper return-to-play criteria for collegiate athletes.

Comparing Concussion Incidence Rates by Gender During Military Combatives Training

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Context: The Global War on Terror has changed military training due to the prevalence of small-scale urban combat. This has emphasized the need for proficiency in close quarters and hand-to-hand combat techniques. As a result, training requirements in this area have been increased. As Athletic Trainers expand their role in caring for military service members, it is important to understand the incidence of concussion associated with military combatives training requirements. **Objective:** The purpose of this study was to compare concussion incidence rates between males and females participating in compulsory military combatives training. **Design:** Retrospective cohort. **Setting:** US Service Academy. **Patients or Other Participants:** Military cadets enrolled in compulsory combatives courses (basic and advanced). **Interventions:** Injury surveillance data were collected and reviewed over four academic years from August 2009 through June 2013. Subjects who sustained a concussion during combatives training were evaluated by a certified athletic trainer using a standardized protocol to document the signs and symptoms at the time of injury and throughout recovery and return to participation. All subjects received their care through a closed healthcare system and all concussions were documented in an established injury surveillance database. As a result, nearly all injuries occurring from combatives training during the study period were documented. Exposure data was available through attendance records for all courses during the study period. One athlete-exposure (AE) was defined as one individual participating in one training session. Each training session was approximately 1 hour in duration. **Main Outcome Measures:** The main outcome of interest was the incidence rate per 1000 AE by gender. Incidence rates and incidence rate ratios (IRR) along with 95% confidence intervals (CI) were calculated to compare rates by gender. **Results:** Overall there were 398 concussions observed during compulsory combatives training and 202,228 AE documented during the study period. The overall incidence rate for concussion from combatives training was 1.97 (95% CI: 1.78-2.17) concussions per 1000 AE. The incidence rate for females was 75% higher when compared to males (IRR = 1.76, 95% CI: 1.38-2.21, $p < 0.001$) across the combatives curriculum. When males and females trained separately during basic combatives training, the incidence rate for females was 57% higher (IRR = 1.57, 95% CI: 1.20-2.03, $p = 0.001$); however, when they trained together in advanced combatives training the rate was almost 2.5 times as high (IRR: 2.37, 95% CI: 1.42-3.86, $p < 0.001$) for females when compared to males. **Conclusions:** The Global War on Terror has demonstrated that combatives is a necessary component of military training. Females were more likely to sustain a concussion than their male counterparts, regardless of whether or not training was separated or integrated by gender. Further research is needed to better understand the modifiable risk factors associated with concussion during combatives training in order to develop effective injury prevention interventions.

Free Communications, Oral Presentations: Patient-Reported Outcomes in Chronic Ankle Instability

Friday, June 26, 2015, 11:00AM-12:00PM, Room 132; Moderator: Patrick McKeon, PhD, ATC, CSCS

Development of the Quick-FAAM: A Shortened Version of the Foot and Ankle Ability Measure for Chronic Ankle Instability

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Context: The Foot and Ankle Ability Measure (FAAM) is a region-specific patient-reported outcome instrument commonly used to evaluate function in individuals with chronic ankle instability (CAI). Reducing the number of FAAM items while maintaining strong psychometric properties would be beneficial for clinical and laboratory settings as this would reduce administration and scoring time. **Objective:** Develop a shortened version of the FAAM that could be applied to individuals with CAI. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty individuals with CAI (27 females, age: 23.25 ± 4.79 years, height: 168.85 ± 9.20cm, weight: 72.04 ± 14.36 kg) participated. 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. **Interventions:** Within a single session, participants completed the FAAM Activities of Daily Living (ADL) and Sport subscales and the Short Form-12 (SF-12). **Main Outcome Measures:** The FAAM-ADL and FAAM-Sport contain 21 and 8 items, respectively. Traditionally, each subscale is scored separately (0-100%) with lower scores indicating decreased foot and ankle function. To develop a single reduced-item FAAM instrument, the subscales were combined to collectively examine all 29 items. To identify items for removal, the skewness and corrected item-total correlation was calculated for each item. Items with a z-skewness of ≥±1.96 or a corrected item-total correlation of ≤0.40 were removed. The reduced-item FAAM was examined for dimensionality using principle components analysis, coverage redundancy using inter-item correlations, and internal consistency using Cronbach's α. Convergent and divergent validity was examined through Pearson correlations with the original FAAM, SF-12 Physical Summary Component, and SF-12 Mental Summary Component. Descriptive statistics (mean ± SD) were calculated for all instruments. Alpha was set at $p \leq 0.05$ for all analyses. **Results:** Seventeen items were removed because they exhibited a z-skewness of >±1.96; however, no items were removed based on weak corrected item-total correlations ($r \geq 0.61$). This resulted in a 12-item instrument which included 5 ADL and 7 Sport items. The reduced-item FAAM demonstrated unidimensionality based on a single component exhibiting an Eigenvalue ≥1 (Eigenvalue = 7.47, Explained Variance = 62.11%). The reduced-item FAAM demonstrated acceptable redundancy across items (average r = 0.59, minimum r = 0.36, maximum r = 0.77) and excellent internal consistency ($\alpha = 0.94$). The reduced-item FAAM (70.31 ± 16.60%) was strongly correlated to the original FAAM ($r = 0.95$, $p < 0.001$; 81.21 ± 14.07%), moderately correlated to the SF-12 Physical Summary Component ($r = 0.45$, $p = 0.003$; 55.59 ± 5.79), and weakly correlated to the SF-12 Mental Summary Component ($r = 0.14$, $p = 0.41$; 52.19 ± 6.89). **Conclusions:** The reduced-item or Quick-FAAM provides an alternative region-specific patient-reported outcome for assessing function in physically active adults with CAI. While the original FAAM provided more extensive item coverage, the Quick-FAAM emphasizes items frequently experienced and deemed relevant by individuals with CAI. Other properties of the Quick-FAAM including test-retest reliability, responsiveness, interpretability, and appropriateness for other conditions require further investigation.

Identifying the Specific Factors Contributing to Self-Reported Disability in Individuals with Chronic Ankle Instability

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Context: Self-reported disability is typical in patients with chronic ankle instability (CAI). Neuromuscular alterations and mechanical joint instability associated with CAI are thought to relate with self-assessed disability. However, the individual contribution of these factors on self-perceived disability is unknown. Identifying the specific clinical impairments and limitations that influence self-reported disability will provide a foundation for effective therapeutic interventions to decrease disability caused by CAI. **Objective:** Determine specific factors that make the significant contribution to self-reported disability in individuals with CAI. **Design:** Descriptive study. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen participants with self-reported CAI (10M, 6F; 22.19 ± 3.64 yrs; 172.20 ± 8.58 cm; 76.96 ± 11.51 kg) volunteered. **Interventions:** Participants completed a self-assessed disability questionnaire and assessments of neuromuscular and mechanical joint stability. **Main Outcomes:** Self-reported disability was assessed with the Foot and Ankle Ability Measure Activities of Daily Living subscale (FAAM-ADL). Fourteen outcome variables were measured within seven neuromuscular constructs:1) spinal reflex excitability

of the soleus muscle assessed with the Hoffman reflex normalized to muscle response; 2) efferent soleus neural drive assessed with the Volitional-wave normalized to muscle response; 3) maximum voluntary isometric contraction strength of the plantar flexors; 4) corticospinal excitability of the soleus assessed using active motor threshold and cortical silent period (CSP) evaluated with transcranial magnetic stimulation; 5) static postural control assessed with center of pressure velocity in the anterior-posterior (COPV-AP) and medial-lateral directions (COPV-ML); 6) dynamic postural control assessed with the star excursion balance test (SEBT); and 7) ankle kinematic variability during walking in the sagittal and frontal planes assessed with approximate entropy (ApEn) using a passive retroflective marker motion capture system. Six variables were quantified in three mechanical constructs: 1) ankle joint laxity measured as anterior-posterior displacements inversion-eversion rotation from the tibial-calcaneal bone linkage using ankle arthrometer; 2) weight bearing ankle dorsiflexion range of motion (WB-DF) using the weight bearing lunge test; and 3) open kinetic chain goniometric measurements of active ankle dorsiflexion (OKC-DF). Pearson product moment correlations were performed with the intention of reducing the number of original outcomes into a smaller number of predictor variables. The outcome variables predicting with at least a moderate correlation ($r > 0.40$) with the FAAM-ADL were used as the predictor variables. A multiple liner regression was then performed to determine the influence of selected predictor variables on self-reported disability. Significance was set a priori at $P < 0.05$. **Results:** The FAAM-ADL was moderately correlated with four variables (COPV-AP [$r = -0.53$, $P = 0.02$]; COPV-ML [$r = -0.58$, $P < 0.01$]; ApEnfrontal [$r = -0.48$, $P = 0.03$]; CSP [$r = -0.55$, $P = 0.01$]]). The strongest predictor of the variance in the FAAM-ADL was CSP ($R^2 = 0.31$, $P = 0.03$). **Conclusions:** Decreased corticospinal excitability may negatively influence self-reported disability in participants with CAI. Interventions targeting soleus corticospinal excitability may be beneficial to produce the optimal outcomes in reducing self-reported disability in participants with CAI.

A Randomized Controlled Trial Investigating the Effect of Rehabilitation on Patient-Oriented Outcomes in Chronic Ankle Instability

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Context: There is minimal patient-oriented evidence regarding the effectiveness of interventions targeted to reduce symptoms associated with chronic ankle instability (CAI). Additionally, clinicians aiming to prioritize care by implementing only the most effective components of a rehabilitative program have very little evidence on comparative efficacy. **Objective:** To assess the comparative efficacy of two common ankle rehabilitation techniques [wobble board (WB) balance training and ankle strengthening using resistance tubing (RT)] using patient-oriented outcomes. **Design:** Randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Forty physically active patients with CAI were randomized into two treatment groups: RT and WB. CAI inclusion criteria included a history of an ankle sprain, giving way ≥1 month, and a Cumberland Ankle Instability Tool (CAIT) score ≤ 25. Final groups included 20 RT participants (5 males, 15 females, age = 21.5 ± 3.2 years, height = 1.66 ± 0.87 m, weight = 76.4 ± 19.34 kg), and 20 WB participants (6 males, 14 females, age = 22.6 ± 5.9 years, height = 1.66 ± 0.15 m, weight = 70.3 ± 15.08 kg). **Interventions:** Participants completed an injury history questionnaire and demographic data, followed by 5 patient-oriented questionnaires: the CAIT, the Foot and Ankle Ability Measure (FAAM) Activities of Daily Living (ADL) and FAAM Sport scale, the Short-Form 36 (SF-36), and a Global Rating of Function (GRF). Following baseline test, participants were randomized to treatment group (WB or RT), and then completed 12 sessions over 4 weeks of graduated WB or RT exercise according to the treatment protocol. Following the 12th session, participants repeated all baseline patient-oriented questionnaires. **Main Outcome Measures:** Dependent variables were

pre- and post-intervention score on the CAIT, FAAM-ADL, FAAM-Sport, SF-36 Physical Component Summary, and GRF. For each questionnaire, a separate 2x2 repeated measures ANOVA analyzed differences between groups over time (alpha set at p = 0.05). Separate paired t-test for each group were used to investigate significant interactions (alpha Bonferroni correct to P = 0.025). **Results:** There was a significant interaction between group and time for the FAAM-ADL ($F_{1,38} = 4.381$, $P = 0.043$). Specifically, the WB group improved post intervention ($t = -4.199$, $df = 19$, $P < 0.001$; WBpre = 91.10 ± 8.22, WBpost = 97.19 ± 3.89) whereas the RT group remained the same ($t = -1.080$, $df = 19$, $P = 0.294$; RTpre = 91.34 ± 7.52, RTpost = 93.00 ± 5.50). There were no other significant interactions or significant differences between groups, nor time differences for GRF (all $P > 0.05$). There were significant time differences for the CAIT ($F_{1,37} = 31.42$, $P < 0.001$; WBpre = 16.63 ± 5.55, WBpost = 22.20 ± 3.82, RTpre = 16.15 ± 5.65, RTpost = 19.30 ± 4.85), FAAM-Sport ($F_{1,38} = 17.997$, $P < 0.001$; WBpre = 59.61 ± 14.94, WBpost = 71.75 ± 9.80, RTpre = 60.21 ± 11.80, RTpost = 66.25 ± 9.75) and SF-36 ($F_{1,38} = 22.696$, $P < 0.001$; WBpre = 54.77 ± 5.40, WBpost = 57.57 ± 3.94, RTpre = 52.36 ± 5.94, RTpost = 55.56 ± 4.11). **Conclusions:** Both RT and WB interventions were successful at increasing patient-oriented outcomes as measured by the CAIT, FAAM-Sport and SF-36. However, only WB training successfully improved FAAM-ADL scores. Clinicians should note that a simple 4 week intervention with 1 exercise (WB or RT) can decrease symptoms and improve health related quality of life in individuals with CAI. There is limited evidence to indicate that WB training was more effective than RT.

Performance Barriers and Functional Limitations: Athletes' Perspectives Recovering From Ankle and Foot Injuries

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Context: Identifying functional limitations and performance barriers during the end stages of recovery from ankle and foot injury is a critical component of establishing effective patient care and positive outcomes. For athletes however, these limitations and barriers have not been thoroughly reported following foot and ankle injury. **Objective:** Explore the functional limitations and performance barriers following ankle and foot injury from the athlete perspective. **Design:** Qualitative design using semi-structured in-person interviews. **Setting:** Collegiate athletic training room. **Patients or Other Participants:** Seventeen (11 men, 6 women; Mean age = 20.6 ± 1.5 years) Division I collegiate athletes recovering from an ankle or foot injury volunteered. Participants represented football (8), volleyball (4), wrestling (2), softball (1), and track & field (1). The injuries included: lateral ankle sprains (10), foot strains (4), syndesmotic sprain (1), foot fracture (1), and tibia/fibula fracture (1). **Data Collection and Analysis:** Participants were recruited in person from collegiate athletic training rooms. Data collection included demographic information followed by a semi-structured in-person interview addressing five questions: 1) what is preventing you from complete recovery, 2) what are/were your most difficult tasks while recovering, 3) when will you know your recovery is complete, 4) what was the most difficult daily living activity, and 5) what advice would offer someone else recovering from your injury. Interviews were recorded and transcribed. Data were reduced, coded, and analyzed for common themes and subthemes. Accuracy was established via member checks and peer review. **Results:** 1) Changing directions or speeds, lateral movements, and pain were identified as the most common reasons for incomplete recovery. 2) Thirty-five different tasks were identified as the most difficult during recovery, and accordingly, many involved cutting and lateral movements. However, most of the tasks were specific to each athlete's sport and often their specific position. 3) Absence of pain during activity was most commonly cited as the marker of full recovery. Confidence, trust, full speed lateral movement, and jumping were cited by multiple athletes. 4) Maneuvering stairs was the daily activity that presented the greatest challenge, followed by "getting around" in general, driving, and standing in one place. 5) Two messages were clearly emphasized as advice to others: don't return to soon and listen to your athletic trainer. Specific comments such as "don't push it too early, it can get worse if you go too early, give it rest," and "don't rush it" were repeated. **Conclusions:** Although common themes exist when recovering from ankle and foot injuries, athletes cite sport specific tasks when addressing their limitations at the end-stages. We should therefore consider addressing specific and individualized outcome markers to optimize our patient care. Furthermore, based on the athlete's suggestions, the long-term impact of accelerating a return to participation should be considered.

Utilization of Ankle Injury Prevention Strategies by Adolescent Athletes

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Context: Ankle sprains occur frequently in sports. The efficacy of ankle injury prevention strategies such as ankle taping (AT), ankle braces (AB) and ankle injury exercise programs (AIEP) pre and post injury, are well established. However, there is limited data as to the extent these prevention strategies are utilized by adolescent athletes. **Objective:** To determine the utilization of ankle injury preventions strategies in adolescent athletes. **Design:** Cross sectional study. **Setting:** Data were collected at a series of sport camps and club team competitions. **Patients or Other Participants:** Adolescent basketball, football, soccer and volleyball players were recruited to participate. **Interventions:** Subjects completed a paper/pencil, validated survey (reliability: r = 0.698) used to quantify utilization of ankle injury prevention strategies and consisted of a series of dichotomous (Yes, No) and Likert scaled questions. **Main Outcome Measures:** The dependent variables included the percentage of subjects utilizing ankle injury prevention strategies. Fisher's Exact tests ($p < 0.05$) were used to analyze responses by sex and previous ankle sprain (PAS) and No Ankle Sprain (NoAS). **Results:** A total of 800 out of 1,312 athletes (61%) agreed to participate. Subjects (age = 15.7 + 1.6 yrs.) included female (n = 408) and male (n = 392), basketball (n = 258), football (n = 158) soccer (n = 232) and volleyball (n = 152) players. Two hundred seventeen (27%) reported a PAS on one or both ankles. Ninety eight (12%) reported currently using AT for one (61%) or both (39%) ankles, and utilized AT 1 - 2 days/week (56%), 3 - 4 days/week (37%) or daily (7%). There was no difference ($p = 0.161$) in the use of AT between females (13 %) and males (11%) although, PAS subjects (27%) used AT more often ($p < 0.001$) than NoAS subjects (7%). Two hundred forty nine subjects (31%) reported currently wearing AB on one (37%) or both (63%) ankles, 1 - 2 days/week (46%) 3 - 4 days/week (37%) or daily (17%). AB were utilized more ($p < 0.001$) in females (40%) than males (23%) and higher ($p < 0.001$) in subjects with PAS (56%) than NoAS subjects (27%). Ninety five subjects (12%) reported participating in an AIPP. The AIPP most often consisted of a 20 - 30 minute program (58%), 2 - 3 days per week (56%) and coordinated by their coaches (49%). Females (16%) were twice as likely ($p = 0.001$) than males (8%) to use an AIPP but there was no difference ($p = 0.264$) between PAS subjects (11%) and NoAS subjects (15%). **Conclusions:** The utilization of AIPP strategies varies considerably by sex and previous ankle sprain status. Athletic trainers need to consider these variables when recommending and implementing various ankle injury prevention strategies in adolescent sport settings.

Influence of a Shortened Duration Injury Prevention Program on Balance and Power in Female Adolescent Athletes

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Context: High school athletics result in over two million musculoskeletal injuries each year, with the highest risk for injury occurring in female athletes. Injury prevention programs (IPP) have been shown to be successful in reducing the rate of injury in this high-risk population but are not being utilized at the high school level. These programs typically require at least twenty minutes of time per session and are associated with poor compliance. **Objective:** To examine if an 8-week IPP of a shortened session duration is able to elicit improvements in balance and power equivalent to, or greater than, a proven, effective lower extremity IPP (F11+) in a female, athletic, adolescent population. **Design:** Randomized controlled trial. **Setting:** High School. **Patients or Other Participants:** Fifty-one healthy, high school female athletes (Age = 14.77 ± 1.15yrs, Mass: 56.67 ± 14.73, Height: 62.63 ± 12.83) volunteered to participate in the study. **Interventions:** Participants were stratified by team (sport: field hockey, soccer, volleyball; level: Freshmen, JV, Varsity) and their score on the function, sport and recreational activities sub subscale of the Knee Injury and Osteoarthritis Outcome Score and then randomized into one of three groups: Focused (FOC = 25), Traditional (TRA = 24) or Control (CON = 27). The Focused warm-up was a ten-minute IPP consisted of flexibility, agility, plyometric, strengthening, and balance exercises. Participants completed a test session before and after their 2014 fall interscholastic season. Each participant completed three trials of

standing long jump and two trials of the Y Balance Test on her dominant limb in the anterior, posteromedial and posterolateral direction. **Main Outcome Measures:** Participants' best score of each direction on the Y Balance was normalized to dominant limb length and the best of three standing long jump trials was used for analysis. A composite score was also calculated as a sum of all three reach distances normalized to limb length. Change scores were then calculated from the best values from Pre and Post sessions. Separate One-way ANOVAs were used to assess the change score of each variable to evaluate each warm-up's effect on balance and power ($\alpha \leq .05$). **Results:** No significant differences were seen between groups ($P > 0.05$) for either power or balance variables. Long Jump ($P = 0.081$) (FOC: -6.83 ± 31.50 cm, TRA: 12.07 ± 19.68 cm, CON: 0.84 ± 14.72 cm) Y-Balance Composite Score ($P = .296$) FOC: -0.175 ± 7.75, TRA: 1.92 ± 6.98, CON: 3.33 ± 5.79) **Conclusions:** A shortened duration IPP of ten minutes was not able to elicit improvements in balance or power when compared to a twenty-minute, proven IPP. It many take longer than ten minutes to elicit the neuromuscular and performance benefits needed to decrease injury risk and increase coach and athlete adoption of IPPs at the high school level. Supported by a NATA Research and Education Foundation Doctoral Grant.

Influence of Sport Specialization on Landing Technique in Youth Soccer Athletes

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Context: It has been theorized that early sport specialization could have deleterious effects on youth athletes. However, it is unknown if sport specialization actually increases injury risk. The Landing Error Scoring System (LESS) is a clinical tool to evaluate landing technique and has been proven to predict lower extremity injury risk in youth soccer athletes. **Objective:** The purpose of the study was to evaluate the influence of early sport specialization on injury risk as measured by landing technique in youth soccer athletes. **Design:** Cross-sectional. **Setting:** Municipal soccer fields. **Patients or Other Participants:** Forty seven male and 54 female youth soccer athletes (age 9-13 years) volunteered to participate. **Interventions:** Participants and their legal guardian filled out a questionnaire that asked about sport participation history. We divided participants into single-sport and multi-sport athletes. Single-sport athletes were defined as participants that only reported playing one sport within the previous year and multi-sport athletes were required to report playing more than one sport within the last year. Participants performed three trials of a jump landing task while being video recorded from the frontal and sagittal plane. The jump landing task required participants to jump forward from a 30-cm high box a distance of half their height and jump for maximal vertical height immediately after landing. **Main Outcome Measures:** A single rater graded the video from the jump landing task using the LESS, which is a valid and reliable screening tool. The total LESS score was calculated and averaged from the three trials for analyses. An analysis of covariance was performed to evaluate LESS scores between the two groups (single sport, multi-sport) while controlling for sex ($\alpha = 0.05$). **Results:** There were 27 (9 males, 23 females, age = 11 ± 1 year) participants in the single-sport athlete group. There were 74 (38 males, 36 females, age = 11 ± 1 year) participants in the multi-sport athlete group. We observed a significant difference between groups for LESS scores ($P = 0.03$). Single-sport athletes performed the landing task with more errors (6.92 ± 1.22) than multi-sport athletes (6.12 ± 1.74). **Conclusions:** This preliminary analysis suggests that early sport specialization may increase injury risk as demonstrated by higher LESS scores, or poor landing technique.

The Effect of Sport Specialization on Y-Balance Anterior Reach Asymmetry and Distance: A Pilot Study

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Context: Sport specialization at an early age may cause the development of asymmetries due to the repetitive nature of only practicing specific movements. Certain components of the y-balance test, such as anterior reach asymmetry, have been linked with increased risk of injury. However, little research has been conducted to examine the effect of early sport specialization on y-balance test performance. **Objective:** To examine the effect of sport specialization on anterior y-balance reach distance and asymmetry in high school athletes. **Design:** Cross-sectional. **Setting:** High school. **Patients or Other Participants:** One hundred and forty-eight healthy athletes (age = 15.4 ± 1.2 years; height = 171.2 ± 8.5 cm; mass = 64.5 ± 11.3 kg, 84 female, 64 male) from two high schools and three different sports (volleyball, tennis, soccer). **Interventions:** Participants were screened at the start of their respective sport seasons. Sport specialization was dichotomized using a 6-question survey ("Yes" to 4 or more questions = specialized, N = 84, 33 males, 51 females; "Yes" to 3 or less questions = non-specialized, N = 62, 29 males, 33 females). Up to four practice trials in the anterior direction of the y-balance test were followed by three recorded trials, with the average of the recorded trials used for analysis. Anterior reach distance was normalized to limb length (%LL). Anterior reach asymmetry was calculated as the absolute value of the difference between the average dominant and non-dominant limb reach distances. A two-way analysis of variance was used with gender and specialization category as independent factors to determine between group effects. The p-value was set a priori at $p < .05$. **Main Outcome Measures:** Sport specialization score (0-6), anterior y-balance reach asymmetry between legs, and dominant leg anterior y-balance reach distance. **Results:** Specialized athletes displayed more anterior reach asymmetry (3.79 ± 3.11 cm) than non-specialized athletes (2.93 ± 1.92 cm, $p = .02$). There was also a trend towards specialized athletes having greater anterior reach distance (.67 ± .07% LL) than non-specialized athletes (.65 ± .07% LL, $p = .06$). Differences were also observed between genders, with males (4.02 ± 3.27 cm) having greater anterior asymmetry than females (2.99 ± 2.09 cm, $p = .02$) but females having greater anterior reach distance (.69 ± .06% LL vs .64 ± .07% LL, $p < .001$). **Conclusions:** Specialized athletes exhibited greater anterior y-balance reach distance and asymmetry than non-specialized athletes. Males were also more asymmetrical than females, with females having greater anterior reach distance. Sport specific training may exacerbate asymmetry by only emphasizing movements specific to the sport. These results indicate that specialized athletes and male athletes are at risk of developing movement asymmetries that can increase the potential for injury. Clinicians should be aware of these differences in order to correct asymmetries, however, a more thorough examination of sport specialization is needed to determine the extent of the relationship.

Shoulder Biomechanical Adaptations and Injury Among Collegiate Swimmers

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Context: Several studies have observed soft tissue and bony alterations among overhead throwing athletes. The swimming freestyle stroke requires less force to decelerate the arm than throwing, but it is repeated more often over the course of seasons and careers. However, in a swimming population, few studies have examined whether these adaptations occur or if they are related to the high incidence of injury. **Objective:** To determine if adaptations develop in swimmers' shoulders, how the adaptations are related, and whether they are related to injury history. **Design:** Post-test only. **Setting:** Research laboratory. **Patients or Other Participants:** 29 collegiate swimmers [9 males (19.7 ± 1.6 years old, 182.3 ± 3.5 cm, 78.6 ± 5.5 kg, 11.1 ± 3.8 years swimming); 20 females (19.7 ± 0.9 years old, 170 ± 5.6 cm, 64.1 ± 5.8 kg, 11.4 ± 3.6 years swimming)] volunteered for this study. Subjects were included if they currently competing on a collegiate swimming team. Exclusion criteria included shoulder surgery within one year of testing and any neurological disorder. **Interventions:** The independent variables were injury history and arm dominance. Prior to testing all subjects completed a questionnaire to assess injury and swimming history. A digital inclinometer was used to analyze glenohumeral external (ER) rotation, glenohumeral internal rotation (IR), and posterior shoulder tightness (PST). PST is a measure of humeral horizontal adduction. Posterior capsular thickness (PCT) and humeral retrotorsion (HR) were examined by diagnostic ultrasound. All measurements were performed on both the dominant and non-dominant arms. The dominant arm was defined as the arm used to throw a ball for maximum distance. **Main Outcome Measures:** 2 x 2 mixed model ANOVA's were used to compare the influence of arm dominance and injury history on the dependent variables of IR, ER, PST, PCT, and HR. A Pearson correlation analysis was performed to determine the relationship between dependent variables. **Results:** Swimmers' dominant arms (ER = 124.7 ± 9.7, IR = 49.2 ± 11.1°) were found to have greater ER (P = 0.002), but less IR (P = 0.064) than their non-dominant arms (ER = 119.8 ± 9.3°, IR = 52.6 ± 11.4°). Swimmers with no injury history (-14.8 ± 10.4°) had significantly greater HR (P = 0.006) than their injured counterparts (-24.4 ± 10.4°). No further interaction effects, main effects for arm dominance, or main effects for group were observed. There was a significant correlation between HR and IR on both the dominant (r = -.461, P = 0.014) and non-dominant (r = -.428, P = 0.023) sides, suggesting that more HR was associated with less IR. **Conclusions:** Competitive swimmers exhibit some soft tissue adaptations but to a lesser extent of those found in other overhead athletes. These soft tissue changes did not relate to injury history. However, less retrotorsion seems to be a dominant factor among adult swimmers who have been previously injured, compared to their uninjured counterparts. The lesser retrotorsion could affect GH range of motion measurements and perceived anterior capsule laxity, which may be used in screening athletes.

Comparing Glenohumeral and Scapular Musculoskeletal Adaptations Between Youth and Collegiate Swimmers

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Context: Approximately two-thirds of elite swimmers exhibit shoulder pain during their competitive lifetimes. This pain, which may begin as early as 8 years of age, has been attributed to the demands of high swimming stroke volume. However, little data exist determining which tissue adaptations and shoulder motion changes occur in swimmers or at what age they begin. **Objective:** To compare adaptations in shoulders of swimmers and controls at two different ages. **Design:** Cross-sectional, post-test only. **Setting:** Research laboratory. **Patients or Other Participants:** 40, 8-10 year old athletes (20 swimmers [age = 8.8, height = 138.7 cm, weight = 34.0 kg, years swimming = 3.3], 20 controls [age = 9.2, height = 138.9 cm, weight = 34.4 kg]) and 51 active college-aged students (30 collegiate swimmers [age = 19.8, height = 174.1 cm, weight = 68.9 kg, years swimming = 11.4], 21 controls [age = 21.1, height = 172.4 cm, weight = 71.3]) participated in this study. Controls were defined as recreationally active individuals who have never competed in organized overhead sports. **Interventions:** The independent variables used in this study were age and arm dominance. Arm dominance was defined as the arm used to throw a ball for maximum distance. Diagnostic ultrasound was used to examine tissue adaptations in the shoulder, and a digital inclinometer allowed for range of motion measurements. **Main Outcome Measures:** The dependent variables of posterior capsule thickness, humeral retrotorsion, glenohumeral range of motion, and scapular upward rotation at three different angles (60°, 90°, 120°) were measured bilaterally. Dependent variables were analyzed using 4x2

mixed model ANOVAs. Scheffe post-hoc testing was used when ANOVA models were significant. **Results:** No interaction effects were observed for any dependent variables, but main effects were present. College-aged swimmers exhibited significantly greater posterior capsule thickness (1.61 ± .16 mm) than all other groups ($P < .001$). College-aged controls (1.31 ± .17 mm) also had significantly greater posterior capsule thickness ($P < .001$) than both youth groups (swimmers = 1.12 ± .13 mm, controls = 1.04 ± .11). Both youth athlete groups displayed more retrotorsion (-11.3 ± 7.3°) than the collegiate groups (-18.80 ± 8.92°) ($P < .001$), and the dominant shoulder was more retrotorted (-13.9 ± 9.5°) ($P < .001$) than the non-dominant shoulder (-17.1 ± 9.7°). College-aged swimmers exhibited less internal rotation (51.2 ± 10.4°) than youth swimmers (66.8° ± 6.9°) and youth controls (65.7 ± 9.1°), but all college-aged subjects had lower external rotation values (122.5 ± 8.9°) than both groups of youth athletes (139.4 ± 9.4°). No external rotation differences existed between swimmers and controls of the same age. Finally, college-aged swimmers (6.0 ± 4.4°) displayed less scapular upward rotation at 60° ($P < .001$) than all other groups (average = 10.5 ± 3.3°). **Conclusions:** Youth swimmers do not present with the same shoulder adaptations as other youth overhead athletes. Instead, it appears that posterior capsule thickness and scapular rotation changes develop sometime between the ages of 10-18 in swimmers versus controls. Retrotorsion and range of motion changes occur with age regardless of swimming participation. Therefore, clinicians may want to begin scapular stabilization exercises and posterior capsule stretching in teenagers to decrease injury risk in swimmers.

Effect of Swim Training on Physical Characteristics in Competitive High School Swimmers

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Context: Previous literature has theorized that shoulder physical characteristics, such as subacromial space distance and forward shoulder posture, change as a result of the repetitive high loads accumulated during swimming; thereby, increasing the risk of developing swimmer's shoulder. To date, the effect of swim training on these physical characteristics that may be causative of impingement and the development of swimmer's shoulder have not been investigated. **Objective:** To prospectively identify the effect of swim training on subacromial space distance and forward head and forward shoulder posture and evaluate the relationships between these variables. **Design:** Cohort repeated-measures. **Setting:** Field laboratory at local high schools and swimming pools. **Patients or Other Participants:** 45 competitive high-school swimmers and 31 non-overhead high-school athletes (control participants) that were not currently experiencing any shoulder, neck, or back pain that limited their participation in sports activity were included in the study. **Interventions:** All participants were evaluated prior to the start of the swimming training season and at 12 weeks following the initial testing session. At each test session, participants underwent a physical exam that included evaluation of posture using lateral photographs and subacromial space distance using diagnostic ultrasound. **Main Outcome Measures:** Percent change from baseline in normalized subacromial space width, forward shoulder posture, and forward head posture was calculated. A 2(time) X 2(group) mixed model ANOVA was used to analyze the percent change score of each variable **Results:** Swimmers presented with significantly greater decreases in normalized dominant-limb subacromial space distance during the training season compared to non-overhead athletes ($F_{1,70} = 26.0$, $p < 0.001$). There was an 8.4 ± 1.0% decrease in dominant limb subacromial space width in the swimmers compared to a 0.1 ± 1.3% change in the non-overhead athletes. Swimmers also demonstrated significantly greater increases in forward shoulder posture compared to non-overhead athletes during the training season ($F_{1,70} = 19.8$, $p < 0.001$). There was a 16.2 ± 2.2% decrease in forward shoulder posture in the swimmers compared to a 0.6 ± 2.7% change in the non-overhead athletes. There was a significant fair-to-moderate relationship between changes in forward shoulder posture and changes in dominant normalized subacromial space distance ($r_{68} = -0.49$, $p < 0.001$) and changes in forward shoulder posture. As forward shoulder posture increased, both dominant and non-dominant subacromial space significantly decreased. **Conclusions:** Due to training loads, high-school swimmers experience a decrease in subacromial space distance and increase in forward shoulder posture compared to controls, potentially making swimmers more vulnerable to the development of shoulder pain and injury. These findings indicate the importance of implementing an injury prevention strengthening and stretching program, which targets the correction of these altered shoulder characteristics among competitive swimmers. These results should also be considered during the evaluation and treatment of swimmers with the various shoulder pathologies associated with swimmers shoulder. This research study was funded by the NATA Research and Education Foundation (Grant # 13DGP004).

Epidemiology of National Collegiate Athletic Association Men's and Women's Swimming and Diving Injuries, 2009/10–2013/14

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Context: Although swimming and diving are two different sports, they compete as one team in collegiate sports. Recent injury surveillance data for collegiate-level swimming and diving are limited. Previous injury data are limited to samples of elite and national team athletes, or data from emergency departments. **Objective:** To describe the epidemiology of National Collegiate Athletic Association (NCAA) men's and women's swimming and diving injuries during the 2009/10-2013/14 academic years. **Design:** Descriptive Epidemiology. **Setting:** Aggregate injury and exposure data collected from nine men's swimming and diving programs providing 23 seasons of data, and 13 women's swimming and diving programs providing 30 seasons of data. **Patients or Other Participants:** Collegiate student-athletes participating in men's and women's swimming and diving during the 2009/10-2013/14 academic years. **Interventions:** Men's and women's swimming and diving injury and athlete-exposure (AE) data from the NCAA Injury Surveillance Program (ISP) during the 2009/10-2013/14 academic years were analyzed. **Main Outcome Measures:** Injury rates, injury rate ratios (RR), and injury proportions by body site, diagnosis, and event were reported with 95% confidence intervals (CI). **Results:** The ISP captured 149 and 208 injuries for men's and women's swimming and diving, respectively, leading to injury rates of 1.54/1,000 AEs (95% CI: 1.29, 1.79) and 1.71/1000 AEs (95% CI: 1.48, 1.94). Among females, divers had a higher injury rate (2.49/1000 AEs) than swimmers (1.63/1000 AEs; RR = 1.53; 95% CI: 1.07, 2.19; P = 0.03). Injury rates for male divers (1.94/1000 AEs) and swimmers (1.48/1000 AEs) did not differ (P = 0.27). Most injuries occurred to the shoulder in men's swimming (34.7%), men's diving (32.0%) and women's swimming (31.3%). In women's diving, the trunk comprised the largest proportion of injuries (37.8%). The most common injury diagnosis was muscle/tendon strains in men's swimming (21.8%), men's diving (20.0%), women's swimming (17.0%), and women's diving (16.2%). Swimmers also had large proportions of entrapment/impingement (men: 14.5%; women: 11.1%) and tendonitis (men: 13.7%; women: 15.8%). The majority of injuries were classified as overuse (men's swimming: 44.4%; men's diving: 24.0%; women's swimming: 63.7%; women's diving: 21.6%) and no apparent contact (men's swimming: 25.0%; men's diving: 28.0%; women's swimming: 17.0%; women's diving: 27.0%). Female swimmers had a higher rate of overuse injuries (1.04/1000AEs) than male swimmers (0.66/1000AEs; RR = 1.58; 95% CI: 1.14, 2.19; P = 0.01). No sex differences in overuse injury rates existed among divers (P = 0.78). Contact with water also accounted for large proportions of injuries in men's and women's diving (32.0% and 16.2%, respectively). **Conclusions:** Shoulder, muscle/tendon strain, and overuse injuries were common in collegiate men's and women's swimming and diving. Programs should emphasize good technique and avoid rapid increases in the frequency of training to avoid development of overuse shoulder injuries. In addition, divers may have higher injury rates than swimmers, although small reported numbers in this study warrant additional research.

Free Communications, Oral Presentations: Altering Central Nervous System Function

Friday, June 26, 2015, 2:45PM-4:00PM, Room 132; Moderator: Charles Swanik, PhD, ATC, FNATA

Immediate Effects of Therapeutic Ultrasound on Quadriceps Spinal Reflex Excitability

Norte GE, Saliba S, Hart JM: Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville, VA

Context: Persistent quadriceps weakness is often reported following knee joint injury and plays a role in activity impairments and re-injury risk. Aberrant sensory information arising from damaged joint receptors has been hypothesized as a contributing factor in the development of post-traumatic muscle weakness via arthrogenic muscle inhibition (AMI). Therapeutic ultrasound has been reported to influence peri-articular mechanoreceptors, which may help resolve AMI and improve strength outcomes in patients. **Objective:** To investigate the influence of therapeutic ultrasound on quadriceps spinal reflex excitability in patients with neuromuscular impairment. **Design:** Double blinded, randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Thirty participants with a history of knee joint pathology and documented quadriceps dysfunction (defined as a quadriceps central activation ratio <90%) were randomly allocated to ultrasound (n = 15, 10M/5F, 22.8 ± 3.6 years, 175.3 ± 9.7 cm, 76.0 ± 17.1 kg), or sham (n = 15, 5M/10F, 24.1 ± 4.9 years, 169.5 ± 10.2 cm, 68.4 ± 10.4 kg) treatment. **Interventions:** A non-thermal continuous ultrasonic (1 MHz frequency, 0.3W/cm2 intensity, 100% duty cycle) or sham (0 MHz, 0 W/cm2) current was applied to the anteromedial knee joint for 17 minutes. Measurements were recorded at baseline, immediately post, and 20 minutes post intervention. **Main Outcome Measures:** Peak H-reflex amplitude normalized to the peak muscle response (Hmax:Mmax ratio) was measured from the vastus medialis using surface electromyography as an estimate of quadriceps motorneuron pool excitability. Square-wave pulses of progressively increasing intensity were delivered to the femoral nerve at the inguinal fold until Hmax and Mmax were obtained. A 2 x 3 analysis of variance with repeated measures was used to assess group differences over time. Post hoc, we performed univariate analysis of covariance within each treatment group and at each post-intervention time-point, using baseline Hmax:Mmax ratio as the covariate. Cohen's d effect sizes with 95% confidence intervals were calculated between baseline and posttest measures within groups. **Results:** No significant group ($F_{1,28} = 1.38$; $p = .250$) or time ($F_{1.54,56} = 0.37$; $p = .641$) main effects were observed, however, a significant group x time interaction ($F_{2,56} = 4.44$; $p = .016$) was observed. Post hoc tests revealed no group differences detected immediately following the intervention ($F_{1,27} = 3.14$; $p = .088$), however, the ultrasound group displayed significantly higher Hmax:Mmax ratio 20 minutes post application ($F_{1,27} = 6.73$; $p = .015$). The ultrasound group displayed small magnitude effect sizes immediately [d = 0.1 (-0.6, 0.8)], and 20 minutes post [d = 0.2 (-0.6, 0.9)] application. The sham group displayed small magnitude effect sizes in the negative direction immediately [d = -0.03 (-0.8, 0.7)], and 20 minutes [d = -0.1 (-0.9, 0.6)] post application. **Conclusions:** Quadriceps motoneuron pool excitability was increased 20 minutes following the application of a non-thermal therapeutic ultrasound treatment. These data provide supporting evidence of the contribution of peripheral receptors in modulating the arthrogenic response in patients with persistent quadriceps dysfunction.

Delayed Onset Muscle Soreness of the Plantar Flexors Facilitates Motor Neuron Pool Excitability in the Peroneus Longus and Gastrocnemius

Hammill RR: Bridgewater College, Bridgewater, VA

Context: Delayed onset muscle soreness (DOMS) is a common condition among the physically active. DOMS has been shown to cause pain shortly after an exercise bout and is at its greatest at 48 hours post exercise. Methods to control the inflammation associated with DOMS have been investigated previously, but how the neuromuscular system adapts to it is still vague. Neuromuscular adaptations based on the micro trauma associated with DOMS could predispose an individual to other injuries. **Objective:** To identify changes in motor neuron pool availability of the medial gastrocnemius, soleus, and peroneus longus muscles 48 hours after an exercise protocol causing muscle soreness. The hypothesis was that micro tears of the plantar flexor muscles would cause a change in the number of motor neurons available post-synaptically. **Design:** Pretest-posttest randomized controlled trial. **Setting:** Academic facilities. **Patients or Other Participants:** Volunteer sample (n = 10) with 8 females and 2 males (166.1 cm ± 8.40, 71.9 kg ± 22.2, 26.2 yrs ± 10.0) assigned randomly to an exercise (n = 4) or control group (n = 6). **Interventions:** The exercise group performed five sets of single leg toe raises holding 10% of their body weight until failure with 30 second rest periods between sets. The control group did nothing. **Main Outcome Measures:** Visual Analog Scale scores were used to confirm muscle soreness. Hoffman reflexes normalized to muscle responses (H:M ratios) were used to quantify motor neuron pool availability in the gastrocnemius, soleus, and peroneus longus muscles. Groups were allocated randomly and data were measured at pretest and

then 48 hours later (posttest). A 2x2 Analysis of Variance (ANOVA) with repeated measures for time (pretest and posttest) and a between subjects variable of group (muscle soreness and control) was performed for each muscle and for the visual analogue scale. **Results:** Significant soreness was measured using the visual analog scale (Mean Difference ± SEdiff = 33.3 ± 10.5 mm, CI (95%) = 9.2 mm-57.5 mm, P = 0.013). H:M ratios were significantly increased in the exercise group for the peroneus longus (Mean Difference ± SEdiff = 0.266 ± 0.063, CI (95%) = 0.120-0.412, P = 0.003) and trended that way for the gastrocnemius (Mean Difference ± SEdiff = 0.246 ± 0.110, CI (95%) = -0.008-0.500, P = 0.056). No difference was noted in the soleus (Mean Difference ± SEdiff = 0.006 ± 0.117, CI (95%) = -0.265-0.277, P = 0.959). **Conclusions:** The exercise protocol led to significant lower leg pain in the plantar flexor musculature. The peroneus longus muscle and, maybe, the gastrocnemius muscle become facilitated during periods of significant plantar flexor micro trauma. The change in these two muscles is likely due to their roles as plantar flexors of the talocrural joint. Perhaps the neural changes occurring are an attempt to maintain the ability to perform tasks like walking or running. The central nervous system may be making additional motor neurons available during delayed onset muscle soreness to generate levels of torque consistent with those times when muscle soreness does not exist.

Associations of Quadriceps Strength, Voluntary Activation, and Isokinetic Power With Self-Reported Function in Patients Following Anterior Cruciate Ligament Reconstruction

Harkey MS, Luc BA, Pamukoff DN, Blackburn JT, Pietrosimone BG: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Quadriceps function is critical for maintaining physical and self-reported function following anterior cruciate ligament reconstruction (ACL-R). While quadriceps strength is strongly associated with disability following ACL-R, it is unclear which index of muscle function is most indicative of disability following ACL-R. Isokinetic power and voluntary activation are associated with disability following other knee pathologies, yet evidence in patients with ACL-R is lacking. Establishing which indices of muscle function associate with self-reported function following ACL-R may help guide the development of treatment strategies that maintain quality of life. **Objective:** To determine the association of quadriceps strength, voluntary activation, and isokinetic power with self-reported function in ACL-R patients, as well as determine which combination of these muscle function variables best explains the variance in self-reported function. **Design:** Cross-sectional. **Setting:** Research Laboratory. **Patients or Other Participants:** Fourteen ACL-R patients (50% Females, 20.6 ± 6.7 years old, 168.4 ± 11.6 cm, 70.2 ± 10.4 kg, 55.6 ± 37.7 months post ACL-R) volunteered for the study. **Interventions:** Quadriceps strength and voluntary activation were measured during a maximal voluntary isometric contraction. Voluntary activation assessments involved evaluation of the ratio of voluntary peak torque to peak torque resulting from a superimposed electrical stimulus applied to the quadriceps during a maximal contraction. Quadriceps isokinetic power (torque x velocity) was measured at 60°/s from 90° to 0° of knee extension range of motion. **Main Outcome Measures:** Peak quadriceps strength was quantified as the peak voluntary isometric torque normalized to body mass (Nm/kg). Voluntary activation was calculated as the central activation ratio (i.e. the ratio of voluntary peak torque to peak torque with the superimposed stimulus). Peak isokinetic power was normalized to body mass (W/kg). Self-reported function was quantified with the International Knee Documentation Subjective Knee Evaluation form, with higher scores indicating greater function. Separate Pearson product-moment correlations were used to assess associations between each index of muscle function and IKDC total score. Hierarchical linear regression was used to determine which combination of muscle function indices explained the greatest variance in self-reported function. **Results:** Quadriceps strength (r = 0.68, p = 0.004), voluntary activation (r = 0.66, p = 0.005), and isokinetic power (r = 0.53, p = 0.027) were all moderately associated with self-reported function. Quadriceps strength alone explained 46.8% (r2 = 0.468, p = 0.007) of the variance in self-reported function, and the addition of isokinetic power increased the explained variance to 68.4% (r2 = 0.684, r2 increase = 0.216, p = 0.002). Voluntary activation was not included in the hierarchical regression because its inclusion did not significantly increase the variance explained in self-reported function. **Conclusions:** All three measures of muscle function were significantly associated with self-reported function. The combination of quadriceps isometric strength and isokinetic power uniquely explained the most variance in self-reported function. Therefore, rehabilitation protocols following ACL-R that target both the maximum force capacity and the rapid force production of the muscle may best combat declines in self-reported function.

Ankle Injury Alters the Muscle Spindle Response to Repeated Instrumented Joint Mobilization

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Context: Ligamentous injury to the ankle has been associated with an array of functional and mechanical deficits contributing to sensations of giving way. Recently, joint mobilizations have been proposed as a therapeutic intervention for improving mechanosensory function in the ankle. Theories suggest that joint loading will stimulate capsuloligamentous receptors, which may serve to improve muscle spindle sensitivity and proprioception; however, no studies have directly quantified these sensory gains. **Objective:** To determine the effects of repeated joint loads on muscle spindle afferent (MSA) activity in subjects with a previous history of ankle sprain. **Design:** Case control with repeated measures. **Setting:** University laboratory. **Patients or Other Participants:** Forty-two participants were recruited with 22 providing adequate data for analysis (21.4 ± 3.0 yrs; 169.9 ± 12.2 cm; 63.8 ± 12.4 kg). Participants were grouped based on previous history of ankle sprain (≥1 year) into uninjured (CON, n = 11) and injured (INJ, n = 11). **Interventions:** Participants were supine on a padded table as microneurographic recordings were obtained from the common peroneal nerve at the level of the fibular head. MSA recordings were confirmed by observing the signal's response to stretch, shortening, and cutaneous stimulation of the ankle. Once confirmed, an instrumented ankle arthrometer was used to perform 125 N anterior translations to the ankle joint at a rate of 50 N/sec. Loading was performed in blocks of 10 trials in this manner, while force, laxity, and MSA activity were synchronized at 1000Hz. **Main Outcome Measures:** MSA amplitude (%Max) at 0, 25, 50, 75, 100, and 125 N were averaged across 3-trial blocks corresponding with loads 1-3, 4-6, and 7-9. Differences were tested using a 3-way analysis of variance to compare the effects of group, force, and trial block. **Results:** MSA amplitude increased with force application across all blocks ($F_{5,95} = 59.6$, $p < 0.001$). A significant Group-by-Trial interaction effect was also observed ($F_{2,38} = 3.716$, $p = 0.034$). Pairwise comparisons revealed that during the first 3 trials, CON had less MSA activity than INJ (CON = 0.321 ± 0.05%; INJ = 0.495 ± 0.04%, $p = 0.012$) that equalized in subsequent trials. Accordingly, while the MSA activity of INJ participants did not change across trials, activity was elevated for CON in the 2nd block of trials ($p \leq 0.04$). **Conclusions:** These results suggest that joint mobilizations have the capability to improve MSA function in uninjured ankles. However, in subsets of injured subjects, the dosage used in this study was not sufficient to elicit a change in muscle spindle sensitivity. While this could indicate altered fusimotor function among injured ankles, it also suggests that sensorimotor benefits observed after joint mobilization may be due to alterations within the central nervous system.

Alterations in Intracortical Inhibition and Facilitation Following Anterior Cruciate Ligament Reconstruction

Luc BA, Harkey MS, Pamukoff DN, Blackburn JT, Pietrosimone BG: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Decreased quadriceps neuromuscular function is common following anterior cruciate ligament reconstruction (ACL-R), and may prevent full recovery of quadriceps strength and contribute to long-term disability. ACL-R patients demonstrate decreased corticospinal excitability, possibly originating from neurons in the primary motor cortex of the brain. Decreased neural drive from areas of the motor cortex may be responsible for impaired neuromuscular function following ACL-R. The precise causes of decreased corticospinal excitability following ACL-R remain unknown. Specifically, understanding whether overactive inhibitory or underactive facilitatory intracortical circuits influence the overall decrease in neural drive may provide very specific targets for future interventions. **Objective:** Determine if differences in intracortical inhibition and facilitation of the quadriceps exist between limbs of individuals with unilateral ACL-R. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Nineteen unilateral ACL-R patients (12F/7M; 21.73 ± 2.64 yrs; 168.85 ± 10.99 cm; 70.52 ± 14.03 kg; 50.63 ± 36.3 months post ACL-R; Tegner Score = 8.67 ± 1.14). **Interventions:** First, active motor threshold (AMT) was determined using single-pulse transcranial magnetic stimulation (TMS) to detect the lowest stimulus intensity required to elicit a measurable motor evoked potential ([MEP]>100μV; ICC = 0.93). Next, paired-pulse TMS was used to assess intracortical inhibition and facilitation through stimulation of the primary motor cortex of the brain. Both intracortical inhibitory and facilitatory measurement paradigms required a conditioning stimulus at 80% of active motor threshold (AMT) followed by a second stimulus at 120% of AMT, which was applied 3 and 15msec after the conditioning

stimulus, respectively. MEPs were collected bilaterally from the vastus medialis using electromyography. **Main Outcome Measures:** Peak-to-peak MEP amplitudes elicited from the second stimulus for intracortical inhibitory and facilitatory paradigms were separately averaged over 8 trials and normalized to MEP amplitudes collected with single-pulse TMS at 120% AMT. Outcome measures, termed short interval intracortical inhibition (SICI) and intracortical facilitation (ICF), were analyzed for inter-limb differences using separate paired-samples t-tests. Alpha level was set a priori at $P \leq 0.05$. Lower SICI ratios indicate greater intracortical inhibition, while larger ICF ratios indicate greater intracortical facilitation. **Results:** AMT averages (Injured: 48.16 ± 12.66; Uninjured:46.31 ± 13.44) were similar to means reported for ACL-R patients in the literature. The injured limb had significantly greater intracortical inhibition compared to uninjured limb (Injured: 0.47 ± 0.17, Uninjured: 0.68 ± 0.32, $P = 0.05$) There were no significant differences between limbs for ICF (Injured: 1.37 ± 0.71, Uninjured: 1.16 ± 0.40, $P = 0.361$). **Conclusions:** Alterations in voluntary neural drive of the quadriceps from the motor cortex following ACL-R may be caused by increased intracortical inhibition rather than insufficient intracortical facilitation. Understanding the specific intracortical circuits implicated in decreased neural drive to the lower extremity musculature following ACL-R may open up multiple treatment options including rehabilitative, pharmacological, or psychomotor interventions to improve muscle function and movement. Future therapeutic interventions may attempt to decrease the levels of intracortical inhibition to improve voluntary neural drive following ACL-R.

Free Communications, Rapid Fire Poster Presentations: Using the Functional Movement Screen in Athletic Populations

Wednesday, June 24, 2015, 8:00AM-9:30AM, Room 125/126; Moderator: Melanie McGrath, PhD, ATC

Screening of NCAA Division I Athletes Using the Functional Movement Screen

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

Context: The Functional Movement Screen (FMS) is an evaluation tool composed of 7 tests that assess the fundamental movements of an individual. To date there are no known studies that report normative values utilizing NCAA Division I athletes from a variety of sports. **Objective:** To determine if the total score on the FMS might predict incidence of lower extremity injury in Division I athletes. **Design:** Cohort study. **Setting:** Division I university athletic training facility. **Patients or Other Participants:** 305 Division I intercollegiate athletes (male: n = 134, female: n = 171; age = 19.6 ± 1.3years, height = 175.2 ± 11.4cm, weight = 70.9 ± 13.2kg) participated in this study. Athletes represented 11 different sports. **Interventions:** All subjects completed the seven FMS tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotational Stability). The FMS tests were evaluated on a four-point integer grading scale, 0-3, with a possible total score of 21. Each test was completed, at most, three times and the best score was used for the final score. The sum of all seven tests was used as the Total FMS score. Injury records were tracked for 12-months post-test period. If an athlete sustained an injury which resulted in being held out from one day of practice they were placed in the injured group. All other athletes were placed in the uninjured group. **Main Outcome Measures:** Total FMS score. A t-test was calculated to determine differences between the injured and uninjured participants. A priori alpha level was set at $p < .05$. A Receiver Operator curve (ROC) was used to calculate and identify if a particular total score would maximize sensitivity and specificity of who might sustain a lower extremity injury. **Results:** Out of the total of 305 participants, 130 sustained a qualifying injury during the study period (43%). The mean total FMS score of all athletes was 16.6 ± 1.9 (range 10-21). No significant difference existed between the injured (mean = 16.5 ± 2.0) and uninjured (mean = 16.7 ± 1.8) groups for the Total FMS score ($t303 = .70$, $p = .49$). ROC identified the area under the curve as .51, indicating that the total FMS score does not help to predict whether or not an athlete is more at-risk of sustaining an injury. **Conclusions:** From these data it appears that no specific Total FMS score was effective in identifying who might be at an increased risk of sustaining an injury. Subsequent studies should focus on the correlation between injuries and asymmetry in one of the five bilateral FMS tests or between injuries and the presence of a score of 1 on any of the seven tests.

Deep Squat Score Predicts Functional Movement Screen Asymmetries

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Context: Recent evidence suggests identification of movement asymmetries may be a valuable component of the Functional Movement Screen (FMS) when performing injury risk screening. The (FMS) assesses movement dysfunctions and asymmetries in performance of seven tests to predict musculoskeletal injury risk in a variety of populations. Despite the potential benefits of identifying movement asymmetries and corresponding injury risk, time constraints may prevent clinicians from administering tools like the FMS. Identifying one FMS component that can function as a screening mechanism for full testing may reduce time constraints and allow more clinicians to administer this tool to assess injury risk. **Objective:** To determine if performance on the deep squat test predicts the occurrence of asymmetries during the Functional Movement Screen. We hypothesize that deep squat scores of 0 or 1 will be associated with an increased risk of asymmetry. **Design:** Cross-sectional study. **Setting:** Biomechanics research laboratory and collegiate athletic training facility. **Patients or Other Participants:** 66 healthy NCAA Division I athletes (19.2 ± 1.12 years, 1.76 ± 0.14 m, 73.86 ± 14.70 kg) were recruited to participate in this study. **Interventions:** All participants performed the Functional Movement Screen and were scored utilizing the standard method. **Main Outcome Measures:** Participants were divided into high-risk and low-risk groups based on deep squat scores and presence of asymmetries. Asymmetry was defined as having a side-side score difference on any FMS test that was performed bilaterally. Scoring a 0 or 1 on the deep

squat and having an asymmetry on any FMS test were considered high-risk. A binomial logistic regression was performed to determine the odds ratio between deep squat risk category and asymmetry risk category. Alpha level was set a priori at $p < 0.05$. **Results:** Scoring a 0 or 1 on the deep squat increased the odds of having a FMS assessed asymmetry by 2.38 (95% CI: 1.03, 5.50, $p = 0.043$). **Conclusions:** Performance on the deep squat test may predict presence of asymmetries on the FMS. Specifically, the odds of having at least one asymmetry is 2.38 times higher for individuals with high-risk deep squat scores. This finding suggests that administering the deep squat test to identify individuals who are more likely to have an asymmetry may be a viable method for reducing time constraints while identifying patients who require further assessment.

Evaluation of the Functional Movement Screen as an Injury Prediction Tool Among Active Adult Populations: A Systematic Review and Meta-Analysis

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Context: The Functional Movement Screen is an assessment tool designed to assess quality of human movement. Research reports a significant difference between comprehensive or individual FMS scores of subjects who later experienced injury and those uninjured. These data provide support indicating that the test may identify those at high risk of sports related injury. **Objective:** The purpose of this study was to systematically review literature related to the predictive validity of the Functional Movement Screen (FMS). From the aggregated data, meta-analysis was conducted to determine prognostic accuracy of the FMS. **Data Sources:** PubMed, Ebscohost, Google scholar, and the Cochrane Review databases were searched between 1998 and Feb. 20th 2014 with terms and Boolean phrases: "Functional movement screen" and "Functional Movement Screen" AND "Prediction of Injury". **Study Selection:** All studies examining the ability of the FMS to predict injury among active adults were considered for inclusion. Inclusion was limited to studies published in peer reviewed journals. The study selection was unblinded and conducted by the primary researcher. **Data Extraction:** The primary author conducted risk of bias assessment according to guidelines recommended by the PRISMA statement and Cochran Handbook. The QUADAS-2 study quality assessment tool was utilized and data relevant to predictive validity of the FMS were extracted. Overall bias for the included seven studies was low in respect to patient selection and flow and timing. Study quality assessment scored one study 5/7, two studies were scored 3/7 and four studies were scored 2/7 for quality. **Data Synthesis:** The meta-analysis indicated the FMS to be more specific (85.7%) than sensitive (24.7%) with a positive predictive value of 42.8% and a negative predictive value of 72.5%. AUC was determined to be 0.587, LR + 1.7, LR- .87, CI (95%) = 0.6-6.1 and effect size was determined to be 0.68. **Conclusions:** Based upon analysis of the current literature, findings do not support the predictive validity of the FMS. The methodological and statistical limitations identified by this study threaten the ability of the research to determine the predictive validity of FMS.

Associations of the Star Excursion Balance Test and Functional Movement Screen With Isolated Lower Extremity Strength and Range of Motion

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Context: Emphasis on pre-participation examinations for prediction of musculoskeletal injury risk is growing. The Star Excursion Balance Test (SEBT) and Functional Movement Screen (FMS) are established as simple and efficient functional performance measures capable of predicting lower extremity injury risk. While suboptimal SEBT and FMS performances are influenced by multiple factors, the contribution of hip strength and flexibility to these global measures of function is unknown. Examination of hip strength and flexibility influences on the SEBT and FMS may direct clinicians to better methods of correcting functional deficits. **Objective:** Determine the relationships of isometric hip strength (IHS) and hip passive range of motion (PROM) with functional performance measures. **Design:**Cross-sectional. **Setting:** Athletic training facility. **Patients or Other Participants:** Forty-two NCAA Division I women's soccer players (19.65 ± 1.12 yrs; 166.93 ± 3.84 cm; 60.99 ± 4.31 kg) volunteered. **Interventions:** Prior to the competitive season, all participants cleared for soccer competition were tested bilaterally in the anterior (SEBT-A), posteromedial, and posterolateral directions of the SEBT; the deep squat, in-line lunge, hurdle step, and straight leg raise, comprising a modified FMS (mFMS); PROM of hip internal (IR) and external rotation (ER) in a prone position; and IHS-extension in a prone, knee-flexed position. Twenty-one participants were also assessed bilaterally for IHS-abduction in a side-lying position and IHS-ER in a prone position. **Main Outcome Measures:** Three trials of each SEBT direction were averaged and normalized as a percentage of stance leg length. The mean of the three averaged, normalized SEBT scores was used to create a SEBT composite score. The lowest scores of three trials for each of the mFMS tests were summed to obtain a single value (#/12). PROM (degrees) was measured using a goniometer with the participant prone and knees flexed to 90°. Three five-second IHS trials were assessed using a handheld dynamometer. Peak IHS scores were recorded in Newtons. Normalized torque values were obtained by multiplying the average force output by the length of the moment arm, then dividing by body mass (Nm/kg). Pearson product correlations were used to assess relationships of SEBT and mFMS scores with PROM and IHS. Significance was set a priori at $P < 0.05$. **Results:** IHS-extension ($r = -0.314$, $P = 0.003$), IHS-abduction ($r = -0.569$, $P < 0.001$), and IHS-ER ($r = -0.416$, $P = 0.006$) were negatively correlated with SEBT-A scores. PROM of IR ($r = 0.365$, $P = 0.001$) and ER ($r = 0.231$, $P = 0.032$) were positively correlated with SEBT-A scores. IHS-extension was positively correlated with mFMS scores ($r = 0.231$, $P = 0.032$). **Conclusions:** The SEBT-A was inversely related to all IHS variables, indicating that higher SEBT-A scores could potentially mask underlying hip strength deficits in female soccer players. The SEBT and mFMS were weakly correlated with PROM and IHS-extension. Thus, the SEBT and mFMS may not be appropriate indicators of isolated hip strength and PROM, suggesting these outcomes should be measured independently from the SEBT and mFMS.

Relationship Between Functional Movement Screen Score and Single Leg Anterior Reach Performance

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Context: The Functional Movement Screen (FMS) assesses movement during seven tests to predict musculoskeletal injury risk in a variety of populations. Although it is theorized that the FMS partially assesses postural control, there is little evidence regarding the relationship between dynamic postural control ability and FMS performance. The Single Leg Anterior Reach (SLAR) test is a clinical tool developed to assess dynamic postural control. Identifying relationships between SLAR scores and FMS performance may indicate that dynamic postural control ability may alter FMS performance. Understanding differences in dynamic postural control between FMS risk categories may help clinicians determine intervention strategies to reduce functional movement deficits. **Objective:** To determine if there is a difference in SLAR distance between individuals who score above and below a 14 on the FMS. We hypothesize that individuals who score below a 14 on the FMS will have poorer dynamic postural control indicated by reduced reach distance. **Design:** Cross-sectional study. **Setting:** Biomechanics research laboratory and collegiate athletic training facility. **Patients or Other Participants:** 43 NCAA Division I athletes (19.22 ± 0.97 years, 1.73 ± 0.12 m, 69.69 ± 12.64 kg) were recruited to participate in this study. **Interventions:** All participants performed the SLAR test bilaterally and the Functional Movement Screen. **Main Outcome Measures:** Participants were divided into high-risk and low-risk groups based on FMS composite scores; scoring below a 14 on the FMS was considered high-risk. The reach distance of three trials on the SLAR test were normalized to the individuals' respective leg lengths and then averaged for data analysis. Independent samples t-tests were performed to determine

if there were statistically significant differences in mean SLAR distance between high-risk and low-risk FMS groups. Alpha level was set a priori at $p < 0.05$. **Results:** Left and right leg mean SLAR distances were significantly different between high-risk and low-risk FMS groups (Left: high-risk = 65.85 ± 5.13%, low-risk = 73.41 ± 3.91%, $p < 0.001$; Right: high-risk = 67.15 ± 5.07%, low-risk = 73.40 ± 5.08%, $p < 0.001$). There was a reach difference of 7.56% (95% CI: 4.41,10.70) between groups when performing the SLAR on the left leg and a difference of 6.25% (95% CI: 2.93,9.58) between groups on the right leg. **Conclusions:** The results of this study indicate that performance on the Functional Movement Screen may be partially affected by dynamic postural control ability. Specifically, individuals who score below a 14 on the FMS may have postural control deficits compared to individuals who score above a 14. Clinicians should consider assessing dynamic postural control in individuals who are categorized as high-risk following FMS testing.

Is There a Relationship Between the Functional Movement Screen, Star Excursion Balance Test, and Balance Error Scoring System?

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Context: The Functional Movement Screen (FMS), Star Excursion Balance Test (SEBT), and Balance Error Scoring System (BESS) are common screening tools for estimating injury risk. Understanding potential relationships between these instruments may increase time efficiency for clinicians and provide insight into the association between movement capacity and postural stability. **Objective:** To evaluate associations between FMS, SEBT, and BESS scores. **Design:** Correlational. **Setting:** Athletic training facilities. **Patients or Other Participants:** Fifty-two intercollegiate athletes (males = 36, age = 19.6 ± 1.2 years, height = 185.4 ± 7.6 cm, weight = 86.9 ± 12.4 kg; females = 16, age = 21.0 ± 3.1 years, height = 164.9 ± 7.1 cm, weight = 74.9 ± 19.7 kg) representing eight sports and cleared for unrestricted sport participation. **Interventions:** Participants completed the FMS, SEBT, and BESS, in random order, during one testing session. Testing order was randomized to control for fatigue and learning effects. **Main Outcome Measures:** The FMS includes seven movement tasks, which are scored on a 0-3 scale. Task scores are summed to produce a composite score, with higher scores indicating better movement capacity. The SEBT includes three reaching tasks (anterior, posteromedial, posterolateral). Reach distances are used to calculate a composite score, with higher scores indicating better dynamic postural stability. The BESS consists of three stance conditions (double leg, single leg, tandem) on two surfaces (firm, foam). Errors are counted for each task and summed to produce a composite score, with lower scores indicating better static postural stability. All screening tools report acceptable intra-rater (intraclass correlation: FMS = 0.74-0.92, SEBT = 0.67-0.96, BESS = 0.50-0.98) and inter-rater (intraclass correlation: FMS = 0.18-0.98, SEBT = 0.84-0.93, BESS = 0.44-0.96) reliability. All tests were administered by one rater. Spearman's rho correlations were used to evaluate the relationships between the task and composite scores of the FMS, SEBT and BESS. **Results:** A fair negative correlation was found between FMS asymmetry and SEBT composite ($r = -.31$, $p = .03$) scores. Fair positive correlations were reported for the FMS rotary stability task and SEBT anterior ($r = .37$-$.41$, $p \leq .007$) and posteromedial ($r = .31$, $p = .03$) reaches. When comparing FMS and BESS scores, fair negative correlations were reported for the following: FMS deep squat and all BESS foam tasks (double leg: $r = -.34$, $p = .02$; single leg: $r = -.33$, $p = .02$; tandem: $r = -.40$, $p = .003$), FMS inline lunge and BESS single leg-foam ($r = -.39$, $p = .004$), FMS trunk stability push up and tandem-foam ($r = -.31$, $p = .025$), and FMS composite and BESS single leg-foam ($r = -.37$, $p = .007$). Little to no correlations were reported for the remaining comparisons. **Conclusions:** Results indicate that each instrument provides distinct information about function, with only small areas of overlap. Associations between the FMS asymmetry score and SEBT composite score may indicate a relationship between movement asymmetry and postural stability. Associations between the FMS deep squat and BESS foam tasks may be related to underlying neuromuscular control factors. Further research is needed to examine these, and other relationships that may exist between commonly used screening tools.

Functional Movement Screen Asymmetry Scores and Side of Injury in Collegiate Athletes

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Context: Pattern asymmetry in the Functional Movement Screen (FMS) increased relative risk of injury among professional football players. However, the relationship between side of asymmetry and side of injury is unclear and could assist in corrective program design. **Objective:** To determine if individuals with asymmetry have an equal distribution of injuries to the higher scoring side, lower scoring side, and neither side. **Design:** Prospective cohort. **Setting:** Athletic Training Room. **Patients or Other Participants:** Collegiate athletes in 12 Olympic sports (n = 232; 142 female, 90 male). **Interventions:** FMS scores were obtained by trained raters in August 2011. Asymmetry was defined as the presence of unequal total right and total left FMS scores. Injuries were tracked during the fall semester by the teams' athletic trainers. Injury was defined as a documented incident in which an athlete was evaluated and provided medical attention, regardless of time loss. **Main Outcome Measures:** A Chi-Square goodness of fit (one-sample) test was used to determine if an equal distribution of injury occurrence to the lower scoring, higher scoring, or neither side existed among those with an asymmetry (α=0.05). The expected distribution was set as an equal probability of injury to the lower or higher scoring side or neither side (33%). Follow up tests were performed and effect size and power were calculated. **Results:** Of the 232 participants, 92 (40%) presented with an asymmetry and 140 (60%) without asymmetry. In the asymmetrical group, injury occurred to the lower scoring side in 11/92 (12%) and the higher scoring side in 9/92 (10%) participants, while 72/92 (78%) had no injury ($\chi2(2, N = 92) = 83.63$, $p < .001$, Cohen's $w = 0.45$, $1-\beta = 0.98$). Follow up tests indicated there was a difference in proportion of injuries between the lower scoring side and neither side ($\chi2(1, N = 83) = 44.83$, $p < .001$, Cohen's $w = 0.54$, $1-\beta = 0.99$) and the higher scoring side and neither side ($\chi2(1, N = 81) = 49.00$, $p < .001$, Cohen's $w = 0.60$, $1-\beta = 0.99$). There was no difference in proportion of injuries to the higher or lower scoring side ($\chi2(1, N = 20) = 0.20$, $p = 0.66$, Cohen's $w = 0.01$, $1-\beta = 0.05$). **Conclusions:** The asymmetrical group did not injure their lower or higher scoring side more frequently. Proportions of injuries to the lower scoring side (12%) and higher scoring side (10%) were similar and less than the hypothesized proportion of 33%. Despite the presence of asymmetry, the majority of participants did not sustain an injury. The proportion of the asymmetrical group with no injury (78%) was greater than the hypothesized proportion of 33%. Clinicians should consider implementing corrective exercise programs for both limbs in those with asymmetry. Future research should address the presence of upper versus lower extremity asymmetry in relation to side and location of injury, to determine if corrective programs should target higher or lower scoring limbs or both in those with asymmetries.

Relationships Between Core Stability Measurements and the Functional Movement Screen in Collegiate Female Soccer Players

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Context: The Functional Movement Screen (FMS) requires muscle strength, motor control, and flexibility; and therefore, may assist in identifying individuals who are at risk for injury. Since, core stability includes many of the same physiological components measured by the FMS, it is hypothesized that core stability plays a role in an individual's performance of the FMS. However, there is a gap in the current literature supporting this theory. **Objective:** The purpose of this study was to investigate the relationships between the FMS and measurements associated with core stability. **Design:** Cross-sectional design. **Setting:** Core stability measurements and FMS data were collected in the athletic training room. **Patients or Other Participants:** Nineteen female college players (age: 19.1 ± 0.91 yr., weight: 64.5 ± 8.06 kg, height: 1.66 ± 0.07 m) volunteered for the study. **Interventions:** Core stability measurements administered included tests to assess trunk and hip strength, flexibility and motor control. Isometric trunk flexion and extension, hip extension, abduction, and external rotation comprised the strength tests. The flexibility group included hip flexor and hamstring flexibility and the stork test, single leg hop for distance, and leg lowering test comprised the motor control group. The core stability measurements and seven tests of the FMS were conducted on a separate days. **Main Outcome Measures:** Separate Spearman's Rho correlations were performed to identify the associations between the core stability measurements and the FMS tests. **Results:** Significant correlations were observed between the deep squat and trunk flexion strength (Spearman's = 0.427, p = 0.027), trunk extension

strength (Spearman's = 0.432, p = 0.025), hamstring (Spearman's = 0.588, p = 0.002) and hip flexor flexibility (Spearman's = 0.427, p < 0.001), and leg lowering test (Spearman's = 0.429, p = 0.023). The Hurdle step had a significant relationship with hip flexor flexibility (Spearman's = -0.363, p = 0.049), and the in-line lunge had a significant correlation with the one-minute sit-up test (Spearman's = 0.447, p = 0.019). Significant correlations between the shoulder mobility test and trunk extension strength (Spearman's = -0.420, p = .029), hip abduction strength (Spearman's = 0.468, p = 0.016), and sit-up test (Spearman's = -0.366, p = 0.047) were observed. The active straight leg raise had a significant correlation with hamstring flexibility (Spearman's = 0.420, p = 0.026) and the trunk stability push up had significant relationship with the sit up test (Spearman's = -0.434, p = 0.022). Last, the rotary stability test had significant correlations with hip extension strength (Spearman's = 0.429, p = 0.026), leg lowering (Spearman's = 0.637., p = 0.001), and single leg hop for distance (Spearman's = -0.380, p = 0.041). **Conclusions:** Based on the results, there were several significant relationships between the FMS tests and core stability measurements. However, several of the correlations were negatively related; therefore, the association between core stability and the FMS cannot be determined.

The Influence of Physical Characteristics and Self-Reported History on Functional Performance Tests

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Context: Recent evidence suggests that risk for lower extremity injuries may be predicted by assessing musculoskeletal function with the SEBT and FMS. However, these prediction tools may be influenced by multiple factors such as previous history of lower extremity injury, competition level, age, and body mass index (BMI). In order to develop comprehensive and successful predictive models, it is important to understand these potential associations, especially in high-risk populations such as football players. **Objective:** Examine the association of previous history of ankle or knee injury, level of competition (high school [HS] or college division I [DI]), age and BMI has on SEBT and FMS performance in football players. **Design:** Cross-sectional descriptive study. **Setting:** Athletic Training facility. **Patients or Other Participants:** Seven hundred forty-eight football players from DI NCAA (n = 331, 19.85 ± 1.38 years, 186.52 ± 7.02 cm, 103.29 ± 19.08 kg) and HS (n = 417, 15.80 ± 1.14 years, 177.11 ± 8.41 cm, 80 ± 17.25 kg) teams volunteered. **Interventions:** All participants were cleared for full participation in football at the time of testing. Anterior (SEBT-A), posterior-medial (SEBT-PM) and posterior-lateral (SEBT-PL) reach directions of the SEBT, and the hurdle step, straight-leg raise, in-line lunge, and the deep squat of the FMS, were collected before the start of each team's season. **Main Outcome Measures:** The SEBT-A, SEBT-PM and SEBT-PL scores were calculated by taking the average of three trials for each direction and normalizing those to stance leg length(%). A composite score was calculated from the mean of the three normalized reach directions. Scores on the SEBT and composite were represented as percentages. A modified FMS score (FMS-M) was calculated by taking the sum of the performance of the four selected movements (#/12). BMI was calculated from the height(m) and mass(kg) for each participant. Previous history of ankle or knee injuries was self-reported. As data were non-normally distributed, separate Mann-Whitney U tests were used to assess differences between each categorical variable (previous history and competition level) for all outcome measures. Spearman correlations were run between continuous variables (age and BMI) and each outcome variable. Significance was set a priori at $P \leq 0.05$. **Results:** Compared to DI players, HS athletes scored higher on the SEBT-PM (HS:88.5 ± 11.5%,DI: 84.2 ± 9.8%; P < 0.001), but lower on the SEBT-PL(HS:72.64 ± 1.2%,collegiate:78.5 ± 11.2%;P < 0.001), and SEBT composite score (HS:75.6 ± 8.4%, DI: 79.2 ± 8.1%; P < 0.001). In addition, HS players scored lower on the FMS-M (6.8 ± 1.6) versus DI players (9.6 ± 1.6; P < 0.001). Age was weakly correlated with SEBT-PM (ρ = 0.224; P <0.001), SEBT-PL (ρ = 0.223; P < 0.001) and the SEBT composite score (ρ = 0.213; P < 0.001). Age was moderately correlated with FMS-M (ρ = 0.551; P < 0.001). Lastly, BMI was weakly correlated with SEBT-A (P < 0.001, ρ = -0.276) and FMS-M (P < 0.001, ρ = 0.194) scores. Performance on the functional tests did not differ between participants with or without ankle or knee injury history (P > 0.05). **Conclusions:** Level and age should be considered when assessing SEBT and FMS outcomes. This has important implications for developing successful prediction models for lower extremity injury risk in football players.

The Relationship Between Weighted Functional Movement Screening and Military Physical Performance Tests

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Context: The Functional Movement ScreenTM (FMS) is used in military settings to predict both injury risk and physical performance. Previous findings have demonstrated only weak relationships between FMS scores and performance outcomes. This lack of association may stem from (1) a ceiling effect whereby relatively low performing individuals can achieve a high score on the screen, and (2) a lack of specificity with respect to performance outcomes. A modified FMS that challenges the postural control system with added load may increase the screen's sensitivity to movement deficits that affect military physical performance. **Objective:** To quantify the effect of load on FMS scores and determine the extent to which military physical performance outcomes can be predicted using the modified FMS condition with a load (FMSM) and the unloaded FMS control condition (FMSC). **Design:** Crossover Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Thirteen female and six male recreationally active adults (170.0 ± 10.1 cm, 65.4 ± 12.2 kg, 21.4 ± 1.3 years). Participants were free of injury for the 6 months preceding data collection. **Interventions:** The FMS was administered with and without an 18.10 kg weight vest. This standardized load was chosen to reflect standardized military occupational demands and is similar to loads used in previous investigations into military performance. Condition order was randomized. After completing the screen in both conditions, participants completed a physical performance battery consisting of sprints (27.43 m), a 400 m run, an agility course, and a simulated partner rescue (68.04 kg). Differences in FMS scores were compared using a one-tailed dependent t-test ($\alpha = .05$). One-tailed simple linear regression was used to predict performance outcomes from FMS scores ($\alpha = .05$). **Main Outcome Measures:** Composite FMS scores (0-21) were recorded for both screening conditions by a single rater. Performance in the physical test battery was evaluated via completion times (seconds) recorded by infrared timing gates. **Results:** Compared to FMSC, composite scores were lower in the FMSM condition (FMSC = 15.16 ± 1.77, FMSM = 12.68 ± 1.77, $t(18) = 6.18$, $P < .001$). Mean completion times for performance tests were as follows: sprint = 4.50 ± .58 s, 400 m = 98.86 ± 19.76 s, agility course = 156.53 ± 23.13 s, and partner rescue = 30.54 ± 11.46 s. Higher FMSC scores were predictive of faster completion times on the agility course ($B = -6.29$, $R^2 = .23$, $P = .02$). Higher FMSM scores were predictive of faster times in the 400 m ($B = -4.28$, $R^2 = .15$, $P = .05$) and agility course ($B = -5.01$, $R^2 = .15$, $P = .05$). **Conclusions:** Movement quality as assessed by the FMS is reduced when the screen is performed with an 18.10 kg load. Relationships between performance outcomes and composite scores from either condition were modest; however, the addition of a load may help address concerns regarding lack of specificity and ceiling effects related to the FMS. Future research should seek to identify specific biomechanical and neural mechanisms by which movement quality supports agility and 400 m run performance.

Gender Differences in the Overhead Squat Assessment

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Context: Movement pattern deficits have been strongly linked to musculoskeletal injury (MSK-I) in military and athletic populations. However, such deficits, and potential gender differences in movement patterns have not been assessed in those entering military basic training. **Objective:** To investigate movement pattern deficits as a function of gender in U.S. Navy applicants entering basic training. **Design:** Cross-sectional study. **Setting:** Military Entrance Processing Station (MEPS). **Patients or Other Participants:** U.S. Navy applicants (Male = 270, Female = 77). **Main Outcome Measures:** The overhead squat (OHS) is a clinical assessment tool used to identify movement compensations (errors) at the shoulder, trunk, hip, knee and ankle during a double leg squat. U.S. Navy applicants (N = 347: Male n = 270, 22.5 ± 10.5 yrs, 177.4 ± 7.1 cm, 77.2 ± 11.3 kg; Female n = 77, 22.0 ± 11.0 yrs, 162.2 ± 7.6 cm, 77.2 ± 11.3 kg) from the Baltimore MEPS performed the OHS 24 hours before being shipped to basic training. OHS performance was evaluated anteriorly for foot external rotation, medial knee displacement, and lateral knee displacement; laterally for excessive forward trunk lean, lower back arching, lower back rounding, and arms falling forward; and posteriorly for heel or foot rise, foot arch flattening, and asymmetrical lateral weight shift. Movement errors in each view were ordinally scored from 0 to 2. A score of 0 indicated the movement was completed without error; 1 indicated the error occurred unilaterally; and 2 indicated the error occurred bilaterally. Overall impression scores

were also incorporated, with a score of 0 indicating excellent execution, 1 for good execution, and 2 for poor execution, yielding a maximum OHS score of 14. Independent samples t-tests were conducted to determine gender differences in overall OHS scores. Individual item differences were evaluated with Pearson Chi-Square tests or Fisher's Exact test when error counts were low. **Outcome Measures:** Means ± standard deviations. Pearson Chi-square, Fisher's Exact test and significance values. **Results:** Female applicants demonstrated a greater number overall OHS errors compared to male applicants (6.1 ± 2.7 vs. 4.8 ± 2.5 errors, $t345 = -3.89$, $p < 0.001$). Individual item analyses showed females displayed more medial knee displacement errors than males (61% vs. 40%; $\div 2 = 10.34$, $p = 0.001$). Additionally, females had more lower back arching (25% vs. 9%; $\div 2 = 14.7$, $p < 0.001$), lower back rounding (7% vs. 2%; Fisher's Exact test, two-tailed $p = 0.047$), and asymmetrical lateral weight shift errors (43% vs. 26%; $\div 2 = 8.23$, $p = 0.004$). A higher percentage of females displayed poor squat execution (51% vs. 33%; $\div 2 = 12.45$, $p = 0.002$). **Conclusions:** Female Navy applicants showed significantly greater numbers of movement compensations and poor execution on the OHS assessment compared to males, one day prior to shipping to basic training. Females also exhibited more medial knee displacement, asymmetrical lateral weight shifts, lower back arching, and lower back rounding errors compared to males. This cohort will be followed to determine whether OHS scores predict MSK-I incidence or dropout during basic training.

Interrater and Intrarater Reliability of the Functional Movement Screening: A Systematic Review

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Context: The Functional Movement Screen (FMS) is a 7-item assessment tool designed to evaluate functional movement patterns essential to physical activity participation. This tool has been used to assess injury risk and as an outcome during patient treatment. Numerous studies have examined the interrater and intrarater reliability of the FMS. However, a synthesis of this literature to make an overall recommendation of the clinometric properties of this tool is not available. **Objective:** The purpose of this systematic review was to synthesize and critically appraise the published evidence describing the interrater and intrarater reliability of the FMS. **Data Sources:** PubMed and EBSCOhost (CINAHL, MEDLINE, SportDiscus) databases were systematically searched from inception to September 2014. Searches were limited to English, humans, and used key words including functional movement screen, FMS, reliability, interrater reliability, intrarater reliability, adolescent, high school, interscholastic, adult, college, intercollegiate, military and physically active. A hand search of the references in the articles identified was also conducted. **Study Selection:** Studies were included if the primary purpose was to determine the interrater or intrarater reliability of the FMS, assessed and scored all 7-items using the standard 0-1-2-3 scoring system, provided a composite score and employed intraclass correlation coefficients to determine reliability. Studies were excluded if reliability was not the primary aim, subjects reported injury at the time of data collection, or a modified FMS or scoring system was utilized. **Data Extraction:** Two reviewers assessed studies for inclusion and methodological study quality using the Quality Appraisal of Reliability Studies (QAREL). Studies were deemed high quality if they received a QAREL score > 60%. Relative reliability was summarized by extracting the ICCs. ICCs were interpreted as acceptable (> 0.75) or unacceptable (< 0.75). Study quality and results were synthesized qualitatively with a modified level of evidence approach. **Data Synthesis:** The search resulted in 82 possible studies and seven met the eligibility criteria. Six studies assessed inter-rater reliability of which two were high quality. The median interrater ICC was 0.88 (range: 0.18-0.98). Six studies assessed intrarater reliability of which two were high quality. The median intra-rater ICC was 0.89 (range: 0.37-0.96). The combination of study results and study quality indicated there is moderate evidence that interrater and intrarater reliability of the FMS is acceptable. **Conclusions:** The results of the interrater analysis indicate multiple clinicians can utilize the FMS and expect similar total scores when assessing the same client. The results of the intrarater reliability analysis indicate clinicians can score the same client similarly when there is no change in health status. For both interrater and intrarater reliability, less experienced clinicians demonstrated lower reliability estimates. Overall, the FMS is a reliable tool for clinical practice; however, methods to improve reliability in novice raters should be examined.

Community Associated Methicillin Resistant Staphylococcus Aureus (CA-MRSA) Infection Incidence and Management of Suspicious Bacterial Lesions in Northeastern High Schools and Intercollegiate Athletic Programs

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Context: Community Associated Methicillin Resistant Staphylococcus Aureus (CA-MRSA) infections are an increasing management challenge among both the general population and at risk groups such as athletes. Research has focused on retrospective outbreaks and environmental studies, which have provided information to create recommendations and position statements regarding best practices. Although recommendations offer effective solutions to controlling and managing infections, prospective investigations into recommended treatment protocol efficacy is lacking. Few studies prospectively examined incidence rates, referral practices and physician management protocols for CA-MRSA infections among student-athletes. **Objective:** To prospectively assess CA-MRSA infection incidence, sport risk, referral practices and physician management protocols for suspicious bacterial lesions over the 2013-2014 academic year. **Design:** Descriptive epidemiology study. **Setting:** Intercollegiate and high school athletic programs within the National Athletic Trainers Association (NATA) District Two. **Patients or Other Participants:** Eight-seven Certified Athletic Trainers (ATs) responded to survey request. The ATs provided care for 41,011 student athletes. **Interventions:** Bimonthly questionnaires consisted of 14 questions within four content areas: (1) demographic sport information, (2) CA-MRSA infection rate, (3) suspicious bacterial skin lesion infection rate, (4) management of CA-MRSA infections and suspicious bacterial skin lesions. Three experts in the field assessed the questionnaire for content validity. The internal consistency of the selected items is considered acceptable (Cronbach's alpha = .713). **Main Outcome Measures:** Frequencies, ANOVA, incidence rates and relative risk were calculated to determine differences between settings and sports for CA-MRSA infections. **Results:** The overall CA-MRSA infection incidence was 16.3 per 10,000 athletes (95% CI, 13 to 21). The incidence and relative risk were significantly higher in wrestling (89.0 per 10,000, 95% CI, 50, 158: RR = 6.18, 95% CI 3.25, 11.75, $P < .05$) and football (61.4 per 10,000, 95% CI, 42, 90, RR = 5.51, 95% CI, 3.38, 9.00, $P < .05$) compared to remaining queried athletic population. The majority of the suspicious bacterial lesions requiring referrals (66.5%, n = 125) were referred to either primary care or general physicians. Of the 324 suspicious bacterial lesions presenting to ATs, 23.1% (n = 75) underwent culture testing and 8.6% (n = 28) had susceptibility testing. The majority of patients (48.9%, n = 67) with specifically designated antibiotics received prophylactic antibiotic coverage for CA-MRSA regardless of diagnostic confirmation. **Conclusions:** Athletes, particularly contact athletes, suffer a higher rate of CA-MRSA infections compared to the general population. Despite recommended and practiced preventative measures and recommendations, the incidence of CA-MRSA infection among athletes remains high. Upon referral, many cases of suspicious bacterial lesions are issued prophylactic antibiotics, yet management protocols with regards to diagnostic confirmation vary from established recommendations. Likewise, the variance in referral and management protocols necessitate that ATs continue to assess the current standard of care to better treat and advocate for student-athletes.

Myasthenia Gravis in a Division I Female Soccer Player: A Case Report

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Background: A 21-year-old Division I women's soccer player (Height: 117 cm, Weight: 68 kg) reported to pre-participation physicals prior to her junior year with symptoms including blurred vision, slurred words, blackouts, and incontinence. The physician ordered an MRI of the brain and lumbar region and a 48 hour Holter Exam, all returned normal. A month after testing, the athlete was referred to a neurologist who ordered a Magnetic Resonance Angiogram (MRA) and Electroencephalogram (EEG) of the brain to evaluate symptoms. The MRA revealed a 3mm aneurism and the EEG was normal. Subsequently, she was referred to a neurosurgeon for evaluation of the aneurism, and cleared by the neurologist to participate contingent on symptoms not worsening. Three weeks later the athlete presented with loss of vision, drooping of the left eye, severe headache, hoarse voice, and decreased muscular control during a training session. The athlete was taken to the hospital and diagnosed with Bell's palsy. **Differential Diagnosis:** Bell's palsy, Myasthenia Gravis, Thymoma, Mitochondrial Myopathy, Multiple Sclerosis, lymphocyte disorder. **Treatment:** Two days after admittance to the hospital she followed up with the neurologist who found elevated creatine kinase levels. A CT scan of the chest and EMG were ordered to rule out Thymoma and muscular disease. The athlete was also prescribed a trial of medications for possible Myasthenia Gravis (MG). Chest CT scan and EMG were clear and medications were effective in controlling the symptoms. Three months later, the patient sought a second opinion from The Mayo Clinic, which confirmed previous symptoms and no new diagnoses. Four months following the initial evaluation a muscle biopsy returned negative ruling out muscular sclerosis and Mitochondrial

Myopathy. The athlete underwent a spinal tap and genetic testing for lymphocyte disorder due to elevated lymphocyte levels, but both returned negative. Based on the effectiveness of the medication to control her symptoms, and the exclusion of other diagnoses with the various tests performed, consulting physicians finalized their diagnosis of MG. Pyridostigmine Bromide, an acetylcholinesterase inhibitor, was prescribed to control the symptoms of MG with ice immersion following activity for core temperature regulation. **Uniqueness:** MG also known as "grave muscular weakness" is a very rare autoimmune disease that affects 1/5,000 Americans. When acetylcholine receptors at the neuromuscular junction are altered or destroyed, as in the case of MG, there is a decrease in the nerve impulses sent to the muscle which results in muscular weakness. There is no known cure for MG but there are treatments to help manage it. Patients with MG normally do not engage in elite level of muscular activity as a Division I soccer athlete would, exacerbating the difficulty of the athlete to regain muscle strength and control her symptoms. **Conclusions:** The athlete returned to practice 14 months after initial complaints and one month later was able to play 24 minutes in a game with no limitations. The athlete currently remains on medication, though she no longer plays soccer. She still struggles with controlling MG and still has frequent ER visits, but lives a relatively normal life. When athletes present with neurological symptoms, it is important to continually evaluate and maintain open communication with other health care professionals. Frequent follow-ups and additional testing may be necessary to come to a final diagnosis. Alternative approaches should be considered to both provide the most appropriate medical care and allow the athlete to continue to participate in their sport.

Management of Primary Cortisol Resistance in a Collegiate Basketball Athlete

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Background: An 18-year-old female collegiate basketball player presented to the athletic training room during preseason physicals with a history of Primary Cortisol Resistance (PCR). She reported having symptoms of fainting since age 14. Before she faints, the athlete experiences a prodromal phase of numbness, mostly in her arms, dizziness, tachycardia, and dysphasia. In high school, initial tests were conducted on her heart, including stress tests, electrocardiograms and echocardiograms; all results were inconclusive. She also reported a history of low blood pressure (~85/55), which would drop throughout the day. Doctors believed stress and psychological factors to be the cause of her symptoms before diagnosing her with pre-syncope. She reported she was constantly fatigued, nauseous, and dizzy and started fainting daily by age 16. At that time, CT scans and MRIs were conducted on her brain and returned negative, then her hormones were tested through extensive blood testing. The endocrinologist diagnosed her with PCR at 18 years old. The athletic trainer notified the team physician, who ordered more blood tests, which came back similar to previous tests. The athlete is currently prescribed dexamethasone, prednisone, Florinef, and iron and vitamin supplements. **Differential Diagnosis:** PCR confirmed through cortisol level tests. **Treatment:** The certified athletic trainer monitors her during practice and games. Every 10 minutes the athlete takes a mandatory water break, supervised by the athletic trainer or coach. The athlete is also given electrolytes before every practice. With this intervention, the athlete has fainted on average once a week since the season started, typically coinciding with exams. Although exercise stress increases the chances of fainting and other symptoms, the athlete is cleared for full participation. Academic stress is known to increase her symptoms as well, explaining the syncope episodes before exams. Due to the prodromal symptoms, the athlete is advised to sit or lie down at the onset of numbness, dizziness, tachycardia, or dysphasia. The athlete looks as though she is falling asleep while she faints, and about 10 seconds later, she is re-energized and ready for practice. The athletic trainer holds her out for 5 minutes post-syncope episode, and then has her run a lap around the gym. At this point if she reports no symptoms, she is allowed to return to play. **Uniqueness:** There are few studies on PCR, and no available literature on PCR in athletics. PCR is a rare genetic disorder, with unknown prevalence. Typically, hypertension is a symptom, yet this athlete presented with hypotension which is being managed with medication. **Conclusions:** Student-athletes undergo significant stresses, but it is important for athletic trainers not to disregard their symptoms as solely stress-related. PCR is an uncommon hereditary condition where the body is unable to respond to cortisol. Cortisol is released in response to stress and low blood glucose levels, functioning to increase blood sugar and activating anti-inflammatory and anti-stress pathways. Proper medication can help control symptoms, yet cannot cure the condition. This athlete's main symptom is syncope, preceded by numbness, dizziness, tachycardia, and dysphasia. The athlete's main goal is to continue playing basketball throughout her collegiate career, and with the intervention of water breaks and electrolytes, the athlete has been successful in achieving her goal but will be closely monitored for symptom progression.

Rare Elongated Heart Rhythm in a Female Basketball Player: Case Report

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Background: The patient is a 16 year old, female, high school basketball player. The patient has been diagnosed with prolonged QT syndrome. She had unreported episodes of chest pain leading up to the incident. The chest pain incident lasted for 30 minutes throughout a routine warm-up and game. The patient's described pain pattern was left precordial without the presence of radiating symptoms. During an in-season basketball game, the patient began experiencing a sudden onset of shortness of breath and dizziness. She reported a single visual blackout episode during a basketball game without suffering a complete loss of consciousness with duration of two minutes; signs and symptoms included light-headedness, foggy vision, and black spots. EMS activation was not necessary and the patient's parents were notified. She does not have a past medical history or family history of any cardiac related episodes, sudden death, arrhythmias, or cardiac abnormalities. **Differential Diagnosis:** Mildly prolonged QTc without prolonged QT syndrome, non-cardiac chest pain, Marfan's Syndrome, pericarditis, acute angina, cardiac arrhythmia, secondary symptoms of asthma. **Treatment:** The patient was instructed to cease activity immediately as the initial treatment. The rescue inhaler was administered after the visual blackout due to confusion of what had just occurred. The athlete was referred to a cardiologist following a visit to her primary care physician three days after the initial episode. Her initial resting vitals were all within normal limits (her heart rate was 62 bpm with a regular rhythm, a respiratory rate of 12 that was unlabored, and her blood pressure was 121/73). A cardiac exam showed a quiet precordium. The precordium is characterized by the part of the ventral surface of the body overlying the heart and stomach that comprises the epigastrium and the lower median part of the thorax. Her EKG showed the presences of a mild prolonged QTc. The specific EKG results were interpreted as a sinus rhythm with a minimally prolonged QTc at between 440 and 450 milliseconds. This patient does not require any further treatment, such as medication or follow up EKGs. She was cleared for physical activity without restrictions and was not prescribed an event monitor. She is not required to have any follow-up visits scheduled with her cardiologist unless an issue would arise, such as worsening of symptoms or an increased frequency of episodes. The athlete is cleared for ongoing physical activity with no restrictions until complications arise. **Uniqueness:** This athlete falls into the 2 percent of the female population that has an elongated QTc that ranges between 440 and 460 milliseconds. Approximately 4000 people between the ages of 1 and 22 die suddenly from long QT syndrome annually. About one in every 7,000 people has LQTS. Treatments for most common cases of LQTS include beta-blocker medication, internal cardioverter defibrillator for those patients who have experienced cardiac arrest, and simple changes to the patient's diet and lifestyle. **Conclusions:** The nature of this condition is significant to understand in the athletic training profession. It is important to recognize the signs and symptoms of cardiac related episodes for proper referral and patient safety. The athletic trainer is the first line of defense when monitoring a patient with prolonged QT syndrome. Document of reoccurring signs and symptoms is vital in order for necessary referrals to the proper specialists and follow up exams with her primary care physician. Patients with prolonged QT syndrome may encounter physiological, psychological, social, and physical problems in the future.

Return to Play at 30 Days, Grade 1 Spleen Laceration in a Club Sport Hockey Player

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Background: 24 year old male Club Sports Hockey player with no prior medical history went into contact with an opposing player. As the opposing player fell to the ice the butt end of his hockey stick contacted the player in the abdomen in the upper left quadrant (ULQ). Athlete immediately complained of shortness of breath and pain in his left ribs. Initial examination revealed that the athlete was not able to control their breathing within a one minute time frame from arrival at the bench. With shortness of breath and pain still present in the ULQ, palpation of the area revealed that the ribs had diffuse tenderness at a 3/10, whereas direct palpation of the ULQ recreated point tenderness at a 7/10, rebound pain was also at 7/10. **Differential Diagnosis:** Rib fracture, intercostal contusion and spleen laceration. **Treatment:** The athlete was immediately transported to the nearest major medical center via team transport, upon arrival a Complete Blood Count (CBC) and CT scan with contrast were performed and an intravenous (IV) morphine drip was administered. Test results confirmed a grade 1 laceration of the spleen as defined by less than 10% of subcapsular hematoma and laceration less than 1cm in depth. Athlete was held overnight for observation and given a prescription for Percocet before release the following morning as no surgical intervention was indicated. Instructions were given from the physician to be withheld from practice and competition for at least 4 weeks and to complete a follow up evaluation prior to return to contact. Because no protocol currently exists for grade 1 splenic laceration return to play, the athlete's physical exertion was limited until asymptomatic. The athlete was pain free at day 12, began light physical exertion (biking) at day 16, and non-contact skating at day 23. At 30 days post injury a diagnostic ultrasound

was performed which revealed splenic recovery. The athlete was allowed to return to full contact practice at that time. **Uniqueness:** Due to conflicting opinions and lack of research on return-to-play criteria for varying degrees of splenic injury, this case is a prime example of how a grade 1 splenic laceration can be managed and returned to contact sport successfully and in a timely manner. At present this is the first documented case of a non-surgical grade 1 splenic laceration having been returned to play, as well as the only documented return to play splenic laceration at 30 days post injury of any grade in the literature at this time. **Conclusions:** At present this athlete has returned to play at 30 days post injury which is well before the typical 3 to 4 month time frame for splenic injuries. These types of lacerations are not uncommon in contact sports, however their treatment and rehabilitation times are not well documented and there is an air of uncertainty with regards to how they should be assessed and returned to play. In assessing this type of injury it is important to recognize the ability of the spleen to splint itself within the abdominal cavity and provide a false negative to the assessing athletic trainer. Furthermore, precaution must be taken by health care professionals when faced with a strong MOI and inability of the athlete to catch their breath coupled with a tenderness of the abdomen and not the surrounding ribs.

Management of Adult-Onset Runner's Dystonia: A Clinical Case Study

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Background: The patient was a 50-year-old female runner presenting with a 6 year history of difficulty with running secondary to poor control of her left foot and ankle during gait. Primarily she had trouble clearing the foot during the swing phase. Initial onset of her symptoms was during running, though at the time of her initial examination she reported symptoms could also be present with prolonged or fast ambulation. She denied any current low back pain or history of pain or numbness/tingling in the lower extremity. Initial examination revealed normal gait mechanics on walking, normal active and passive ROM, normal strength and negative neurologic screen. Running gait analysis revealed increased plantar flexion and inversion of the left foot and ankle from mid-swing to initial contact with a forefoot strike pattern. The patient displayed normal ankle dorsiflexion through swing phase and a heel-strike pattern on the right side. **Differential Diagnosis:** Onset of the condition was insidious. Differential diagnosis at the time was a peripheral neuropathy, lumbar radiculopathy, or a central pathology including a task-specific dystonia. Running gait analysis reproduced symptoms, but the patient was able to correct with real-time visual feedback and cues for "heel-first contact." Lumbar and lower extremity clinical examination was normal. She was referred to a neurologist specializing in movement disorders for further examination. **Treatment:** Neurologic exam did not reveal any positive findings on sensory or motor examination. Brain and lumbar MRI were normal. Blood labs were normal. For further examination of the runner's movement, a biomechanical analysis was performed at the University of Oregon Motion Analysis Laboratory using a 10-camera 3D motion capture system. For this test, the patient ran both overground and on a treadmill so that kinematic differences between limbs and between modes of running could be quantified. Most notably, the patient displayed less dorsiflexion at initial contact on the involved side in both treadmill and overground conditions, with this difference being more pronounced on the treadmill. The dorsiflexion angle at initial contact for the involved limb also had significantly more variability in both conditions. Due to clinical and biomechanical tests, a diagnosis of Runner's Dystonia, a type of task-specific dystonia, was made. Treatment was initiated and included core strengthening and balance, as well as the addition of a "sensory trick," in this case, the use of an ASO ankle brace, both of which have been shown to diminish symptoms of a task-specific dystonia by improving somatosensory feedback about the involved body region. She was started on a gait- retraining program due to her ability to correct the movement with visual and verbal feedback. Over 6 weeks she was seen in the clinic twice per week. She was given a real-time sagittal view of herself running with verbal cues to land "heel first" on the left. She was to run until she could not actively suppress her symptoms. During the last 3 weeks visual feedback was gradually removed, and she was instructed to run 1-2 days outside of the clinic without symptoms. At the time of discharge the patient was running up to 15 minutes without symptoms. **Uniqueness:** Runner's dystonia is a rare condition, and as such, little research currently exists on treatment strategies. Research on gait retraining for runners is also in its infancy. This case study adds unique insight into gait retraining as a treatment strategy for this rare condition. **Conclusions:** This case study described diagnosis and treatment for a case of runner's dystonia. Running gait retraining using visual and verbal cues was an effective treatment strategy, leading to a positive outcome for this patient.

Sudden Cardiac Arrest in a Semi-Professional Baseball Player and Subsequent Familial Diagnosis

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Background: A 25 year old baseball player was approximately one year status post flutter ablation, with no lasting symptoms. He went on a 6 mile run in a local park where he went in to cardiac arrest. Bystanders, including two physicians and one nurse, performed CPR for 20 minutes. An automated external defibrillator (AED) was used twice before the patient regained a normal pulse. He was taken to the local emergency department. **Differential Diagnosis:** Long QT Syndrome, Wolff-Parkinson-White, Brugada syndrome, Atrial Arrhythmias **Treatment:** Once at the emergency department, the patient was stabilized. The EKG showed a significant amount of atrial contractions. The cardiac MRI showed a slightly enlarged atria. Echocardiogram, and an Electrophysiology (EP) study conducted with a proclainamide challenge all showed no signs of Long QT syndrome, Wolff-Parkinson-White, or Brugada syndrome. His coronary arteries had a normal course. He was admitted to the Cardiac Care Unit. After two days of being in a medically induced coma, the patient awoke and slowly regained normal function. The decision was made to have an implantable cardioverter defibrillator (ICD) implanted prior to hospital discharge due to atrial arrhythmias and sinus brachycardia. After 10 days in the hospital, the patient was discharged home. The patient's twin brother, younger brother, and father were subsequently tested for cardiac abnormalities. The younger brother and father were found to have no cardiac abnormalities. The patient's twin was diagnosed with Brugada syndrome after an EP study with proclainamide challenge. He was implanted with an ICD approximately two months after his brother's sudden cardiac arrest. Because of the twin brother's diagnosis of Brugada syndrome, the patient underwent genetic testing which showed no link to Brugada syndrome. **Uniqueness:** Flutter ablation has a 98% cure rate, but the patient went in to cardiac arrest less than one year after the procedure. There had been no family history of cardiac abnormalities, but the patient's twin brother was diagnosed with Brugada syndrome. **Conclusions:** A 25 year old baseball player with a history of flutter ablation went in to cardiac arrest. The patient was revived and implanted with an ICD, although there was no known etiology. Subsequent testing of the patient's twin brother revealed his diagnosis of Brugada syndrome, and he was also implanted with an ICD. Currently the patient has returned to normal daily activities. He currently runs approximately 6 miles 4-5 days per week with no problems. He has decided to not return to baseball activities. The patient's twin brother has also returned to normal activities. He jogs 3-4 miles 4 times per week, and has also decided to forego competitive baseball.

Viral Costochondritis in a Female Basketball Athlete

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Background: A 21 year old women's basketball player reported to the athletic training room complaining of left shoulder and chest pain. The athlete reported experiencing shoulder and chest pain with deep breathing and bending down for one week prior to seeking medical attention. However, the primary complaint at the time of presentation was persistent chest pain. The athlete had no previous history of chest pain and had never been diagnosed with asthma. The athlete did report having a recent upper respiratory infection with mild cough. The athlete was removed from all sporting activity pending further medical evaluation by the team physician. The following morning the athlete texted the athletic trainer complaining of extreme chest pain that prevented her from sleeping. The athletic trainer was not on campus at this time and therefore referred the athlete to the local ER for further assessment. In the ER she was diagnosed with viral pleurisy and was given cyclobenzaprine (Flexeril) and ibuprofen for pain and inflammation. The athlete went home for the summer break shortly thereafter and did not report any additional issues to the athletic trainer prior to departing campus. Following summer break the athlete returned back to campus and began conditioning for basketball. The athlete reported to the athletic training room five months following the initial presentation complaining of a return of similar chest pain and difficulty breathing. She reported that over the summer she had continued to have minor chest pain which was exacerbated by the start of basketball conditioning. Physical exam revealed no tenderness to palpation over the AC joint, clavicle, scapula, or thoracic spine and breath sounds were equal with no abnormalities or wheezing during auscultation. No swelling or discoloration was present on exam. **Differential Diagnosis:** Undiagnosed Cardiac Pathology, Pleurisy, Asthma, Walking Pneumonia **Treatment:** The athlete was examined by the team physician the next and was diagnosed with exercise-induced

asthma and received an inhaler. She was instructed to use the inhaler prior to practice and during practice as needed. She reported minimal relief from the inhaler and was referred back to the doctor two weeks later. The athlete then underwent laboratory bloodwork to determine if c-reactive protein levels were elevated to evaluate for assorted autoimmune diseases and a chest x-ray to rule out walking pneumonia. Based off of the examination, normal levels of c-reactive protein, and a negative chest x-ray, the athlete was diagnosed with viral costochondritis. The athlete was given dexamethasone and was instructed to take 2 mg, twice a day for 7 days. Once beginning the medication, the athlete reported a resolution of symptoms stating that it was the first time in 5 month that she did not have any chest pain. **Uniqueness:** In athletics costochondritis is typically associated with a direct blow and/or a muscular strain that causes inflammation at the costochondral junction. However, in this case there was no history of trauma and the inflammation was eventually attributed to a virus that lasted for several months in the joint. While the presentation was similar to Tietze syndrome, which is a condition that also involves inflammation at the costochondral junction, it was ruled out due to the lack of elevated c reactive protein and absence of localized swelling over the chest. **Conclusions:** There are many different ways an individual can begin to experience costochondritis. Viral costochondritis is not typically seen in a young athletic population, and may often be a diagnosis of exclusion once asthma and other inflammatory diseases are ruled out. However, appropriate diagnosis and treatment can lead to a resolution of symptoms.

Epidemiology of Infections in Men's Wrestling: Analysis of 2009/10–2013/14 NCAA Surveillance Data

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Context: Skin infections are considered common injuries within men's wrestling. However, the current epidemiology of skin infections among wrestlers is limited. **Objective:** To analyze and report the epidemiology of skin infections among National Collegiate Athletic Association (NCAA) men's wrestling student-athletes during the 2009/10 - 2013/14 academic years. **Design:** Descriptive epidemiology. **Setting:** Aggregate infection and exposure data collected by the NCAA Injury Surveillance Program (ISP). **Patients or Other Participants:** Collegiate student-athletes participating in men's wrestling during the 2009/10 - 2013/14 academic years. **Interventions:** Infection and athlete-exposure information were collected and analyzed from 17 NCAA wrestling programs providing 35 team-seasons of data to the NCAA-ISP. Data were recorded by collegiate athletic trainers (ATs) and entered via web-based collection. **Main Outcome Measures:** Any viral, bacterial, and fungal infection contracted by a collegiate wrestling student-athlete. Infection rates per 10,000 athlete-exposures (AE), rate ratios (RR), infection proportions, and infection proportion ratios (IPR) were calculated. Additional variables of importance included time in season (preseason, regular season, postseason), event type (practice vs. competition), number of infections contracted by each unique athlete, and time loss. **Results:** Overall, ATs reported 112 infections contracted by 87 unique student-athletes across 78,720 AE. Nineteen athletes (21.8%) contracted multiple infections. A majority of infections (65.2%) were attributable to five seasons occurring within four programs (range of 11-19 infections). The overall infection rate was 14.23/10,000AE [95% Confidence Interval (CI) 11.59, 16.86]. The majority of infections occurred during the regular season (n = 76; 67.9%), were identified during practice (n = 100; 89.3%), and resulted in $\geq$ 24 hours time loss (n = 83, 74.1%). Infection rates during competition (14.47/10,000 AE) and practice (14.20/10,000 AE) did not significantly differ (RR = 1.02; 95% CI 0.56, 1.85; P > 0.99). Most infections were seen by ATs (63.4%), followed by physicians (32.1%). The most common infections were viral (44.6%), particularly herpes simplex I (41.1%). Bacterial infections and fungal infections comprised 25.9% and 21.4% of the total infections, respectively. The rate for viral infections was 1.72 times the rate for bacterial infections (95% CI 1.09, 2.72; P = 0.02), and 2.08 times the rate for fungal infections (95% CI 1.28, 3.39; P = 0.03). Fungal infections were more likely to result in time loss < 24 hours compared to all other infections (75.0% vs 12.5%; IPR = 6.00; 95% CI 3.30, 10.92; P < 0.001). Bacterial infections were more likely to result in time loss > 3 weeks, although this was not statistically significant (10.3% vs 1.2%; IPR = 8.59; 95% CI 0.93, 79.31; P = 0.11). **Conclusions:** The majority of all reported skin infections in college wrestling were attributable to five teams over a small number of seasons. Our findings highlight the contagious nature of skin infections and suggest that infection rates may be attributable to high incidence among particular teams. Ensuring proper student-athletes hygiene and daily mat cleaning with disinfectant solutions may decrease athlete-to-athlete, or mat-to-athlete transmission and infection recurrence.

Relationship Between Hip Strength and Pelvis Kinematics During a Single-Legged Medial Drop Landing in Competitive Female Basketball Players

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Context: Diminished hip strength has been identified to be a risk factor for noncontact anterior cruciate ligament (ACL) injury. Moreover, pelvis motion control plays an important role in maintaining a proper hip muscle function, resulting in ideal knee motion during landing. Therefore, hip strength and pelvis coordination have recently been emphasized in ACL injury prevention programs. However, the relationship between hip strength and pelvis kinematics during weight-bearing activities remain unclear. **Objective:** To determine the relationship between hip strength and pelvis kinematics during a single-legged medial drop landing (SML). We hypothesized that subjects with weaker hip strength would demonstrate excessive pelvis motion. **Design:** Correlational study. **Setting:** Controlled laboratory study. **Patients or Other Participants:** Thirty healthy Japanese female basketball players (age = 19.83 ± 0.95 years, height = 164.01 ± 8.27 cm, weight = 57.95 ± 6.85 kg). **Interventions:** Maximum voluntary isometric strength of hip extension (HEXT), hip abduction (HAB), hip external rotation with prone position (PHER) and hip external rotation with seated position (SHER) were measured on the dominant leg (preferred for kicking a ball) using a hand-held dynamometer. Pelvis kinematics during SML were analyzed using a motion analysis system involving landing medially after jumping from a 20-cm box. The subjects were instructed to stand on the dominant leg, then land on the force plate on the same leg. After landing, each subject held the landing position for 3 seconds. **Main Outcome Measures:** Three dimensional pelvis kinematics during SML, including anterior tilt (AP), lateral flexion (LF) and rotation (RT), were calculated based on the laboratory frames. The initial contact (IC) (VGRF>10N) and peak (PK) (IC to maximum knee flexion) angles of the pelvis were analyzed. The mean hip strength value was normalized to the subject's body mass. Correlation coefficients between hip strength and the pelvis kinematics parameters were calculated using Spearman rank correlation ($P < .05$). **Results:** The LF at IC ($\rho = -0.43$, $P = .02$) and PK ($\rho = -0.41$, $P = .02$) were significantly negatively correlated with SHER. The RT at IC was significantly negatively correlated with HEXT ($\rho = -0.50$, $P = .01$), HAB ($\rho = -0.43$, $P = .02$) and PHER ($\rho = -0.38$, $P = .04$). The RT at PK was significantly negatively correlated with HEXT ($\rho = -0.52$, $P = .00$), HAB ($\rho = -0.45$, $P = .01$) and PHER ($\rho = -0.37$, $P = .05$). **Conclusions:** Japanese female basketball players with weaker hip strength demonstrate more ipsilateral LF and counterclockwise RT of the pelvis during SML. Adequate proximal segment control and hip strength are essential components of controlled knee motion. Based on the current results, increased hip strength results in proper pelvis motion coordination during landing, which may help to prevent noncontact ACL injuries. Therefore, hip strength training should be emphasized in noncontact ACL injury programs for Japanese female basketball players.

Comparison of Knee Kinematics and Kinetics During Different Landing Tasks

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Context: Several tasks have been used to examine lower extremity biomechanics during landing for the purpose of evaluation and rehabilitation, especially in relation to ACL injuries. However, it can be difficult to compare results between studies utilizing different tasks and it is unclear which task may be most appropriate. Additionally, some tasks may have the advantage of simultaneously informing researchers on landing biomechanics and dynamic postural stability, such as the forward jump single-leg landing task. **Objective:** To compare lower extremity biomechanics across five commonly used landing tasks. **Design:** Descriptive laboratory study. **Setting:** University-operated, Special Operations Forces human performance research laboratory. **Patients or Other Participants:** A total of 66 Air Force Special Tactics personnel participated (age = 27.7 ± 5.0 years; weight = 83.1 ± 9.1 kg; height = 176.5 ± 5.7 cm). **Interventions:** Kinematic and kinetic analysis of five different landing tasks including double and single-leg drop-landing (DLDL and SLDL), double and single-leg stop-jump (DLSJ and SLSJ), and forward jump to single-leg landing (FJSL). **Main Outcome Measures:** Hip, knee, and ankle joint kinematics; knee joint forces and moments; and ground reaction forces. Shapiro-Wilk tests were used to assess normality. Repeated measures ANOVA or Friedman's ANOVA, as appropriate, were used to assess within subject

differences across tasks. Significance was set to 0.05 a priori. Appropriate post-hoc pair-wise comparisons used Bonferroni p-value adjustments. **Results:** Peak vertical ground reaction force (GRF) (180.1 – 504.0% body weight, $p < 0.001$) and peak knee flexion angle (58.4 – 101.9 degrees, $p < 0.001$) were significantly different between all tasks. Single-leg landings generated higher vertical GRF (504.0 vs. 342.0% body weight and 271.6 vs. 180.1% body weight, $p < 0.001$) and lower peak knee flexion (68.1° vs. 91.4° and 74.4° vs. 101.9°, $p < 0.001$) with the exception of FJSL which had the lowest peak knee flexion (58.4°) and the second highest peak vertical GRF (435.1% body weight). SLDL generated the highest vertical and posterior GRF (504.0 and 50.2% weight, respectively, $p < 0.001$). Peak valgus moment was significantly higher during DLDL (0.83Nm, $p < 0.001$) but similar for SLDL, DLSJ, SLSJ, and FJSL (0.47, 0.46, 0.44, and 0.43Nm, respectively). **Conclusions:** A distinct within subject pattern of similarity between two tasks was not discernable and it does not appear to be one task that is best for eliciting a wide range of biomechanical risk factors of ACL injuries. Multiple tasks should be considered, as certain tasks may be better suited for evaluating specific strategies as demonstrated by stop-jumps eliciting higher knee valgus angles but drop-landings eliciting higher valgus knee moments and ground reaction forces. Researchers need to be cautious when comparing results between tasks. Athletic trainers and other clinicians need to consider these findings during evaluation of landing mechanics during assessments or rehabilitation. Supported by AFMC/AFRL #FA86501226271.

Jump Strategy Modification Results in Altered Biomechanical Demands During Dance Leap Takeoffs

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Context: Coordinated movement of the entire body is required for dynamic, high-load movements such as jumping. Variations in either vertical or horizontal components of a jump will result in modifications in the trajectory and velocity of the center of mass. Examination of the role and function of lower extremity joints and the impact of modification of task goals during jumping will provide insight regarding skilled athletic performance and implications for lower extremity injuries. **Objective:** To examine the control and distribution of mechanical demands during jump takeoffs when the task goal is modified to focus on either increasing jump distance or increasing jump height. **Design:** Cross-sectional. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Twenty (age = 27.9 ± 2.9 years; weight = 58.9 ± 7.4 kg; height = 1.6 ± 0.1 m) healthy, experienced dancers with an average 22.5 ± 4.5 years of dance training. **Interventions:** A three-dimensional motion analysis system and force plates were used to collect kinematic and kinetic data. Participants performed saut de chat leaps (split jumps involving vertical and horizontal movement) in two conditions: traveling as far as possible (FAR) and jumping as high as possible (UP). A four-segment lower extremity model was used to analyze the takeoff phase of the leap. **Main Outcome Measures:** Horizontal ground reaction force impulses were calculated separately for the posterior (braking) and anterior (propulsive) portions. Sagittal plane kinematics and kinetics of the metatarsophalangeal (MTP), ankle, knee, and hip joints were calculated. Braking GRF impulse, propulsive GRF impulse, and peak net joint moments at the MTP, ankle, knee, and hip joints were compared between conditions using paired samples t-tests. **Results:** Braking ground reaction force impulse was lower (FAR .58 ± .16, UP .99 ± .24 N/kg*s, $P < .001$) and propulsive ground reaction force impulse was greater (FAR .08 ± .04, UP .02 ± .01 N/kg*s, $P < .001$) in the FAR condition compared to the UP condition. Net joint moments at the MTP and ankle joints were greater in the FAR condition, and net joint moments at the knee were lower in the FAR condition (MTP: FAR .53 ± .08, UP .47 ± .08 N/kg, $P < .001$; ANKLE: FAR 3.38 ± .12, UP 3.29 ± .11 N/kg, $P = .004$; KNEE: FAR 3.04 ± .27, UP 3.34 ± .49 N/kg, $P < .001$). **Conclusions:** Biomechanical demands on the lower extremity joints during takeoff were altered in response to the modified task goals; these alterations were exhibited in the horizontal component of the ground reaction force as well as in individual joint kinetics. When the goal of the jump was to focus on distance, demands were increased at the distal joints. Jumping techniques that involve more horizontal movement may place excessive demands on the MTP and ankle joints. Dancers who are experiencing pain or working through injuries to the foot and ankle may be more successful if they approach jumping tasks with a goal focused more on jump height than on jump distance.

An Evaluation of the Magnitude of the Effect of Sex on 3D Landing Characteristics Associated With ACL Injury: A Meta-Analysis

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Context: ACL injuries are relatively rare epidemiological events, indicating that evaluating direct injury risk is difficult. Surrogate risk measures, such as evaluating biomechanical differences between the sexes during functional tasks are often used in lieu of direct etiological evidence. **Objective:** To systematically review and synthesize the literature to determine the magnitude of the kinematic landing differences by sex. **Data Sources:** Electronic databases (PubMed, CINAHL, MEDLINE, SPORTDiscus) were searched through September 2014; reference sections were hand searched. Keywords included variations of "ACL", "sex", "gender", "biomechanics", "landing", and variants of Boolean operators. Search limits were set to publications in English. **Study Selection:** Criteria for inclusion were: 1) evaluated 3-dimensional (3D) lower extremity (LE) kinematics for both sexes during a bilateral, even-footed landing task, and 2) provided means, and standard deviations for peak joint angles during the downward motion of the landing task for the hip, knee, and/or ankle. **Data Extraction:** Three investigators assessed methodological quality with the Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) statement. The quality of evidence was assessed using the Oxford Centre for Evidence-Based Medicine (OCEBM)–Levels of Evidence-II. Sample sizes and mean peak joint angles (with standard deviations) of the LE, as they occurred during the downward motion of a bilateral drop-landing or drop vertical jump, were extracted. **Data Synthesis:** The magnitude of the kinematic differences between the sexes was determined with bias-corrected Hedges' g effect sizes (ES). Based on study heterogeneity, a random-effects meta-analysis was performed to calculate the overall weighted effect [95%CI]. Three separate random effects meta-analyses were also performed on each kinematic plane (sagittal, frontal, transverse) to evaluate the magnitude of sex differences for the hip, knee, and ankle. Positive ES values indicated increased 'risky' kinematics for females (decreased peak flexion angles, increased hip adduction and internal rotation, increased knee abduction and internal rotation, increased ankle eversion and pronation). Sixteen studies were included; 53 separate kinematic data points in these studies were analyzed. The mean STROBE was 18 out of 22 (range 15-21). The level of evidence of all 16 included studies was level 5: Mechanism-based reasoning. The overall summary effect was strong (ES = 0.70 [0.54, 0.86], $p < .001$) demonstrating more risk factor-related kinematics for females compared to males. The summary effect for the sagittal plane was moderate (ES = 0.58 [0.37, 0.78, $p < .001$]; for the frontal plane, strong (ES = 0.82 [0.52, 1.12, $p < .001$]; for the transverse plane, strong (ES = 0.84 [0.40, 1.28, $p < .001$]. **Conclusions:** Based on the results of this meta-analysis, the magnitude of the difference in LE landing kinematics between sexes is considerable. The 'dynamic valgus collapse' (DVC) motion appears to be substantially more pronounced in females compared to males. Assuming that DVC is a risky movement behavior for ACL injury, using the male-to-female comparison as a surrogate model of evaluating risk of ACL injury is logical.

The Influence of Activity Rating Scale Scores on Lower Extremity Kinematics and Kinetics During a Jump-Cut Task

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Context: Abnormal lower extremity mechanics have been shown to increase the risk of ACL injury. Factors contributing to these potentially injurious joint mechanics are unclear; however it has been theorized that lack of experience with performing functional tasks, such as pivoting or cutting, may influence risk of injury. The Activity Rating Scale (ARS) is a reliable ([ICC] = 0.97) and valid (Tegner scale r = 0.66; Cincinnati scale, r = 0.67; and Daniel scale, r = 0.52) tool developed to assess how often an individual performed specific activities over the past year. Objective: To examine the relationship between scores on the ARS and hip and knee joint kinematics and kinetics during a jump-cut task. **Design:** Descriptive laboratory. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Forty healthy males (21.1 + 1.7 yrs, 174.3 + 9.4 cm, 70.4 + 13.4 kg) and forty healthy females (21.2 + 2.0 yrs, 172.7 + 9.4 cm, 69.3 + 11.8 kg) volunteered. **Interventions:** Participants completed the written ARS by indictating the frequency they performed the functional activities of running, cutting, decelerating, and pivoting while in their healthiest and most active state, over the past year. A higher score indicated more experience performing the functional activities. Kinematics and internal moments of the hip and knee were collected on the dominant stance limb during a jump-cut task using a three-dimensional motion analysis system integrated with a force plate. Subjects jumped forward from a 30-cm high box set two-thirds of their height from the force plate and single-leg landed

with the test limb on the force place, immediately upon landing side-step cut into an alleyway set 60° relative to the force plate center. **Main Outcome Measures:** Individual and combined ARS scores were used for analyses. Hip and knee joint excursions and internal joint moments (normalized to body mass and height) across the stance phase were averaged across five jump-cut trials. Separate step-wise linear regressions determined the influence of individual activity and combined scores on hip and knee joint excursions and internal joint moments. **Results:** Higher cutting scores (1.9 ± 1.3) predicted less knee flexion excursion (44.0 ± 8.9°) explaining 5.9% of the variance (P = 0.030). Higher deceleration scores (2.1 ± 1.2) predicted greater hip adduction excursion (-4.5 ± 10.3°) explaining 8.0% of the variance (P = 0.011). Higher pivoting scores (1.9 ± 1.3; R2 = 0.069, P = 0.019) and the combined activity score (8.6 ± 4.3; R2 change = 0.048, P = 0.043) predicted greater internal knee flexion moment (0.01 ± 0.01 Nmkg-1m-1) explaining 11.7% of the variance (P = 0.008). No other activity scores predicted any other joint kinematics or kinetics during a jump-cut task. **Conclusions:** Scores for each activity on the ARS and the combined score were associated with hip and knee kinematics and kinetics during a jump-cut task. However; the strength of these relationships are weak, leaving over ninety percent of the variance unexplained. These results suggest that recent experience with performing functional tasks may not influence lower extremity dynamic motion. Partially funded by a College of Charleston Summer Undergraduate Research with Faculty grant.

Lower Extremity Landing Strategies in Collegiate Athletes With a Self-Reported History of Knee Injury

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Context: Knee injuries are common in physical activity and sport, and are often associated with long-term changes in lower extremity muscle function and movement strategies. Despite a successful return to sport, the long-term effects of injury may linger as persistent adaptations in lower extremity movement strategies. The landing error scoring system (LESS) is a validated tool used to evaluate lower extremity movement strategies during a jump-landing task. **Objective:** To compare lower extremity landing strategies in collegiate athletes with and without a self-reported history of knee joint injury. **Design:** Descriptive laboratory study. **Setting:** Clinical Laboratory. **Patients or Other Participants:** Participants included fifty division-1 varsity collegiate athletes currently in unrestricted sport participation (4 football, 13 track, 12 soccer, 21 lacrosse). Nineteen athletes had a self-reported history of unilateral knee injury (sex: 6f/13m, 20.2 ± 1.3 yrs, 77.6 ± 10.0 kg, 1.77 ± 0.10m), six athletes had a self-reported history of bilateral knee injury (sex: 0f/6m, 20.2 ± 1.5 yrs, 88.4.6.4 ± 16.6 kg, 1.85 ± 0.07m), and twenty-five healthy athletes had no self-reported history of lower extremity injury (sex: 4f/25m, 19.6 ± 1.0 yrs, 83.6 ± 21.4 kg, 1.76 ± 0.13m). **Interventions:** None. **Main Outcome Measures:** Three jump-landing trials were performed by each participant and scored using the LESS. Jump-landing trials involved participants jumping off a 30-cm high box, landing a distance of half of their body height in front of the box, and immediately performing a maximal vertical jump. Jump-landings were recorded using frontal and sagittal view camcorders. Frontal and sagittal LESS errors were summed (0-17) for each trial, with a lower score indicating a more favorable landing strategy. Scores were determined using the injured limb for participants with unilateral injury and both limbs for bilaterally injured and healthy participants. Group membership was determined using self-reported injury history questionnaires. Injuries included both acute and chronic pathologies. The average LESS scores of three trials were compared between unilateral knee injured, bilateral knee injured, combined knee injured (unilateral + bilateral), and healthy groups using Mann-Whitney U tests. Results are presented using median [lower quartile, upper quartile]. **Results:** The bilateral knee injured group (2.5 [1.8, 3.2]) landed with fewer errors compared to the unilateral knee injured group (5.3 [3.3, 7.3], P = .006). There were no significant differences between the healthy group (4.3 [2.5, 6.1]) and the unilateral knee injured group (P = .23), the bilateral knee injured group (P = .08) or the combined knee injured group (5.0 [2.9, 6.3], P = .76). **Conclusions:** There were no differences in landing strategy errors between knee injured and lower extremity healthy athletes. Athletes with bilateral knee injuries landed with fewer errors than athletes of unilateral knee injuries. The distribution of injury types and participant sex may have played a role in group differences.

Frontal Plane Errors During the Single Leg Squat Task Predict History of Knee Pathology

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Context: The ability to assess abnormal movement patterns during a functional assessment is important when screening for injury risk. The single leg squat assessment is frequently utilized to identify faulty mechanics related to lower extremity risk factors, particularly at the knee. The test is simple and inexpensive but it is unknown if the test is sensitive enough to predict whether individuals have a history of a knee joint pathology when using an observational scoring system in the sagittal and frontal planes. **Objective:** To compare single leg squat performance of individuals with a unilateral knee pathology and healthy controls using a 2-dimensional video analysis, and to evaluate inter-tester reliability the scoring system. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 32 recreationally active adults (16 healthy: 8 female/8 male, 22.6 ± 6.6 y, 1.7 ± 0.1 m, 66.4 ± 9.5 kg and 16 with a history of self-reported unilateral knee injury: 8 female/8 male, 21.9 ± 6.3 y, 1.7 ± 0.1 m, 75.5 ± 19.3 kg). **Interventions:** None. **Main Outcome Measures:** Participants performed 3 trials of the single leg squat task, which were recorded by 2-dimensional video in the frontal and sagittal planes. Performance was subsequently scored based on 10 objective criteria: 5 frontal plane, 5 sagittal plane, and combined to yield a frontal plane error score, sagittal plane error score, and overall error score. A binary logistic regression was conducted to determine if group membership (healthy or history of knee pathology) could be predicted based on frontal plane error, sagittal plane error, and total error. Cohen's κ was calculated to determine inter-tester reliability. **Results:** The logistic regression model was statistically significant, . The model explained 24.5% (Nagelkerke R2) of the variance in observed errors and correctly classified 62.5% of cases. Sensitivity and specificity were both 62.5%, and the positive and negative predictive values were both 38.5%. Of the 3 predictors, only frontal plane error score was significant . Increasing frontal plane error scores was associated with an increased likelihood of being in the knee pathology group (Odds Ratio = 5.44; 95% CI: 1.05 to 28.21). Reliability in sagittal plane scoring was strong (κ = 0.815, 95% CI: 0.617 to 1.0) and reliability in frontal plane scoring was very good (κ = 0.750; 95% CI: 0.525 to 0.975). **Conclusions:** Frontal plane error during the single leg squat task predicted history of knee pathology with moderate sensitivity and specificity. This suggests that frontal plane error plays a larger role in prediction of knee pathology history than sagittal plane error and those errors can be identified using a low-tech clinical method. The characteristics analyzed during the single leg squat task showed high inter-tester reliability in both the frontal and sagittal planes.

Differences in Single Leg Rotational Squat Kinematics Between Individuals With and Without a History of Hamstring Strain

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Context: Single leg exercises are commonly included in the sub-acute phase of hamstring rehabilitation. Currently, little is known about the stability limitations caused by a previous hamstring strain and the long-term alterations in movement strategies. **Objective:** The purpose of this study was to investigate the differences in hip and knee kinematics during a single leg rotational squat (SLRS) between individuals with and without a previous hamstring injury. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Eight recreationally active individuals with a history of hamstring strain (5 males, 3 females; age = 21.5 ± 1.19 years; height = 177.56 ± 6.11 cm; mass = 81.27 ± 8.98 kg; Hamstring Outcome Score = 88.59 ± 7.69%) were matched to 8 individuals with no history of hamstring strain (5 males, 3 females; age = 21.5 ± 0.92 years; height = 178.31 ± 8.24 cm; mass = 79.9 ± 11.6 kg; Hamstring Outcome Score = 95.94 ± 3.12%). Inclusion criteria included being physical activity ≥30 minutes, 3 times per week and no lower extremity injury within 4 months. Participants in the hamstring group suffered a strain within 5 years that removed them from physical activity for ≥1 day, but were excluded if lower extremity surgery or history of neurological complications were reported. The limb with a previous hamstring strain and the matched limb of the healthy participants were labeled involved. **Interventions:** Reflective clusters secured to the thigh, shank and calcaneus tracked the pelvis, hip, knee and ankle joints of the involved limb. In four beats of a metronome, set to 72bpm, participants squatted on the involved limb, rotated to reach a marker, returned to the straight-ahead squat, and then returned to the

standing start position. Five trials were performed separated by 10sec of rest. Reach distance and marker height were normalized by each participant's arm length (acromion process to end of third phalanx) and lower leg length (lateral femoral condyle to floor). A practice session was held ≥48hours prior to the test trials. Kinematic data were captured using a motion analysis system. **Main Outcome Measures:** The maximum hip flexion (HF), hip internal rotation (IR) and knee flexion (KF) angles (°) were determined for each trial and averaged for analysis. Independent t-tests with corresponding effects sizes (ES) were performed to analyze between-group differences with an alpha level set at $p < 0.05$. **Results:** There was a statistically significant difference in IR in the involved limb between groups (Hamstring = 9.71 ± 4.00°, Healthy = 3.99 ± 3.91°; p = 0.012; ES = 1.45). There was no statistically significant differences in HF (Hamstring = 99.14 ± 14.25º, Healthy = 99.41 ± 18.77º; p = 0.975; ES = 0.02) or KF (Hamstring = 89.70 ± 13.49º, Healthy = 87.25 ± 9.49º; p = 0.680; ES = 0.21). **Conclusions:** When performing a SLRS, the previously injured limb of the hamstring group demonstrated a higher degree of hip IR than the matched limb of the control group. The presence of increased hip IR may indicate some degree of instability at the hip following a previous hamstring strain. It may be beneficial to include a SLRS element within hamstring rehabilitation to address possible instability.

Associations Between Injury History and Movement Errors on the Overhead Squat Assessment

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Context: Movement pattern and prior history of musculoskeletal injury (MSK-I) are predictive of eventual MSK-I in military training populations. History of MSK-I and its association with movement patterns in males entering military basic training has not been assessed. MSK-I in represents a significant financial and military operational burden, as 25% of males who sustain an MSK-I during basic training do not graduate. **Objective:** To investigate associations between prior MSK-I and movement pattern in male U.S. Navy applicants entering basic training. **Design:** Cross-sectional study. **Setting:** Military Entrance Processing Station (MEPS). **Patients or Other Participants:** Male U.S. Navy applicants (N = 139). **Methods:** 139 medically-cleared male Navy applicants (23.2 ± 13.6 yrs, 177.3 ± 7.0 cm, 77.4 ± 11.2 kg) from the Baltimore MEPS were evaluated using a double-leg overhead squat (OHS) 24 hours prior to leaving for basic training. The OHS is a novel clinical assessment that evaluates movement deficits (errors) based on previously identified biomechanical risk factors. OHS errors included: foot external rotation, medial knee displacement, lateral knee displacement, excessive forward trunk lean, lower back arching, lower back rounding, arms falling forward, heel or foot rise, foot arch flattening, and/or asymmetrical lateral weight shift. Each observed error was scored from 0-2, with 0 indicating no error, 1 indicating the error occurred unilaterally, and 2 indicating the error occurred bilaterally, where applicable. Finally, overall impression was scored as 0 for excellent execution, 1 for good execution, and 2 for poor execution, yielding a maximum OHS score of 14. Injury history was obtained vis self-report. Independent samples t-tests were conducted to determine mean OHS score differences between applicants with and without MSK-I history. Pearson Chi-Square tests evaluated associations between MSK-I history and individual OHS component errors. **Outcome Measures:** Means ± standard deviations. Pearson Chi-square and significance values. **Results:** Over 26% of male Navy applicants self-reported having one or more previous MSK-I. Mean total OHS scores did not differ between applicants with and without MSK-I history (4.3 ± 2.6 errors vs. 4.8 ± 2.8 errors; $t137 = .90$, $p = 0.37$). Applicants with prior MSK-I history were more likely to exhibit lateral knee displacement (30% vs. 9%; $\chi2 = 10.12$, $p = 0.001$) than those without prior MSK-I history. Never injured applicants displayed more medial knee displacement (43% vs. 19%; $\chi2 = 6.8$, $p < 0.01$), foot arch flattening (52% vs. 30%; $\chi2 = 5.6$, $p = 0.02$), and asymmetrical lateral weight shift (25% vs. 5%; $\chi2 = 6.48$, $p = 0.01$) compared to those with prior MSK-I. **Conclusions:** Male Navy applicants with previous MSK-I were more likely to exhibit lateral knee displacement errors versus those without prior MSK-I. Never injured applicants exhibited more medial knee displacement, foot arch flattening and asymmetrical lateral weight shifts during OHS. Implications of these movement pattern differences are not yet known. We are following this cohort to determine whether a combination of injury history and OHS scores predict future MSK-I incidence during basic training.

Lower Extremity Bony Alignment Influences Hip and Knee Kinematics During a Jump-Landing

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Context: Two- and three- dimensional excessive knee valgus motion has been suggested to increase the risk of anterior cruciate ligament tears and patellofemoral pain. Excessive femoral antetorsion (FAT), external tibial torsion (ETT), and forefoot varus (FV) bony alignments may influence frontal and transverse plane hip and knee kinematics because of compensatory joint mechanics that result in increased joint congruency. These compensations result in hip internal rotation and knee internal rotation, which can contribute to increased knee valgus motion. However, the relationships between these bony alignments and frontal and transverse plane hip and knee kinematics are unclear. **Objective:** To examine relationships between frontal and transverse plane hip and knee kinematics during landing and lower extremity bony alignment. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty healthy, physically active females who displayed medial knee displacement (a two-dimensional proxy for knee valgus motion) during a double-leg squat participated (Age = 20.9 ± 3.0 years; Height = 164.9 ± 7.8cm; Mass = 62.5 ± 8.9Kg). **Interventions:** ETT and FV angles were assessed using a standard goniometer while FAT angle was assessed using diagnostic ultrasound. Frontal and transverse plane hip and knee kinematics were assessed using a seven-camera infrared optical motion capture system while participants performed three separate jump-landing (JL) trials. **Main Outcome Measures:** FAT, ETT, and FV measures were averaged across three trials. Peak joint angles of hip adduction (HAD), hip internal rotation (HIR), knee valgus, and knee external rotation (KER) during the stance phase of JL were also averaged across three trials. Peak frontal plane projection angle (FPPA) was calculated as a two-dimensional knee valgus angle. Separate Pearson product-moment correlations were performed to identify the association between each joint angle with FAT, ETT, and FV ($\alpha < 0.05$). **Results:** Significant correlations exist between HAD and FV ($r = -0.37$, $p = 0.048$), HIR and ETT ($r = -0.44$, $p = 0.014$), and FPPA and FAT ($r = 0.45$, $p = 0.022$). There were no other significant correlations ($p > 0.05$). **Conclusions:** Greater HAD was associated with lesser FV, greater HIR was associated with lesser ETT, and greater FPPA was associated with greater FAT in females with MKD. Small variability (r2 ranges = 0.14 - 0.20) of known high risk movement is explained by bony alignment deformities. Individuals who display MKD and these bony alignment deformities may experience limited improvement in biomechanics with neuromuscular control training because these abnormal bony alignments may facilitate the faulty movement and are unable to be corrected with exercise interventions. Clinicians should consider evaluating bony alignment for more comprehensive injury risk factor assessment, and consider global injury risk mitigation strategies such as fatigue management in athletes with MKD and bony alignment deformities.

Health-Related Quality of Life Differs Between Injured and Uninjured Athletes: A Systematic Review and Meta-Analysis

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Context: Assessing HRQOL following injury and throughout the duration of treatment is vital for whole person, patient-centered care. Evidence has demonstrated athletes with an injury or history of injury have decreased HRQOL compared to their uninjured counterparts, suggesting the need to assess and monitor HRQOL throughout treatment and possibly after return to play. However, a synthesis of this evidence has yet to be performed. **Objective:** To perform a systematic review and meta-analysis of the published evidence to determine if HRQOL differs between injured (IA) and uninjured athletes (UA). **Data Sources:** CINAHL, Medline, SportsDiscus and PubMed were systematically searched from inception to November 1, 2014. Searches were limited to English and humans. Key words included HRQOL, adolescent, high school, interscholastic, college, intercollegiate, athletes, and NCAA. A hand search of references was also conducted. **Study Selection:** Studies were included if they compared generic HRQOL outcomes in IA (or those with a history of injury) and UA (or those without a history of injury) and described the subjects as current interscholastic or intercollegiate athletes. Studies were excluded if they included retired athletes, limited to subjects with chronic disease, only used region or dimension-specific instruments, or articles that developed HRQOL instruments. **Data Extraction:** Two reviewers assessed studies for inclusion and quality using the modified Downs and Black (mDB) scale. Studies were deemed high (>75%), moderate (60%-74.9%) or low quality if <60% of the criteria were met. Bias corrected Hedge's g effect sizes (ES, 95% confidence interval) were calculated. A random-effects meta-analysis was performed for all studies using the composite score or individual domains. Separate random-effects meta-analyses were performed for studies reporting composite scores with Physical (PCS) and Mental (MCS) composite scores as a moderator variable. Strength of recommendation was determined using the Strength of Recommendation Taxonomy (SORT). **Data Synthesis:** Five studies met the inclusion and mDB scores ranged from 70.6%-88.2% with 3-high and 2-moderate quality studies. Four studies utilized the Short-Form 36 and one study used the Pediatric Outcomes Data Collection Instrument. The overall meta-analysis revealed a moderate effect (ES = 0.57, 95% CI: 0.35-0.78, $p < 0.001$) indicating IA have lower HRQOL scores compared to UA. There is grade A evidence suggesting IA report lower HRQOL scores on generic instruments when compared to UA. With composite score as a moderator variable the results indicated a strong effect (ES = 0.94, 95% CI: 0.34-3.05, $p = 0.002$) for the PCS and weak effect (ES = 0.15, 95% CI: -0.01-0.31, $p = 0.059$) for the MCS. **Conclusions:** These results indicate injury status or history of injury impacts HRQOL. Specifically injury may impact the physical components of HRQOL and have minimal impact on mental components of HRQOL. Clinicians should monitor HRQOL in patients following injury, throughout treatment, and possibly after return to activity to ensure all dimensions of health are appropriately assessed and treated.

The Impact of Previous Athletic Participation on Health Related Quality of Life in Current Collegiate Athletes

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Context: The SF12v2.0 is used by medical professionals across the US to measure Health Related Quality of Life (HRQL) in their patients. The Physical Composite Score (PCS) and Mental Composite Scores (MCS) from the SF12 v2.0 are recognized as valid measures of an athlete's function prior to and following an injury with a higher score indicating better HRQL. It is accepted that in order to be successful, athletes must undergo rigorous training, make significant time commitments and experience significant levels of stress which may adversely affect their HRQL. The extent that HRQL is affected after the completion of a collegiate sport season has not been reported. Understanding how athletic participation affects HRQL will enable sports medicine professionals to better understand and influence HRQL outcomes of collegiate athletes. **Objective:** To determine if HRQL changes following the completion of a competitive sport season. Design: Prospective cohort. **Settings:** Data were collected at a single Div. I University. **Patients or Other Participants:** Participants included college athletes (age = 20.4 ± 1.8 years) participating in Cross Country (female = 41, male = 15), Football (male = 88), Soccer (female = 23, male = 21) and Volleyball (female = 22). **Interventions:** Each subject completed the SF12v2.0 during the summer prior (PRIOR) to the start of their sport season and one month after the completion of their season (POST). Raw scores were converted to norm-based scores via a linear z-score transformation. Higher MCS and PCS scores indicate improved HRQL. The US norm based scores

for young (age 18 – 24 yrs.) females = 44.3 + 12.8 for the MCS and 52.9 + 8.6 for the PCS while young males = 49.07 + 11.4 for the MCS and 53.1 + 11.0 for the PCS. Paired t tests ($p < 0.05$) were utilized for the analyses. **Main Outcome Measures:** Dependent variables included the change (mean + SD) in from PRIOR to POST MCS and PCS for the subjects. Paired t tests ($p < 0.05$) were utilized for the analyses. **Results:** There was no difference ($p = 0.237$) for females for the MCS (PRIOR = 51.1 + 9.9, POST = 52.1 + 7.9) and no difference ($p = 0.388$) for females for the PCS (PRIOR = 55.1 + 6.0, POST = 54.5 + 6.4). Males exhibited higher ($p = 0.003$) MCS after completion of their season (PRIOR = 52.2 + 11.4, POST 55.4 + 6.2). There was no difference ($p = 0.467$) for males for the PCS (PRIOR = 55.0 + 5.1, POST = 54.5 + 5.8). **Conclusions:** Despite the rigorous training, extensive time commitment and high stress associated with participating in collegiate athletics, HRQL was not adversely affected following the completion of a sport season. Further, males exhibited higher MCS after completion of their sport season. Sports medicine providers should be aware that lower HRQL after completion of a sport season may be caused by factors that are not associated with previous athletic participation.

Two-year Changes in Knee Function and Health Related Quality of Life Following Knee Injury in Active Females

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Context: Recent literature has called for greater attention to the documentation of overall health status and functional impairments following injury. Assessing the effect knee injuries have on young female athletes may allow clinicians to better understand the perspective of the athletes who sustain these injuries and can aid in assessing the influence of injury on long-term health. The 2000 International Knee Documentation Committee (IKDC) Functional Knee Scale is widely used to assess knee function and health related quality of life (HRQOL) is commonly assessed with the Physical Composite Scores (PCS) and Mental Composite Scores (MCS) of eight domains of physical and emotional health from the SF-12 v 2.0 survey (SF-12). **Objective:** Describe changes in self-reported HRQOL and knee function in young females two years after they have sustained a knee injury. **Design:** Prospective cohort. **Settings:** Data were collected at a sports medicine clinic and university health service. **Patients or Other Participants:** A convenience sample of N = 138 high school and college females (age = 17.4 + 2.4 years) who injured their knee participating in sport or recreational activities. Injuries were categorized as anterior cruciate ligament tears (ACL, N = 55), anterior knee pain (AKP, N = 51), patellar instability (PAT, N = 16), meniscus tear (MNT, N = 9), collateral ligament sprain (COL, N = 4), and other (OTH, N = 3). **Interventions:** Self-reported knee function was assessed with the IKDC knee survey and HRQOL was assessed using the PCS and MCS scores of the SF-12 survey at pre-injury and 24 months post-injury. **Main Outcome Measures:** Dependent variables included the paired differences in the IKDC and HRQOL (PCS and MCS) from pre-injury to 24 months post-injury. Data was assessed for normality and confirmed as a non-normal distribution. Paired differences were assessed by injury group using the Wilcoxon Signed Ranks Test ($p < 0.05$) reported as the mean + SD. **Results:** IKDC scores at 24 months were significantly lower than pre-injury scores for ACL (pre = 94.1 ± 13.3%, post = 83.6 ± 14.4%, $p < 0.001$), AKP (pre = 91.0 ± 12.0%, post = 85.5 ± 12.5%, $p = 0.01$), and PAT (pre = 94.1 ± 8.05%, post = 84.6 ± 13.4%, $p = 0.02$). HRQOL PCS scores at 24 months were significantly lower than pre-injury scores for ACL (pre = 56.6 ± 3.71, post = 54.7 ± 6.01, $p = 0.05$) and AKP (pre = 55.3 ± 4.75, post = 52.7 ± 7.6, $p = 0.04$). PAT patients scored significantly lower on HRQOL MCS at 24 months (pre = 57.2 ± 4.87, post = 52.7 ± 5.70, $p = 0.02$). **Conclusions:** Knee injuries can negatively impact knee function and physical and mental components of HRQOL for up to 24 months in young females. Understanding knee function and HRQOL changes after injury will enable sports medicine providers to better address the physical, psychological, and social health outcomes of their patients. The use of patient reported outcomes of knee function and HRQOL may provide clinicians and researchers with a more authentic assessment of the burden of these injuries from the patient's perspective.

Adolescent Patient Self-Reported Pain, Function, and Disability Are Moderated by Participation Status During the First Five Days Postinjury: A Report From the Athletic Training Practice-Based Research Network

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Context: Adolescent patients' perception of pain, function and disability according to participation status may assist clinicians in providing patient-centered care during the early stages of injury recovery. **Objective:** To determine the relationship between participation status and level of pain, function, and disability during the first five-days following sport-related injury (SRI). **Design:** Repeated Measures. **Setting:** Secondary school athletic training clinics within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** 2512 adolescent athletes (n = 1392 males, n = 1120 females; age = 17.8 ± 4.1; height = 64.9 ± 13.7; mass = 148.0 ± 4.6) who suffered a SRI were included. Athletes were grouped by participation status and were included multiple times if group status changed during the five-day window: no participation (NP; n = 1465-1515), limited participation (LP; n = 813-860), and full participation (FP; n = 939-981). **Interventions:** During the first five-days following injury, pain, function, and disability were measured, respectively, using the numeric pain rating scale (NPRS; range = 0-10; 0 = no pain, 10 = extreme pain), global rating of function (GROF; range = 0-100%; 0% = no use, 100% = full use), and global rating of disability (GROD; 7-point Likert; 1 = no difficulty, 7 = cannot perform daily activities). Independent variables were participation status (NP, LP, and FP) and days since injury (0-5 days). **Main Outcome Measures:** Dependent variables included NPRS, GROF, and GROD scores. Generalized estimating equations, gamma with a log link response scale and unstructured working correlation matrices were used for analyses. Bonferroni corrections were employed for pairwise comparisons ($p < .05$, two tailed). Data are reported as means (95% CI). **Results:** A significant interaction between participation status and days since injury was noted for GROF ($p < .001$) but not for NPRS ($p = .419$) or GROD ($p = .870$). Main effects for participation status ($p < .001$) were found for NPRS, GROF, and GROD. Main effects for days since injury were also found for NPRS ($p < .001$), GROF ($p = .001$) and GROD ($p < .001$). NPRS scores were worse for NP [4.2(4.0-4.5)] when compared to LP [3.8(3.5-4.1); $p = .001$] and FP [3.3(3.0-3.6); $p < .001$]. LP NPRS scores were worse than FP ($p < .001$). GROF scores were worse for NP [64.4(62.3-66.5)] when compared to LP [74.9(71.7-78.4); $p < .001$] and FP [78.4(69.8-88.1); $p = .004$], but were not different between LP and FP ($p = .277$). GROD scores were worse for NP [2.9(2.7-3.1)] when compared to LP [2.2(2.0-2.3); $p < .001$] and FP [1.9(1.7-2.0); $P < .001$)], and LP scores were worse than FP ($P < .001$). No differences in rate of recovery were observed between NP ($P = .418$) or LP ($P = .634$) when compared to FP. Rate of recovery of function was different between groups, with NP ($P < .001$) and LP ($P = .05$) recovering faster than FP. No differences in rate of recovery were present between NP ($P = .599$) or LP ($P = .631$) when compared to FP. **Conclusions:** Adolescent athletes restricted to NP following SRI reported worse pain, function, and disability when compared to athletes allowed LP and FP. Single-item measures provide valuable information for providing patient-centered care in adolescent athletes.

PROMIS Physical Function Item Bank v. 1.0: Physical Function Assessment for Athletic Training Clientele

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Context: Establishing efficient outcome instruments that are appropriate for athletic training clientele is a paramount issue in both athletic training practice and research. The universal item banks created by the Patient-Reported Outcome Measurement Information System (PROMIS) provide a framework for creating useful and efficient outcome instruments. Preliminary validity assessments found the PROMIS item bank to be a valid instrument for measuring physical function in general populations when compared to the legacy instrument SF-36PF (Pearson's $r = 0.88$). Although PROMIS item banks have been validated for general populations, their application to athletic training clientele, which may represent a higher level of physical function, has yet to be determined. **Objective:** The purpose of this study was to determine if the PROMIS physical function item bank can accurately distinguish injury status in elite level athletes. **Design:** Cross-sectional design. **Setting:** Division I and Division III collegiate athletic training rooms. **Patients or Other Participants:** A heterogeneous sample of 150 Division I and Division III collegiate athletes volunteered for this study. Participants were divided into three groups depending on current health status: Healthy (H) (33 men, 37 women; Mean age = 19.7 ± 1.1 years), injured and currently participating in sport (IP) (21 men, 29 women; Mean age = 19.9 ± 1.2 years), injured and currently not participating in sport (INP) (12 men, 18 women; Mean age = 19.7 ± 1.3 years). Since participants volunteered to participate in the study prior to receiving the questionnaires, there was a 100% response rate. **Interventions:** Participants completed two assessments in-person using a

computer: 1)an injury questionnaire and 2)the PROMIS physical function item bank v.1.0 in computer adaptive form. The PROMIS assessment provided an overall physical function score between 0 and 100, with higher scores indicating higher levels of physical function. The injury questionnaire provided information on recent orthopedic injuries and current sport participation status. **Main Outcome Measures:** PROMIS physical function score. The three health status groups were compared using a one-way analysis of variance (ANOVA). Tukey post hoc analysis was conducted on any significant differences. A priori alpha level was set at $p < .05$. **Results:** A one-way ANOVA identified a significant difference in mean PROMIS physical function scores between the groups ($F2,149 = 67.42$, $P < .001$). Post hoc analysis revealed that the H group (Mean = 61.7, SD = 6.0) scored significantly higher than the IP group (Mean = 54.9, SD = 7.5). Additionally, the IP group scored significantly higher than the INP group (Mean = 44.1, SD = 8.2). **Conclusions:** The PROMIS physical function item bank v.1.0, when administered in computer adaptive form, can accurately distinguish injury status with elite level athletes on a physical function latent trait continuum. Being able to identify these differences in a quick and easy manner allows practitioners to objectively assess the impact an injury might be having on an athlete's physical function as well as the effectiveness of a treatment which is being employed.

The Development of Summary Components for the Disablement in the Physically Active Scale in Collegiate Athletes

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Context: The Disablement in the Physically Active Scale (DPA) is a generic patient-reported outcome instrument developed by athletic trainers to evaluate constructs of disability in physically active populations. While the DPA includes items designed to assess impairment, functional limitations, disability, and quality-of-life, the scale has yet to be analyzed for summary components. **Objective:** Analyze the scale structure of the DPA for summary components. **Design:** Cross-sectional. **Setting:** Athletic facilities. **Patients or Other Participants:** Four hundred and fifty-six athletes (199 males, 257 females; 19.5 ± 1.3years, 173.9 ± 10.5cm, 71.9 ± 13.7kg) were recruited from two Division-I and one Division-III institution. Athletes were included regardless of participation status creating a diverse sample of current and past injury histories ranging from no history to severe musculoskeletal injuries. **Interventions:** During a single session, participants completed a demographic form and the 16-item DPA. DPA responses were based on a 5-point Likert scale ranging from 'no problem' to 'severe'. Higher scores indicate increased disablement (DPA: score range = 0-64). High test-retest reliability (ICC = 0.943) and internal consistency ($\alpha = 0.890$-0.908) values have been previously reported for the DPA. **Main Outcome Measures:** A principal component analysis (PCA) was conducted with oblique rotation (promax). Sampling adequacy was verified with the Kaiser-Meyer-Olkin measure (KMO > 0.5) and correlations between items were justified using Bartlett's test of sphericity ($p < 0.05$). Factors with eigenvalues >1 that explained >5% of the variance were retained. For identified summary components, internal consistency was examined using Cronbach's alpha and construct validity was established by performing Spearman's correlations with the original DPA ($p < 0.05$). Descriptive statistics are reported as mean±standard deviation. **Results:** The PCA revealed a 2-factor structure for the DPA (13.2 ± 12.5) with Questions 1-12 loading on Factor 1 and Questions 13-16 loading on Factor 2 ($O = 0.939$; $x2(120) = 5022.19$, $p < 0.001$). All items had a factor loading ≥ 0.58. Questions 1-12 addressed items specific to impairment, activity limitations, and participation restrictions. Questions 13-16 addressed items specific to psychosocial well-being. Consideration of item content suggested Factor 1 concerned physical function while Factor 2 concerned mental well-being. Thus, items clustered around Factor 1 were identified as physical (DPA-Physical: score range = 0-48) and Factor 2 as mental (DPA-Mental: score range = 0-16) summary components. Overall, the two factors accounted for 65.1% of the variance in responses. Cronbach's alpha values for the DPA-Physical and DPA-Mental components were 0.941 and 0.878, respectively. DPA-Physical (10.2 ± 10.4, $r = 0.956$, $p < 0.001$) and DPA-Mental (3.0 ± 3.7, $r = 0.691$, $p < 0.001$) scores strongly correlated to the original DPA and moderately correlated to each other ($r = 0.484$, $p < 0.001$) providing evidence for construct validity. **Conclusions:** The DPA demonstrated a 2-factor structure that resulted in DPA-Physical and DPA-Mental summary components. Although the DPA provides a beneficial overview of a patient's health status, analyzing the scale as separate summary components may provide distinct information that can be used to further develop treatment algorithms which reflect the entire spectrum of function and emphasize patient-centered health care.

Confirmatory Factor Analysis of the Pediatric Quality of Life in Adolescent Athletes: A Report from the Athletic Training Practice-Based Research Network

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Context: The use of patient-rated outcome measures (PROM) is important for evaluating health-related quality of life (HRQoL) and delivering whole person healthcare. The Pediatric Quality of Life Inventory (PedsQL™) is a PROM commonly used in sports medicine, but little is known about its construct validity within healthy and injured adolescent athletes. **Objective:** To examine the factor structure of the PedsQL™ in healthy and injured adolescent athletes. **Design:** Confirmatory factor analysis. **Setting:** Athletic training clinics. **Patients or Other Participants:** 1783 healthy (male = 1419, female = 364; mean age = 16.6), 387 concussion-injured (male = 267, female = 120; mean age = 16.0), and 682 musculoskeletally-injured (male = 354, female = 328; mean age = 16.7) adolescent athletes were included. All injured participants were diagnosed by and under the care of an athletic trainer. **Interventions:** The independent variable was injury group: healthy (no injury), concussion injury, and musculoskeletal injury. Healthy and injured participants completed the PedsQL™ during pre-season testing and within 7 days of injury, respectively. **Main Outcome Measures:** Two proposed factor structures of the 23-item PedsQL™ were tested: the conventional 4-factor model (physical, emotional, social, school), and a 5-factor solution proposed by the developer for adolescents with chronic illness (physical, emotional, social, and 2 school factors to accommodate youth who must be absent from school). The fit of the data to these models was examined using the following standard criteria: $\chi 2$/df ratio < 3, Root Mean Square Error of Approximation (RMSEA) < .065, Tucker Lewis Index (TLI) > .90, Comparative Fit Index (CFI) > .95 and the Akaike Information Criterion (AIC) in which smaller values indicate better fit. An asymptotically distribution-free approach was used. **Results:** Indices for the 4-factor structure indicated an unacceptable fit for all groups: Healthy: $\chi 2$/df ratio = 3.36, RMSEA=.036, TLI = .59, CFI = .640, AIC = 782.62; Musculoskeletal: $\chi 2$/df ratio = 3.89, RMSEA = .065, TLI = .750, CFI = .780, AIC = 889.76; Concussion: $\chi 2$/df ratio = 3.24, RMSEA = .076, TLI = .769, CFI = .797, AIC = 758.51. The 5-factor structure yielded more favorable indices than the 4-factor structure but also suggested a poor fit: Healthy: $\chi 2$/df ratio = 2.99, RMSEA = .033, TLI = .66, CFI = .703, AIC = 702.71; Musculoskeletal: $\chi 2$/df ratio = 3.76, RMSEA = .064, TLI = .762, CFI = .795, AIC = 855.24; Concussion: $\chi 2$/df ratio = 3.02, RMSEA = .072, TLI = .792, CFI = .821, AIC = 708.41. **Conclusions:** The proposed factor structures for the PedsQL™ appear to be suboptimal for measuring HRQoL in athletes, regardless of injury status or type of injury. The data from all groups fit the 5-factor model better than the 4-factor model, suggesting that athletes who miss school as a result of injury comprise an important subgroup whose HRQoL is meaningfully impacted. Athletic trainers should be aware that the PedsQL may not capture all HRQoL aspects that are meaningful and important to adolescent athletes. The use and development of athlete-specific PROMs may be needed. Future research should explore injury group differences and whether injury type warrants the development of alternative PROMs.

Preoperative Patient Factors Associated With Neuromuscular Quadriceps Function Prior to Anterior Cruciate Ligament Reconstruction

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Context: Preoperative quadriceps function is a significant predictor of postoperative outcomes in patients who have undergone anterior cruciate ligament (ACL) reconstruction. However, the effects of preoperative patient factors on quadriceps function observed prior to surgery remain unknown. **Objective:** To investigate the relationship between preoperative patient factors and preoperative neuromuscular quadriceps function. **Design:** Cross-sectional study. **Setting:** University musculoskeletal laboratory. **Patients or Other Participants:** 23 patients (15 females, 8 males; age = 18.6 ± 5.6 yr, height = 170.3 ± 9.8 cm; mass = 72.8 ± 18.6 kg) scheduled to undergo ACL reconstruction volunteered to participate this study. **Interventions:** None. **Main Outcome Measures:** The patient factors examined in this study were time-from-injury, pain, joint swelling, and thigh atrophy. Time-from-injury was defined as the number of days from the patient's injury to when they underwent neuromuscular testing. Pain was assessed with a 100 mm visual analog scale. Joint swelling and thigh atrophy were based on clinical girth measurements (cm) taken at the joint line and 1/3 the distance from the tibial tuberosity to the anterior superior iliac spine, respectively. Girth measurements of the injured limbs were divided by those of the uninjured limb to obtain symmetries (%). Both girth measures have demonstrated high reliability (ICC > 0.8) and the ability to detect significant changes. The neuromuscular measures of interest were peak isometric knee extension torque, voluntary quadriceps activation, and cortical excitability at the quadriceps. Bilateral torque and activation measurements were performed on an isokinetic dynamometer with patients' knees fixed at 90° of flexion. Peak torque was normalized to patient bodyweight (Nm/kg). A superimposed burst technique was used to assess quadriceps activation, and central activation ratios were calculated to provide activation levels (%). Cortical excitability was assessed using transcranial magnetic stimulation and surface EMG at the vastus medialis oblique muscle. Active motor thresholds were calculated as the percentage of stimulus output required to produce EMG amplitudes of 100μv. Pearson correlation analyses were performed to examine the relationships between the preoperative patient factors and neuromuscular measures. **Results:** Descriptive statistics (mean ± SD) for all study variables were as follows: time-from-injury (24.3 ± 18.4 days), joint swelling (+2.5 ± 2.0%), thigh atrophy (-3.0 ± 2.6%), pain (53.6 ± 23.3 mm), normalized peak torques of injured (2.7 ± 0.8 Nm/kg) and uninjured limbs (3.0 ± 0.6 Nm/kg), central activation ratios of injured (89.3 ± 8.4%) and uninjured limbs (85.6 ± 9.7%), and active motor thresholds (37.4 ± 8.8% output). Significant correlations were observed between preoperative thigh atrophy and central activation ratios of both injured ($r = 0.45$, $p = 0.04$) and uninjured limbs ($r = 0.65$, $p = 0.001$). There were no significant correlations observed with the other preoperative patient factors ($p > 0.05$). **Conclusions:** The findings of this study demonstrate significant associations between thigh atrophy and quadriceps activation in patients before ACL reconstruction. Thigh girth may be a low cost method of identifying quadriceps inhibition. Disinhibitory interventions should be implemented in the preoperative rehabilitation of these patients to maximize quadriceps activation and limit muscle atrophy.

Knee Extensor Torque Variability and Subjective Knee Function in Early, Mid, and Late Stages After ACL Reconstruction Surgery

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Context: Quadriceps muscle dysfunction is common after anterior cruciate ligament reconstruction (ACL-R) and may play a role in joint function. Impairments in quadriceps motor control have been identified in these patients using measures of maximal knee extensor torque variability. **Objective:** To compare knee extensor torque variability and subjective knee function in groups of patients at early (4-12 months), mid (1-3 years), and late (3-8 years) stages after ACL-R, and healthy controls. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants**: Sixty-seven individuals with a history of primary, unilateral ACL-R and fifty healthy controls. Early group (n = 23): history of ACL-R between 4-12 months (Post-op: 7.3 ± 2.0 months, 8F:15M, 22.4 ± 7.0 years, 76.5 ± 17.7 kg, 1.75 ± .09 m). Mid group (n = 20): history of ACL-R between 1-3 years (Post-op: 21.3 ± 7.2 months, 11F:9M, 22.6 ± 5.2 years, 70.1 ± 12.0 kg, 1.70 ± .10 m). Late group (n = 24): history of ACL-R between 3-8 years (Post-op: 68.5 ± 14.8 months, 11F:13M, 23.5 ± 4.4 years, 75.5 ± 15.0 kg, 1.74 ± .11 m). Healthy (n = 50): no history of lower extremity joint injury (22F:28M, 23.3 ± 4.4 years, 67.4 ± 13.2 kg, 1.70 ± .09 m). **Interventions:** None. **Main Outcome Measures:** Participants completed three, 3-second seated maximal isometric knee extensor contraction trials using a dynamometer (90° flexion), and the International Knee Documentation Committee subjective knee evaluation form (IKDC). A 500-ms epoch at peak torque was processed for mean torque (Nm) and torque standard deviation (Nm). Coefficient of variation (CV) was

calculated for each torque trial using the formula: CV= ([standard deviation/ mean] × 100). Group comparisons of CV and IKDC scores were made using a one-way ANOVA and planned independent t-tests. **Results:** There were overall differences in CV (Early: 1.44 ± .70, Mid: .98 ± .38, Late: 1.26 ± .45, Healthy: .88 ± .41, $P < .001$) and IKDC (Early: 82.3 ± 12.5, Mid: 87.4 ± 11.2, Late: 89.3 ± 9.6, Healthy: 98.9 ± 2.7, $P < .001$) between groups. CV was greater in the Early ($P < .001$) and Late ($P = .001$) groups compared to the Healthy group. CV was greater in the Early ($P = .01$) and Late ($P = .03$) groups compared to the Mid group. There was no difference in CV between the Early and Late groups ($P = .31$). There was no difference in CV between the Mid group and Healthy group ($P = .35$). IKDC was greater in the healthy group compared to the Early ($P < .001$), Mid ($P < .001$), and Late ($P < .001$) groups. IKDC was lower in the Early group compared to the Late group ($P = 04$). There was no difference in IKDC between the Mid group and the Early ($P = .17$) or Late ($P = .56$) groups **Conclusions:** Torque variability was greater in the early and late groups compared to the healthy and mid groups. Quadriceps motor control may decline in the late stages post-surgery following an initial improvement from early to mid stages post-surgery. Subjective knee function was greater in the late stage post-surgery compared to early stage, but still lower compared to healthy individuals.

Temporo-Spatial Asymmetry in Individuals With a History of ACL Reconstruction

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Context: Asymmetries in lower extremity biomechanics have been reported following ACL reconstruction (ACLR). While asymmetry in temporo-spatial gait characteristics, such as ground reaction force, stride length and cadence, have been established as predictors of disability in pathologic populations, the relationship between these measures and knee related outcomes following ACLR remains unclear. **Objective:** To compare temporo-spatial jogging gait asymmetry between healthy individuals and those with a history of ACLR as well as to establish the relationship between asymmetry and patient reported knee related function. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-three recreationally active, healthy individuals (13M/10F: age = 21.9 ± 3.6 yrs, height = 168.5 ± 8.7 cm, mass = 69.6 ± 13.8 kg) and 17 individuals with a history of unilateral, primary ACLR at least 6 months prior to testing (9M/8F: age = 22.4 ± 5.3 yrs, height = 172.0 ± 7.2 cm, mass = 70.6 ± 11.1 kg, time since surgery = 33.9 ± 23.9 mo). **Interventions:** None. **Main Outcome Measures:** Knee related function was assessed using the International Knee Documentation Committee (IKDC) form. Participants jogged at 9.66km/h on a force-plate imbedded treadmill while three-dimensional motion analysis was completed using a 12 camera motion analysis system. Participants completed three 30 second jogging trials. Bilateral vertical ground reaction forces (vGRF, %BW) were measured during initial loading (0-10% gait cycle) and mid-stance (10-40% gait cycle) of the gait cycle. Bilateral cadence (steps/min), stride time (sec), and stride length (cm) were measured during each trial. Symmetry indices (SI, %asymmetry) were calculated for each dependent variable by dividing the product of each limb (ACLR = injured and uninjured, Healthy = non-dominant and dominant) by the mean of both limbs. An SI of 1 indicated optimal limb symmetry. Between group SI differences were measured using independent samples t-tests. The relationship between IKDC score and SI for each variable was established using Pearson's product-moment correlation coefficients (r). **Results:** The ACLR group reported worse IKDC scores (ACLR = 89.6 ± 11.1, Healthy = 99.3 ± 1.6, $t(38) = 4.14$, $P < 0.001$) compared to the healthy control group. The ACLR group displayed greater asymmetry (difference compared to 1) in vGRF during mid-stance (ACLR = 4.05 ± 3.83, Healthy = 2.14 ± 1.72, $t(38) = -2.13$, $P = 0.04$) and jogging cadence (ACLR = 0.01 ± 0.04, Healthy = 0.07 ± 0.14, $t(38) = -2.01$, $P = 0.05$) when compared to the healthy control group. IKDC score was negatively correlated to asymmetry in vGRF ($r = -0.50$, $P = 0.04$) during initial loading for individuals with a history of ACLR. In addition, IKDC score was negatively correlated with asymmetry in vGRF during mid-stance ($r = -0.40$, $P = 0.01$) for all participants. **Conclusions:** Asymmetry in vGRF was greater in those with a history of ACLR despite having made a full return to recreational physical activity. This asymmetry was also shown to be related to reduced knee related function. These findings are consistent with previous studies that have established the relationship between poor knee related function and persistent movement alterations following ACLR. The development of clinically relevant assessment tools to evaluate movement asymmetry following ACLR may be essential to optimizing patient outcomes.

Combination of Eccentric Exercise and Neuromuscular Electrical Stimulation to Improve Knee Mechanics Post-ACL Reconstruction

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Context: Quadriceps activation failure and muscle atrophy are two critical components of quadriceps function that are thought to contribute to the weakness that lingers following anterior cruciate ligament reconstruction (ACLr). We have previously reported that an eccentrically based rehabilitation protocol post-ACLr induced greater quadriceps activation and strength than a neuromuscular electrical stimulation (NMES) intervention. However, the effect an eccentrically based intervention has on restoring normal knee mechanics remains unknown. **Objective:** To evaluate the effects of a combined NMES and eccentric exercise intervention on knee mechanics post-ACLr during a dynamic landing task. **Design:** Parallel longitudinal. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-six individuals post-injury were placed into four treatment groups (N&E, NMES and eccentrics: n = 8, 23.2 ± 6.3 yrs, 1.45 ± 0.6 m, 77.8 ± 16.5 kg; E-only, eccentrics-only: n = 8, 23.2 ± 5.4 yrs, 1.75 ± 0.1 m, 77.7 ± 10.4 kg; N-only, NMES-only: n = 10, 21.8 ± 4.4 yrs, 1.76 ± 0.1 m, 81.65 ± 22.6 kg; STND, standard of care: n = 10, 18.3 ± 3.7 yrs, 1.73 ± 0.1 m, 75.5 ± 24.1 kg) and ten Healthy controls participated (23.5 ± 3.4 yrs, 1.73 ± 0.1 m, 71.7 ± 9.9 kg). **Interventions:** All ACL patients, regardless of group, received the standard of care post-ACLr. N&E received a combined NMES and eccentric protocol post-reconstruction, whereas groups N-only and E-only received only the NMES or eccentric therapy, respectively. The NMES protocol was delivered 2x per week for the first six weeks following ACLr, while the single-legged eccentric leg press protocol was delivered 2x per week for six weeks beginning at week six post-ACLr. **Main Outcome Measures:** Sagittal plane knee mechanics were evaluated at return-to-sport during a single-legged landing task. To evaluate knee mechanics, the area under the curve during the first 50% of stance for knee flexion angle and extension moment was derived and normalized to the contralateral limb to create limb symmetry indices (LSIs). One-way ANOVAs were utilized to compare LSIs differences between groups with post-hoc Bonferroni procedures where appropriate (α-level, $P \leq 0.05$). **Results:** Significant group differences were observed in the LSIs (LSIangle: $F_{4,45} = 2.615$, $P = 0.049$; LSImoment: $F_{4,45} = 5.292$, $P = 0.002$). Specifically, compared to Healthy (LSImoment = 99.87 ± 21.6), reduced sagittal plane knee extension moment LSIs were found for groups N-only (LSImoment = 64.22 ± 19.0, P = 0.020), E-only (LSImoment = 55.35 ± 24.1, P = 0.004) and STND (LSImoment = 58.75 ± 20.1, P = 0.005). No difference was detected between Healthy and N&E (LSImoment = 66.72 ± 19.0, P = 0.060). N-only tended to demonstrate lower knee flexion angle LSI as compared to Healthy (Healthy: LSIangle = 95.77 ± 11.7; N-only: LSIangle = 73.38 ± 18.0, P = 0.083). No other significant post-hoc differences were observed (N&E: LSIangle = 92.38 ± 21.1, P = 1.000; E-only: LSIangle = 83.74 ± 23.3, P = 1.000; STND: LSIangle = 78.10 ± 15.9, P = 0.345). **Conclusions:** N&E was found to restore sagittal plane knee limb symmetry better than the N-only, E-only or the STND post-ACLr. An eccentric intervention lasting longer than six weeks may be beneficial, as this therapy was found to be the driving factor behind strength gains in our previous work, and ACLr patients with less side-to-side strength deficits were able to demonstrate movement patterns that more closely resemble their non-injured limb. Supported by NIH Grant K08 AR053152-01A2 and an NATAREF Doctoral Grant.

Early Cartilage Changes Following ACL Injury/ Reconstruction: Evaluation With Imaging and Serum Biomarkers

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Context: ACL injury and associated bone marrow edema lesions (BMEL) may contribute to the development of osteoarthritis. Longitudinal analyses examining how cartilage and biological markers change over time will help to further elucidate the relationship between ACL injury/reconstruction and knee joint degradation. **Objective:** To determine if knee cartilage matrix and morphology imaged with MRI as well as serum biomarkers of inflammation and matrix degradation differ over time in patients with ACL injury/reconstruction and BMEL when compared with control subjects. **Design:** Case control pilot study. **Setting:** University Hospital and Rehabilitation Clinic. **Patients or Other Participants:** Eleven ACL-injured subjects with associated BMEL scheduled to undergo reconstruction (6 female; age: 19 ± 5.7 yrs; height: 172.6 ± 8.7 m; mass: 69.9 ± 16.1 kg) had measurements recorded prior to and one year following ACL reconstruction, while 11 control subjects (6 female; age 20 ± 5 yrs; height 175 ± 7 m; mass 66.9 ± 9.8 kg) had measurements taken upon study enrollment and one year later. **Interventions:** MRI scans were completed using a 3T research scanner (Phillips Ingenia) to assess changes in the cartilage matrix with T2 mapping and to assess gross cartilage morphology using a modified Outerbridge scale. Venus blood draws at the antecubital fossa were also undertaken and enzyme-linked immulsorbent assay were used to quantify serum cartilage oligomeric matrix protein (COMP) (R&D systems) and C-reactive protein (Calbiotech). **Main Outcome Measures:** Two x two repeated measures ANOVAs were utilized to make group comparisons across time for the lateral and medial tibial plateaus and femoral condyles, as well as the patella. Univariate F

tests and Sidak multiple comparison procedures were used post hoc when significant differences were found. Outerbridge scores were analyzed using Kruskal Wallis tests to compare groups at each time point; while Wilcoxin signed rank tests were used to make comparisons between the baseline and one year Outerbridge scores for each group. The type I error rate for all tests was set at 0.05. **Results:** ACL patients had prolonged T2 relaxation times in the superficial central lateral tibial plateau (ACL: 40.16 ± 1.56; control: 34.07 ± 1.79; P = 0.018) and for the deep sub medial tibial plateau (ACL: 43.40 ± 1.30; control: 35.47 ± 1.17; P < 0.001) when compared with controls. Prolonged T2 relaxation times were also noted over the lateral femoral condyle at baseline for ACL patients compared to controls (ACL: 56.01 ± 6.17; control: 42.75 ± 9.33; P = 0.001)), but differences resolved at one-year (ACL: 46.08 ± 7.82; control: 46.15 ± 8.95; P = 0.986). Serum COMP values were greater in ACL patients compared to controls (ACL: 233.23 ± 88.26ng/mL; control: 169.05 ± 64.53ng/mL; P = 0.02). **Conclusions:** Prolonged T2 relaxation times following ACL injury/reconstruction suggests early cartilage matrix changes that may be related to the premature development of knee osteoarthritis. Elevated COMP levels in ACL patients are reflective of cartilage breakdown that further supports early cartilage changes following ACL injury/reconstruction. Supported by NFL Charities.

Biomarker Response After an Acute Running Bout in Participants With and Without an Acute Knee Injury History

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Context: Individuals with an acute knee injury history (AKIH) are four times more likely to develop knee osteoarthritis (OA) than those without a prior knee injury. Unfortunately, it is unknown why AKIH patients develop OA. Changes in tissue turnover biomarkers after mechanical loading (e.g., running) may be related to abnormal tissue turnover but this has yet to be determined among young physically active individuals. **Objective:** To determine biomarker concentration levels at pre exercise and concentration changes in response to an acute running bout in participants with AKIH in comparison to healthy control participants. **Design:** Two-group pre-test/post-test. **Setting:** Research Laboratory. **Patients or Other Participants:** Based on a priori power computations, 22 physically active individuals between 18 to 25 years of age were recruited. AKIH participants (n = 11, age: 20.1 ± 1.1 years, height: 1.7 ± 0.1 meters, weight: 74.4 ± 14.0 kg, body mass index: 24.5 ± 2.8 kg/m2) had an acute knee injury within 4 years of study participation and were medically cleared for physical activity. Eleven control participants with no AKIH (n = 11, age: 19.9 ± 1.6, height: 1.7 ± 0.1 meters, weight: 73.4 ± 14.4 kg, body mass index: 24.2 ± 2.8 kg/m2) were matched by age, gender, mass, height, and physical activity level. **Interventions:** The independent variable was group (AKIH or CON). Each participant provided a 7mL blood sample that was analyzed for biomarker concentrations pre and post a 30-minute run on a treadmill at 2.2 m/s. Wilcoxon Signed Rank Tests were conducted to determine if there were any significant group differences. Statistical significance was defined as $p \leq 0.05$, medians and [ranges] are reported. **Main Outcome Measures:** Dependent variables of interest were serum biomarker concentrations for cartilage oligomeric matrix protein (COMP), pro-inflammatory marker interleukin (IL)-1β, and type II collagen synthesis marker (CPII). COMP, IL-1β, and CPII assays had mean intra-assay values of <8% and a mean inter-assay value <10% for all biomarkers. **Results:** No significant group differences existed in serum biomarker concentrations pre exercise COMP (AKIH = 610.30 [455.31-1252.21], CON = 680.25 [285.92-1389.37]; p = 0.424), CPII (AKIH = 2763.22 [1318.97-5691.86], CON = 3153.37 [613.07-5491.43]; p = 0.657), and IL-1β (AKIH = 2.48 [1.37-7.91], CON = 1.81 [1.81-15.02], p = 0.091) or in serum biomarker changes pre to post exercise COMP (AKIH = 9.60 [-565.79-881.25], CON = -283.92 [-744.09-970.41]; p = 0.328), CPII (AKIH = -1030.69 [-3025.95-15.02], CON = -283.92 [-3079.21-2052.84]; p = 0.328), and IL-1β (AKIH = 1.50 [-5.13-5.81], CON = -0.49 [-3.58-1.36], p = 0.182) between groups. **Conclusions:** The findings of this study indicate that an acute bout of moderate-intensity running is tolerated in a high-risk AKIH population and does not adversely affect knee biomarker metabolism. However, these findings should be interpreted with caution as it is yet to be determined if varied exercise types, frequencies, and/or intensities elicit adverse biomarker responses within this population or if these findings are replicable in other populations (e.g., older or younger).

Somatosensory Deficits in Patients With a History of ACL Reconstruction

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Context: Sensorimotor alterations, such as decreased postural control have been documented following ACL reconstruction (ACLR). There is a paucity of literature examining somatosensory deficits in cutaneous detection thresholds in these patients. Furthermore, there is no evidence examining sensation deficits in post-ACLR patients using the Semmes-Weinstein Monofilaments (SWM), a clinical measure to assess light touch detection thresholds. **Objective:** Compare lower-limb cutaneous detection thresholds between individuals with and without ACLR using SWM. **Design:** Case-Control **Setting:** Laboratory **Patients or Other Participants:** Sixteen physically active subjects volunteered to participate. Eight subjects with ACLR (4 males, 4 females; age: 22.5 ± 4.1 years, height: 174.0 ± 10.2 cm, mass: 74.9 ± 12.6 kg, years since surgery: 5.5 ± 3.7 years) were matched with eight healthy controls (4 males, 4 females; age: 22.8 ± 3.4 years, height: 168.5 ± 13.3 cm, mass: 72.1 ± 8.5 kg). Subjects were matched based on gender, limb, and age. No group differences in demographics (age, height, mass or physical activity level) were found ($p > 0.05$). **Intervention:** Each subject reported to the laboratory for one testing session. Lower-limb cutaneous sensation was assessed using a 20-piece SWM kit (1.65-6.65) at four locations: the plantar aspect of the head of 1st metatarsal (1st-met) and the base of the 5th metatarsal (5th-met) and the medial (med-mal) and lateral malleolus (lat-mal). Subjects were positioned prone on a plinth with noise canceling headphones. All testing locations were marked prior to assessment. A nylon monofilament was applied perpendicular to the skin with the force to create a "C" shape. Subjects were instructed to state "yes" at any point a monofilament was perceived. Testing was initiated at each site with a 4.74 level monofilament. A 4-2-1 stepping algorithm was used to determine detection thresholds. Based on a positive or negative detection, the monofilament was decreased or increased according to the algorithm until the detection threshold was identified. Testing sites were counterbalanced to avoid an order effect. **Main Outcome Measures:** The dependent variable was detection threshold at each site (1st-met, 5th-met, med-mal, lat-mal) and the independent variable was group (ACLR, healthy). Higher detection thresholds represented lesser sensitivity. Descriptive statistics were calculated (mean ± standard deviation) for all measures. Separate Mann-Whitney U tests examined group differences at each site ($p < 0.05$). **Results:** Significant differences were found at the 1st-met (ACLR = 4.00 ± 0.31, healthy = 3.51 ± 0.45; $p = 0.018$) and the med-mal (ACLR = 4.57 ± 0.45, healthy = 4.05 ± 0.26; $p = 0.018$). No significant differences were found at the 5th-met (ACLR = 4.02 ± 0.32, healthy = 3.70 ± 0.41; $p = 0.132$) or lat-mal (ACLR = 4.46 ± 0.55, healthy = 4.21 ± 0.63; $p = 0.341$). **Conclusions:** Our results suggest subjects with history of ACLR have decreased light touch sensation at the 1st-met and med-mal compared to healthy individuals when assessed using SWM. These somatosensory deficits may be related to other sensorimotor deficits that have been observed following ACLR such as decreased postural control or altered gait. Cutaneous sensation should be considered when implementing a rehabilitation plan which focuses on the entire sensorimotor system following ACLR.

The Relationship Between Clinical Measures of Sensation and Postural-Control in Post-ACL Reconstruction Patients

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Context: Postural control deficits have been documented following ACL injury and reconstruction (ACLR). However, the contributing factors to postural control deficits remain unclear in these patients. The relationship between cutaneous sensation of foot and postural control is well established in various clinical populations but it has not been explored in individuals with ACLR. **Objective:** To determine if relationships exist between cutaneous detection thresholds in the foot and ankle and static postural control in individuals with a history of ACLR. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Eight physically active adults with ACLR (4 males, 4 females; age: 22.5 ± 4.1 years, height: 174.0 ± 10.2 cm, mass: 74.9 ± 12.6 kg with a history of ACLR (years since surgery: 5.5 ± 3.7 years) participated. **Interventions:** Subjects reported to the laboratory for one session. Cutaneous sensation was assessed at the base of fifth metatarsal (5th-met), head of first metatarsal (1st-met), medial (med-mal) and lateral malleolus (lat-mal) using Semmes–Weinstein Monofilaments (SWM) in a counterbalanced order. Subjects were positioned prone on a plinth with noise canceling headphones. Monofilaments were applied perpendicular to the skin with the force to create a "C" shape. Subjects were instructed to verbally indicate when a monofilament was perceived. A 4-2-1 stepping algorithm was used to determine detection thresholds. Based on a positive or negative detection, the monofilament was decreased or increased according to the algorithm until the detection threshold was identified. Higher detection thresholds indicated poorer sensation. Static postural control was assessed using a modified Balance Error Scoring System (BESS). Subjects

completed one practice and one test trial on the single leg firm and foam conditions with eyes closed. Each trial was 20 seconds and the number of errors during each trial was recorded. A greater number of errors indicated poorer postural control. **Main Outcome Measures:** The dependent variables were cutaneous detection threshold at each site (5th-met, 1st-met, med-mal and lat-mal) and BESS errors for each condition (BESS-firm, BESS-foam). Descriptive statistics were calculated for all variables (mean ± SD). Spearman's rank correlations and the coefficient of determination examined the relationship (r) and explained variance (r^2) between dependent variables. Correlation coefficients were interpreted as weak (0.01-0.39), moderate (0.40-0.69) or strong (0.70-1.0). Alpha was set a $p \leq 0.05$ for all analyses. **Results:** There were no statistically significant correlations between cutaneous detection thresholds and static postural control ($p > 0.05$). However, there were moderate relationships between BESS-firm (1.50 ± 1.77) and lat-mal (4.48 ± 0.55; $r = 0.57$, $r^2 = 0.32$, $p = 0.141$) and the BESS-foam (6.88 ± 2.17) and 1st-met (4.00 ± 0.33; $r = 0.47$; $r^2 = 0.22$, $p = 0.236$). **Conclusions:** Although statistical significance was not achieved, these data suggest individuals with ACLR who exhibit poorer postural control also demonstrate higher detection thresholds at the 1st-met and lat-mal (up to 32% explained variance). Rehabilitation strategies which target this aspect of somatosensation may enhance postural control in ACLR patients.

The Effect of Cadet Basic Training on Bilateral Peak Vertical Ground Reaction Force in Patients With Prior ACL Injury

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Context: Those with a prior ACL injury are at an increased risk for subsequent ACL injury. This may be of particular concern for patients entering military service and completing basic training – a time of high physical activity, stress, and fatigue. Understanding if and how lower extremity biomechanics change as a result of basic training may help develop interventions to prevent re-injury for these patients. **Objective:** The purpose of this study was to determine the effect of Cadet Basic Training on peak vertical ground reaction force of the injured and uninjured leg for patients with prior ACL injury. **Design:** Repeated Measures **Setting:** Research laboratory **Patients or Other Participants:** Ten participants were recruited to participate in this study (5 Male, 5 Female; Height: 167.56 ± 17.41 cm, Mass: 74.74 ± 10.94 kg). All participants were entering freshman at the United States Air Force Academy, and all reported a history of a single ACL injury and reconstructive surgery. **Interventions:** Participants completed a double leg jump landing task at the beginning and end of Cadet Basic Training. Time between testing was approximately 6 weeks. Measures were collected using two non-conductive force plates. **Main Outcome Measures:** Peak vertical ground reaction force (N) during the landing phase of the double leg jump landing was recorded bilaterally for the injured and uninjured leg. Values were averaged across trials and normalized to each participant's body weight (N). A 2x2 (Time: Pre-CBT, Post-CBT; Limb: Injured Leg, Uninjured Leg) ANOVA was used to determine between limb differences and changes across time; a priori alpha level 0.05. **Results:** We observed no significant main effects for Time ($p = 0.56$) or Limb ($p = 0.59$). We observed no significant Time x Limb interaction effect either ($p = 0.067$) [Pre-CBT: Injured Leg = 2.91 ± 0.72 N/BW(N), Uninjured Leg = 3.28 ± 0.66 N/BW(N); Post-CBT: Injured Leg = 2.67 ± 0.86 N/BW(N), Uninjured Leg = 3.22 ± 1.08 N/BW(N)] **Conclusions:** We observed no significant changes in peak vertical ground reaction force for the injured or uninjured leg for patients with a prior ACL injury completing Cadet Basic Training. Our observations suggest that how these patients load their legs during a jump landing task is resistant to the demands of Cadet Basic Training. Future research should include kinematics to provide a more thorough assessment as to whether Cadet Basic Training changes a patient's risk for re-injury via alterations in lower extremity biomechanics.

Trunk Frontal Plane Motion in Individuals With and Without History of ACL Reconstruction

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Context: Previous studies suggest that increased trunk motion during functional exercise may be a risk factor for sustaining an ACL injury as it demonstrates decreased dynamic postural control. ACL-reconstructed (ACL-R) individuals have been found more likely to score an error in the Landing Error Scoring System (LESS) for lateral trunk flexion during a jump-landing task than healthy individuals, however there is limited kinematic data about these motions in an ACL-R population. Increased vertical ground reaction forces (VGRF) are also thought to be predictive of increased ACL loading. **Objective:** To evaluate trunk frontal plane motion and VGRF during a jump-landing task between individuals with and without a history of ACL-R. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty-two active, healthy participants volunteered to participate. Twenty-one participants reported a history of an ACL-R (ACL-R; 14 males, 8 females, age = 22 ± 4 years, height = 174.6 ± 7.3 cm, mass = 76.7 ± 9.9 kg) and were matched by sex, height, mass and limb to 21 individuals without a history of ACL-R (HC; 14 males, 8 females, age = 22 ± 4 years, height = 173.3 ± 9.3 cm, mass = 75.2 ± 10.7 kg). All ACL-R participants were cleared by their physician and had returned to high-level sport activities involving landing and/or cutting at the time of testing. **Interventions:** During a single test session, lateral trunk displacement and VGRF were assessed during three trials of a jump-landing task using an electromagnetic motion analysis system synchronized with a non-conductive force plate. During the jump-landing task, participants jumped forward from a 30-cm box a distance of half their body height, landed with their feet on separate force plates and jumped for maximal height immediately upon landing. **Main Outcome Measures:** Total joint displacement for trunk frontal plane motion between initial ground contact (VGRF>50N) and peak knee flexion were calculated using a customized software program. Trunk frontal plane motion at initial ground contact, as well as peak VGRF, were also assessed. The average values from the three trials were used for analyses. Peak VGRF were normalized to % body weight (N). We performed separate independent t-tests to compare groups (ACL-R vs HC) for all dependent variables ($\alpha < 0.05$) **Results:** VGRF was found to be significantly different between the two groups ($p < 0.01$), with HC individuals landing with more force (1.88 ± 0.12N) than their ACL-R counterparts (1.26 ± 0.68N). No other significant differences were observed ($p > 0.05$). **Conclusions:** We hypothesized ACL-R individuals would land with increased frontal plane motion at the trunk given it is predictive of sustaining an ACL injury; however, we found no difference between ACL-R and HC individuals for peak trunk frontal plane motion. Increased VGRF in the HC group was an unexpected finding and we believe this is potentially due to feedback regarding landing mechanics during post-surgical rehabilitation and subsequent return to landing and/or cutting activities.

The Effects of Cryotherapy on Electrically Evoked Muscle Force

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Context: Neuromuscular electrical stimulation (NMES) is commonly included when managing musculoskeletal injury. When the therapeutic goal is to delay muscle atrophy or to preserve or enhance muscle strength, the strongest electrically evoked contraction is typically desired. However, this is usually limited by nociceptor stimulation and patient tolerance. Thus, it is common practice to combine cryotherapy with NMES for a stronger contraction through cold-induced analgesia and a higher pain threshold. Unfortunately, the efficacy of this practice has not been fully investigated. **Objective:** To determine if the combination of cryotherapy and NMES will elicit stronger contractions than NMES alone and if precooling enhances this effect. **Design:** A randomized cross-over design. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Twelve healthy males and females (age = 19.8 ± .8 years, height = 169.5 ± 7.4 cm, mass = 59.5 ± 21.7 kg) who were not suffering from any injury or condition that would affect upper extremity strength or from any contraindication to cryotherapy or NMES. **Interventions:** Subjects were assessed under three randomly ordered conditions; 20-min of NMES alone (ES), 20-min of cryotherapy and NMES combined (C20) and 20-min of cryotherapy alone immediately followed by 20-min of cryotherapy and NMES combined (C40). A typical Russian protocol (Solaris 709, Dynatronics, Salt Lake City, Utah) applied to the non-dominant biceps brachii with a monopolar electrode arrangement was used for all treatment conditions. Cryotherapy consisted of a standard ice pack with 500-mg of crushed ice placed over the active electrode and held in place with plastic wrap. **Main Outcome Measures:** Peak electrically evoked elbow flexion force was assessed using a wireless microFET2™ digital handheld dynamometer (Hoggan Scientific, Salt Lake City, UT) and current amplitude were recorded at 4-, 8-, 12-, 16- and 20-min during the NMES treatment. Skin surface temperature was also assessed at the same time points and prior to treatment using an Iso-Thermex thermometer (Isothermex, Columbus, OH) and SST-1 skin surface probe. **Results:** At each time point, both the C20 and C40 conditions resulted in cooler temperatures than the ES condition and the C40 condition resulted in cooler temperatures than the C20 condition ($F_{10,110} = 128.52$, $p = .001$). Current amplitude progressively increased during each treatment condition ($F_{8,88} = 13.98$, $p = .001$). Additionally, the amplitude during the C40 condition was significantly greater at each time point as compared to both the ES and C20 conditions. However, cryotherapy had no effect on muscle force ($F_{8,88} = .596$, $p = .779$), as no differences were observed between treatment conditions at any time point (ES = 65.1 ± 34.5, 67.1 ± 38.3, 67.0 ± 35.3, 68.6 ± 28.3, 72.3 ± 27.6; C20 = 53.9 ± 34.6, 67.4 ± 30.3, 63.8 ± 31.6, 66.8 ± 30.8, 69.6 ± 24.7; C40 = 51.6 ± 26.8, 65.9 ± 24.3, 67.8 ± 32.5, 67.5 ± 32.8, 68.7 ± 23.2 kg) **Conclusions:** While precooling resulted in colder surface temperatures and a greater tolerable current amplitude, this did not result in a stronger electrically evoked contraction. Thus, the combination of NMES and cryotherapy is not superior to NMES alone when considering strength of contraction.

The Effect of Elevation on Volumetric Measurements of the Lower Extremity

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Context: The acronym RICE (rest, ice, compression, elevation) has received recent scrutiny regarding its clinical effectiveness. The component of RICE that has the least literature regarding its effectiveness is elevation. **Objective:** The objective of this study was to determine if various positions of elevation result in volumetric changes of the lower extremity. **Design:** A randomized crossover design was used to determine the effects of the four following conditions on volumetric changes of the lower extremity: seated at the end of a table (seated), lying supine (flat), lying supine with the foot elevated 12 inches off the table (elevated), and lying prone with the knees bent to 90 degrees (prone). The conditions were randomized using a Latin Square. Each subject completed all conditions with at least 24 hours between each session. Pre and post volumetric measurements were taken using a volumetric tank. **Setting:** The study took place in an athletic training room on a university campus. **Patients or Other Participants:** The subjects included 21 healthy, college-aged students (9 males, 12 females) ages 19 – 22 with an average age of 21.05 (males - 21; females - 21.09) and no previous (6 month) history of low leg injury. The average height, weight, and BMI were 174.18 cm (males – 176.16 cm; females – 172.2 cm), 74.11 kg (males – 77.4 kg; females – 70.82 kg), and 24.36 (males – 24.82; females – 23.91), respectively. **Intervention(s):** The subject was placed in one of the four testing positions (seated at the end of a table, lying supine, lying supine with the foot elevated 12 inches off the table,

and lying prone with the knees bent to 90 degrees) for 30 minutes. **Main Outcome Measures:** The change in weight of the displaced water was the main outcome measure. The data was analyzed using an ANOVA of the pre and post measurements with a Bonferroni post hoc analysis. The level of significance was set at $P < .05$ for all analyses. **Results:** The only statistically significant difference was between the gravity dependent position (seated) and all other positions ($p < .001$). There was no significant difference between lying supine (flat), on a bolster (elevated), or prone with the knees flexed to 90 degrees (prone). The following values represent the means ± standard error of measure (seated: 11.7 ± 6.47; flat: -14.3 ± 3.58; elevated: -9.3 ± 2.83; prone: -16.3 ± 4.46). **Conclusions:** At this point, the extent of elevation does to appear to have an effect on changes in low leg volume. This study was conducted on healthy individuals and more information is needed to determine if these effects would occur in an individual with swelling.

Ankle Skin Temperature Changes Following Ice Bag Application With Varying Levels of Elevation

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Context: Ice is often applied in conjunction with elevation following an orthopedic injury. It is suggested that this elevation is necessary for minimizing the negative effects of gravity. In recent years there has been some question regarding the necessity and efficacy of elevation in post-acute care. Moreover, it is unknown if varying degrees of elevation impact cooling. **Objective:** The purpose of this study was to determine if lower extremity elevation influences skin cooling during or following a 30-minute ice bag application. **Design:** A 2x3x3 factorial design guided data collection. The independent variables were treatment (yes or no), elevation (0°, 45° or 90°) and time (baseline, immediately postapplication, and 30 minutes postapplication). **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Twenty-one recreationally active subjects (female = 16, age = 20.94 ± 1.69years, ht = 162.40 ± 9.43cm, mass = 62.05 ± 8.87kg: male = 5, age = 22.0 ± 0.0years, ht = 179.49 ± 10.30cm, mass=86.67±14.35kg) with at least 90° of passive hip flexion range of motion volunteered. **Interventions:** Subjects were randomly assigned to a treatment order to determine if they were to receive ice bag application or no ice bag application on the first day of data collection. Subjects were then randomly assigned to an elevation group to determine if their lower extremity would be positioned at 0°, 45° or 90° on the two days of data collection. To measure surface skin temperature we secured a copper-constant thermocouple overtop the subjects' anterior talofibular ligament. Baseline temperatures were then measured for 5 minutes prior to a 30-minute ice bag application or no ice bag application. Following the treatment, subjects remained in the same position for an additional 30-minute rewarming period. Surface skin temperatures were recorded every minute during the baseline, postapplication, and 30-minute postapplication. **Main Outcome Measures:** Surface skin temperature (°C). **Results:** There was a significant 2-way interaction for treatment and time ($F_{2,108} = 83.0$ $P = .001$; $1–\beta = 1.0$). There was no difference between baseline surface skin temperatures (ice: 29.22 ± 1.77°C and no ice: 29.40 ± 1.54°C; Tukey-Kramer, $P > .05$). As expected, surface skin temperature decreased following ice application and at 30 minutes following application ($F_{1,108} = 241.3$; $P = .001$; baseline: 29.22 ± 1.77°C, postapplication: 16.01 ± 3.82°C, 30 minutes postapplication 21.67 ± 1.98°C). Baseline surface skin temperatures did not change regardless of elevation (0°: 29.73 ± 2.36°C, 45°: 29.28 ± 1.44°C, 90°: 28.93 ± 0.76°C; Tukey-Kramer, $P > .05$). Ankle joint cooling was not influenced by the level of elevation ($F_{2,108} = 2.4$; $P = .09$; $1–\beta = .48$). Elevation also did not influence surface skin temperature at 30 minutes following application. (Tukey-Kramer: $P > .05$). **Conclusions:** The level of elevation does not influence surface skin temperature cooling. This study supports recent evidence that elevation does not enhance tissue cooling. Elevation, however, may be beneficial in post-acute injury care through other mechanisms (e.g., tissue oncotic pressure changes).

Ankle Joint Angle and Lower Leg Musculotendinous Unit Response to Cryotherapy

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Context: Clinicians often utilize modalities in therapeutic rehabilitation. One modality that has been debated for its influence on ROM and tissue extensibility is cryotherapy. It is suggested cryotherapy decreases nerve conduction velocity, which in turn allowing for greater increase in ROM. It is also suggested that cryotherapy limits ROM by increasing muscle and joint stiffness. **Objective:** To determine if a 30-minute cryotherapy to the plantarflexor muscles or ankle joint influences passive ankle dorsiflexion ROM, lower leg musculotendinous stiffness (MTS), and relative MTS using corrected calf girth (CCG) and cross-sectional area (CSA). **Design:** A randomized crossover design. Independent variables were gender (males and females), treatment (a 2-kg crushed ice bag over the posterior lower leg muscles, ankle joint, and nothing), day (1st, 2nd, and 3rd), and time (pre-treatment, 10-minute and 20-minute during-treatment, immediately post-, 10-, 20-, and 30-minute post-treatment). **Setting:** Controlled laboratory. **Patients or Other Participants:** Thirty-six individuals (males: n = 16, age = 21.76 ± 2.07 yrs, ht = 177.44 ± 5.70 cm, mass = 84.28 ± 8.73 kg, lower leg skinfold = 0.95 ± 0.37 cm; females: n = 19, age = 20.79 ± 1.00 yrs, ht = 168.74 ± 7.66 cm, mass = 73.47 ± 22.43 kg, lower leg skinfold = 1.79 ± 0.26 cm) with no history of lower leg injury 6 months prior to data collection volunteered. **Interventions:** Subjects reported to the laboratory on 4 days separated by 48 hours. The first day consisted of familiarization. The subsequent 3 days consisted of testing. Subjects were positioned on the chair of the isokinetic dynamometer where surface electromyography and skin surface temperature sites were prepped prior to the measures. Two trials of maximal voluntary isometric contractions (MVICs) of the ankle plantarflexor muscles, passive ankle dorsiflexion ROM, and passive torque measures were then performed. Subjects then received an ice bag to the posterior lower leg, ankle joint, or nothing. **Main Outcome Measures:** Maximum passive ankle dorsiflexion ROM (°), maximum passive ankle plantarflexion torque (Nm), absolute passive ankle plantarflexor MTS (Nm/°) at 4 common joint angles (θ1-4), relative MTS normalized by CCG (cm) and CSA (cm2) of the gastrocnemius, surface electromyography (sEMG), and surface skin temperature (°C). **Results:** Significant gender by treatment interaction at MTSθ1 ($F_{2,658} = 3.55$, $P = .029$) and CSAMTSθ1-4 ($P < .001$) were observed. Gender and time main effects were also observed in MTSθ1-4 ($P < .001$) and CCGMTSθ1-4 ($P < .001$). Significant treatment by time interactions for passive torque was also observed ($F_{12,658} = 1.77$, $P = .04$). Skin surface temperature decreased below baseline at each time point during and following application to the lower leg and ankle ($P < .001$). Ice application did not influence ROM (lower leg = 27.12 ± 9.10, ankle = 27.06 ± 9.39, control = 27.28 ± 9.41, $P > .05$). sEMG amplitude changed was less than 1% during passive ROM measure. **Conclusions:** A 30-minute crushed ice bag application to the lower leg muscles or ankle joint increases maximum passive ankle plantarflexor torque. Cryotherapy does not appear to influence passive ankle dorsiflexion ROM and absolute and relative MTS. The degrees of differences on passive lower leg tissue resistive properties also vary based on gender.

Post-Surgical Application of Cryotherapy Leading to Frostbite in Middle Aged Active Male: A Case Report

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Background: This report documents the case of a superficial burn of the skin in a 43-year-old male while using a cold compression therapy unit following a right hip arthroscopy with synovectomy, labral refixation, capsular repair, and cam and rim osteoplasty. Post-operation the patient was prescribed a DonJoy IceMan CLEAR3 Cold Therapy (DonJoy LLC, Vista, CA) unit to control post-surgical edema and pain. The units sleeve was secured over the anterior hip and quadriceps while being continuously used over the 36-hour hospital stay. During this period the ice water in the unit was changed approximately every 8 hours. Discharge instructions called for patient to continue use of unit, with no specific instructions about use concerning time on/off or length of use. **Differential Diagnosis:** Frostbite, frostnip, and dermatitis. **Treatment:** One week following surgery, the patient's caregiver (wife) prepared the cold compression therapy unit for nighttime use. The patient had been experiencing increased quadriceps pain versus hip pain so the sleeve was secured more over the anterior thigh using the unit's velcro sleeve. Compression shorts were then applied over the sleeve. Crushed ice and water was put in to the unit's container and the unit ran continuously for the next eight hours. Upon waking, the patient began experiencing discomfort, pruritus, and burning sensation over the anterior thigh; however, the patient did not note any additional symptoms and continued use of the unit for the next 12 hours. It was not until that evening (20 hours use) that the patient began to report significant discomfort and permanently discontinued the unit's use. Over the subsequent 24 hours the anterior quadriceps began demonstrating erythema and edema formation following the pattern of the unit's sleeve. The patient reported continued, pruritus, erythema and edema for the next week. During the post-operative physician appointment (day 15) the physicians' assistant noted

the erythema and diagnosed the patient with a superficial burn from the cold compression unit. The patient was instructed to report any changes in the color or any associated symptoms. Within two weeks the tissue had healed and with no permanent disfigurement or complications. **Uniqueness:** Frostbite is a common injury resulting from prolonged cold temperature exposure, although this exposure is normally due to environmental temperatures. With post-surgical application of cryotherapy there is normally specific instructions as to the proper application and use to ensure maximal effectiveness that accompany the treatment. In this case the instructions only included the order to continue use and left the specifics of the prolonged use left out. This led to the patient and his caregiver making the decision to use the unit consecutively for 20 hours resulting in a superficial burn to the skin. In addition, while in the hospital the sleeve was applied in a loose manner, whereas during the 20 hours of use at home, the sleeve was applied tightly with additional compression being applied by compression shorts. The unit itself may have hindered the situation itself, due to its lack of temperature of regulation and a lack of an on/off switch. **Conclusions:** Improper use of cryotherapy, specifically cold compression units, can lead to damage of the skin tissue. Proper instruction and education of patients and their caretakers is of upmost importance when being prescribed cryotherapy. Release instructions concerning cryotherapy should include therapeutic temperature range, treatment time (on/off times), frequency of treatment, and sign and symptoms to watch for, on top of the instructions to continue and how to operate the equipment.

The Effect of Cryotherapy on Muscle Fatigue Between Maximal Endurance Exercise Bouts

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Context: Cryotherapy treatment to athletes after exercise for acute injury management and recovery strategies is common. Interval cryotherapy relies on decreased muscle temperature to modulate tissue temperatures to limit inflammatory response and delay fatigue onset, while maintaining proper temperature that does not decrease performance. Previous authors have primarily investigated small samples of male athletes self-reporting fatigue, without measuring fatigue through decreasing torque measurements. **Objective:** To determine if interval cryotherapy or interval thermotherapy between maximal bouts of endurance exercise affects the onset of muscular fatigue and total work performed. **Design:** Randomized crossover study. **Setting:** Controlled research laboratory. **Patients or Other Participants:** Thirty-two healthy physically active participants (age = 21.65 ± 1.69 yrs, height = 174.70 ± 8.96 cm, mass = 72.05 ± 15.24 kg) were tested. **Interventions:** Participants performed multiple sets of 20 repetitions with glenohumeral (GH) internal rotation (IR) and external rotation (ER) on the Biodex Isokinetic Dynamometer 4 while being positioned at 90° GH abduction. Baseline peak torque was recorded during the initial set. After each set, a randomized treatment intervention of interval cryotherapy, thermotherapy, or control (no treatment) was applied during the four-minute rest interval. Participants continued performing multiple sets of the same repetitions and rest intervals until reaching 3 consecutive repetitions below 50% initial peak torque. **Main Outcome Measure(s):** The isokinetic dynamometer was used to measure dependent variables of IR peak torque, ER peak torque, total work to 70% max (TW70%) and total work to 50% max (TW50%). Muscular fatigue was calculated as the number of repetitions completed until torque declined to 70% max (Reps70%), and 50% max (Reps50%). **Results:** No differences for IR or ER peak torque among treatments were found ($P > 0.05$) The interval cryotherapy treatment resulted in a significantly greater number of repetitions at Reps70% and Reps50% peak torque compared to both the thermotherapy and control conditions ($P < 0.001$). Interval cryotherapy treatment resulted in significantly greater total work at Reps70% peak torque compared to both thermotherapy and control conditions ($P = 0.001$, $\eta p2 = 0.349$) and ($P = 0.003$, $\eta p2 = 0.559$), respectively. Following the same trend, cryotherapy treatment resulted in a significantly greater amount of total work at Reps50% torque values when compared to thermotherapy and control conditions ($P < 0.001$) and ($P = 0.001$), respectively. **Conclusions:** Applying interval cryotherapy between bouts of endurance exercise delays the onset of muscular fatigue and allows for completion of more total work at 70% and 50% levels of fatigue. Interval cryotherapy may offer the same benefits for acute recovery between sets of exercise as it does between training sessions.

Rhabdomyolysis in a Female Caucasian Adolescent Distance Runner

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Background: A 17-year-old hypoglycemic, female collegiate distance runner (162cm, 57kg) participating in her first 6k race, complained of multiple systemic symptoms. The patient had been sick with an upper respiratory infection for 2 weeks prior to the race and was still taking prescribed antibiotics. During illness, the patient was unable to maintain her normal diet regimen and complained of diarrhea. The patient completed the first 5k of the race, but was unable to finish and chose to withdraw from the race. She arrived at the medical tent, by cart, showing signs of dizziness, nausea, confusion, muscle cramping, and syncope. The patient was immediately treated for heat stroke by submersion in a cold tub. The patient began to recover and was able to converse clearly with medical staff. Once moved out of the cold tub to a chair, her vitals blood/glucose levels were checked and were unremarkable. She was able to fly home that evening with the team under observation of the athletic trainer. Her symptoms did not change throughout flight or later that evening. The next morning, the patient reported to Athletic Training room reporting a headache, lack of appetite, and body aches. **Differential Diagnosis:** Fatigue, dehydration, heat stroke, rhabdomyolysis. **Treatment:** The patient was given fluids for hydration and instructed to rest and eat food that her body could handle. The following day, she was seen by a university team physician and referred to university health services for severe dehydration and fatigue. At this time, the patient's blood pressure was 134/66 with a pulse rate of 55 beats per minute. She was given three IV's and blood work was initiated. Lab results yielded normal Complete Blood Count and Myoglobin levels, but elevated Creatine Kinase, and Creatine Kinase MB levels in addition to increased Liver Function Tests (Alanine Aminotransferase and Aspartate Aminotransferase). Patient's urine was discolored with a dark orange tint despite the IV treatments and abundant intake of fluids. The patient was diagnosed with rhabdomyolysis and told to avoid all physical activities. Follow up laboratory tests taken three days later showed a decrease in Alanine Aminotransferase, Aspartate Aminotransferase, Creatine Kinase, and Creatine Kinase MB isoenzyme levels from three days prior, but all were still above normal ranges. All physical activity, except walking to class, was eliminated for 1 week and increased fluid intake was encouraged. After the 1-week removal from activity, a 9-day bike exercise regimen under the supervision of the Athletic Trainer was initiated, progressing up to 45 minutes at low intensity. She began a transition to running following her bike progression. The patient returned back to full activities and is currently competing without limitations. **Uniqueness:** This case is unique because the athlete is under 18 years old, is Caucasian, and was not running an unusual amount of mileage in her training. This case of rhabdomyolysis appears to be initiated by a heat stroke event, yet it was not excessively hot or humid during the race (73ºF, 58% humidity). It is also unique given the amount of time needed to recover from the illness based compared to the existing literature. This case report helps extend the knowledge base given the limited amount of level I evidence in treatment and return to participation protocols in rhabdomyolysis patients. **Conclusions:** Rhabdomyolysis should be considered following a heat illness event and necessary treatments should be performed immediately. If symptoms do not diminish at an expected rate, the patient must be referred for further evaluation and necessary laboratory tests. Patients must complete a supervised return to play protocol that slowly reintroduces their body to stress.

Management of Heat and Exercise-Induced Anaphylaxis in a Collegiate Soccer Player

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Background: This case study presents a sophomore women's soccer goalkeeper who started experiencing exercise and heat induced anaphylaxis in May 2013. The athlete had a prior history of several minor food allergies, but no reported previous severe reactions. The athlete had surgeries to correct bilateral hip impingement and was diagnosed with ADHD in January 2013. Beginning in May 2013, she experienced multiple reaction episodes that have each presented with a different range of symptoms, including swollen tongue, droopy face, airway constriction, and sometimes chest pain, involving 17 separate emergency room visits. **Differential Diagnosis:** Differential diagnoses included specific food dependent anaphylaxis, non-food dependent exercise induced asthma, and cholinergic urticaria. Through a series of medical tests and assessments, cholinergic urticaria was presented as the diagnosis in July 2013. An additional medical condition of Postural Orthostatic Tachycardia Syndrome (POTS) was diagnosed in November 2013. **Treatment:** A heavy regime of daily antihistamines was initiated with a planned return to play progression. The athlete was cleared by the team physicians for full participation in August 2013 with a stipulation wearing a cooling vest prior to activity to control core temperature. In spite of strict compliance by the athlete, sporadic reactions continued, regardless of the activity demands or environmental conditions, including unexpected symptoms during ADLs. Monthly Xolair injections were initiated to combat the anaphylactic reactions. Subsequently, the athlete was cleared to resume a slow return to play progression, starting with attending class, followed by a progression of goalkeeper drills

before experiencing another reaction episode, with a new set of symptoms including chest pain and tachycardia. Upon referral to a cardiologist, she was diagnosed with POTS. There are several causes of POTS, including hormonal and mast cell activation. Adderall is the primary treatment for POTS, which the athlete recently resumed taking for her academic studying. Her medications were again modified and she was once again cleared to resume an activity progression. Currently, treatment continues with monthly Xolair injections and a heavy daily medication regime. She has been episode free since October 2013 and is currently running and lifting weights and has completed 5K runs. Activity modifications are in place to avoid quick positional transitions. Because the exact trigger remains unknown and the risk of severe reactions was still present, team physicians medically disqualified this athlete in December 2013. **Uniqueness:** Both POTS and cholinergic urticaria are rare medical conditions in the general population, even more so within the elite athletic population. The sudden cause of both of these conditions continues to be a mystery and adds to the uniqueness of this case. The overlap of symptoms between these two different medical conditions contributed to prior misdiagnoses and clouded the determination of a more serious condition. **Conclusions:** This case illustrates several key points, including the importance of working as a team of healthcare professionals and communication between many healthcare providers. Additionally, the importance of a sound emergency action plan is critical. This case also sparks several discussion points as to when it is prudent to consider medical disqualification.

A Seventeen-Year-Old High School Football Player Returns to Play After Exertional Heat Stroke

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Background: A 17-year-old male football player (Height: 185 cm, Weight: 145.5 kg) with no pertinent past medical history incurred exertional heat stroke during a preseason conditioning test. The athlete is a defensive tackle who had been in Florida for 5 days prior to the event after recently moving from Canada. At initial presentation, the athlete had just completed a conditioning test (14 x 110 yard sprints) on a warm evening and fell to the ground complaining of difficulty breathing. He was conscious but very anxious and not acting himself. On the field, the athlete was evaluated by his athletic trainer who noted tachypnea, elevated pulse and a shirt that was wet with sweat in an athlete who was no longer sweating. EMS was summoned. **Differential Diagnosis:** Exertional heat stroke, heat exhaustion, sickle cell associated collapse, rhabdomyolysis. **Treatment:** The athlete was transported to the hospital via EMS to a local Emergency Center where his initial temperature was 103.3 °F orally. The athlete was stabilized then transported to a nearby children's hospital. He was hospitalized for 11 days and was treated for elevated Creatine Phosphokinase which peaked at greater than 48,000 IU/L (this is the upper limit of our analyzer), Alanine Aminotransferase and Aspartate Aminotransferase which peaked at 3835 IU/L and 6672 IU/L and renal failure with an elevated creatinine which peaked at 2.72 mg/dL. The athlete's labs were monitored weekly after hospital discharge and the patient was cleared to begin a return to play protocol when they had adequately normalized. We followed a 14-day protocol that started with light activity and progressed to moderate speed and agility exercise then to football drills and finally to football practice. The athlete was monitored using an ingestible thermometer, a heart rate monitor and a rate of perceived exertion chart. We charted the athlete's measurements before, during and after all exercise sessions. Each session used a heart rate range as the minimum and maximum threshold for exertion and we used a maximum internal temperature of 103.1 °F, heart rate greater than 90% of max or symptoms of heat stress as the criteria to stop activity. We also tracked the athlete sweat loss during all sessions to help determine his sweat rate. **Uniqueness:** While exertional heat stroke is rare in youth athletes, return to play with this population after EHS is even rarer. There is very little research or information on a return to play protocol for athletes. We utilized a newer protocol intended for the athletic setting, where the focus was to ensure he was heat tolerant, he had adequate physical fitness, and that he could safely return to tackle football. This athlete not only recovered with no lasting effects but also was able to successfully complete the return to play protocol and returned to compete in the final 5 games of the season. **Conclusions:** Using a gradual return to play progression using a heart rate monitor, ingestible thermometer and a perceived rate of exertion chart we successfully returned a 17-year-old football player back to football practice and games following exertional heat stroke. Utilizing a 3-week return to play progression that is initiated after physician clearance, an athlete can safely return to participation. This is important because there are very few documented cases of athlete's returning to play after exertional heat stroke in the literature and much of our experience comes from military protocols.

The Effects of Cardiovascular Fitness and Body Composition on Maximal Core Temperature Values in Collegiate Football Players During Preseason

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Context: Current literature suggests that higher body mass index (BMI) and poor aerobic fitness increases metabolic heat production, but minimal field studies validate this relationship. The direct correlations between BMI and maximal core temperature (Tcmax) and aerobic fitness and Tcmax during exercise have not been examined. Moreover, there is limited research on this topic during the pre-season of American football when most exertional heat illnesses (EHI) occur. **Objective:** To evaluate the effects of BMI and aerobic fitness (VO2max) on maximal Tc values (Tcmax). **Design:** Observational cohort. **Setting:** Data was collected at an NCAA Division III University during pre-season. **Patients or Other Participants:** Seventeen Division III football players volunteered for this study including nine backs (BKs) and eight linemen (LM) [age: 19.82 ± 1.01y, mass: 104.52 ± 18.94 kg, height: 180.50 ± 5.24 cm, BMI: 31.92 ± 5.05 kg/m2, VO2max: 42.42 ± 8.46 mL·kg–1·min–1] **Interventions:** VO2max testing was performed one week prior to the start of pre-season. We monitored Tc via ingestible sensor every 10 min during practices on day 5(D1), day 6(D2), day 7(D3), and after acclimatization on day 10(D4). Pre and post-practice body weight were recorded to determine %Δmass. Wet bulb globe temperature (WBGT) was recorded on each collection day. Paired t-tests and Pearson's correlations were performed ($\alpha = 0.05$). **Main Outcome Measures:** Tcmax, BMI, and VO2max. **Results:** We found a significant negative correlation for BMI and VO2max (R = -0.814, P = 0.000). There were no significant correlations between VO2max and Tcmax on D1 (WBGT = 29.07º C) or D2 (WBGT = 30.93º C), but on D3 (WBGT = 31.39 º C) there was a moderate negative correlation with a trend towards significance (Tcmax = 38.34 ± 0.40º C, R = -0.564, P = 0.090). There were no significant correlations between BMI and Tcmax on D1or D2, but on D3 there was a moderate positive correlation with a trend towards significance (R = 0.596, P = 0.069). Paired t-tests revealed that overall Tcmax (D1-3) was statistically higher (38.56 ± 0.32º C) than D4 (WBGT = 30.37º C) (38.16 ± 0.30º C, P = 0.018). The Tcmax values during pre-acclimatization (D1-D3) were significantly higher in LM (38.49 ± 0.16º C) than BKs (38.18 ± 0.14º C) (P = 0.0046). VO2max was significantly (P = 0.006) lower in LM [36.89 ± 6.40 mL·kg–1·min–1] than BKs [47.44 ± 7.09 mL·kg–1·min–1] and BMI was significantly (P = 0.014) higher in LM (35.59 ± 4.00 kg/m2) than BKs (28.68 ± 3.38 kg/m2). There was no correlation between %Δmass and Tcmax on D1 (R = -0.111, P = 0.673), D2 (R = 0.268, P = 0.335), D3 (R = 0.318, P = 0.289), or D4 (R = 0.119, P = 0.698). **Conclusions:** The results of this study suggest that LM are significantly less fit than BKs and have a greater BMI. When WBGT was the highest, on D3, the results suggest that those with lower VO2max and higher BMI experienced a higher Tc. Therefore, aerobic fitness may affect an individual's ability to thermoregulate effectively. Overall, these results suggest that those with lower aerobic fitness and higher BMI may be at a higher risk for suffering from EHI.

Gastrointestinal Temperature of Runners Immediately Post an 11.3km Warm Weather Road Race

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Context: Previous literature has shown that exercise induced hyperthermia due to uncompensable heat stress heightens the risk of exertional heat stroke (EHS) in exercising individuals. The diagnostic criteria for EHS include an elevated core body temperature (≥40°C) and central nervous system (CNS) dysfunction. Although exercise induced hyperthermia has been well studied in laboratory settings, a limited number of studies have investigated the magnitude of core temperature elevation observed immediately after a competitive warm weather road race. **Objective:** To investigate the gastrointestinal temperature (TGI) of runners completing an 11.3km warm weather road race. **Design:** Cross-sectional field study. **Setting:** Data were collected at the 2014 Falmouth Road Race (Falmouth, MA). Ambient temperature, relative humidity, and heat index during the race were 25.3 ± 0.6°C, 73.9 ± 4.0%, and 26.2 ± 0.9°C, respectively. **Patients or Other Participants:** Thirty race participants (mean ± SD; male, n = 15; age, 41 ± 11y; body mass, 77.2 ± 8.0kg; body fat, 19.4 ± 4.7%; female, n = 15; 37 ± 10y; 59.3 ± 7.1 kg; 18.9 ± 5.5%) with a self-predicted race finish time ≤60minutes. **Interventions:** Runners ingested a gastrointestinal thermistor six to ten hours prior to the start of the race. TGI was assessed immediately post race via a hand held receiver. Participants passively rested while symptoms of heat illness were monitored for twenty-minutes following the race. **Main Outcome Measures:** TGI and symptoms of heat illness immediately following completion of the road race. **Results:** Thirty participants finished

the road race. The average finish times for male and female runners were 53.57 ± 8.38 min and 57.95 ± 5.88 min respectively. The immediate post race TGI for male and female runners was 39.53 ± 0.72° C (range, 37.65-40.65° C) and 39.67 ± 0.82° C (range, 38.51-41.06° C) respectively. Nine runners had immediate post race TGI ≥40° C (n = 5 male, n = 4 female). No CNS dysfunction or any heat related illnesses were noted during the twenty-minutes following the race. **Conclusions:** The immediate post race body temperature revealed that TGI was considerably elevated after the race, however, no runners exhibited clinical signs or symptoms of heat illnesses. Furthermore, findings from the nine participants suggested that runners may achieve an elevated body temperature above 40° C during exercise and not experience EHS. This indicates that the heat load on the race day was tolerable for our participants and that runners had no CNS dysfunction despite the presence of exercise induced hyperthermia above 40° C.

Thermoregulatory Responses and Hydration Practices in Female, Semi-Professional American Football Players During Football Activities

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Context: While studies have investigated hydration and thermoregulation in male American football players, little is known about the hydration practices and thermoregulation in females participating in tackle football. **Objective:** To examine the thermoregulatory and hydration responses of female, semi-professional American football players during tackle football activities. **Design:** Observational study **Setting:** Field setting, football field **Patients or Other Participants:** Fifteen females (age: 29.9 ± 7.3 yrs, height: 165.2 ± 6.3 cm, weight: 83.8 ± 24.4 kg) from the same tackle football team volunteered for this study. Participants consisted of players of various offensive and defensive football positions. **Interventions:** We observed participants within and across football practices. **Main Outcome Measures:** Each participant was observed for 4 practices for the following measures: Gastrointestinal temperature (TGI), maximum TGI , heart rate (HR), maximum HR (HRmax), fluid consumption, sweat rate, percent body mass loss (%BML), urine specific gravity (USG), urine color (Ucol), perceptual measures of thirst, thermal sensations, and rating of perceived exertion (RPE). Descriptive data (mean±SD) were calculated for all measures. Variables measured before and after practice (USG) and environmental measures were analyzed using a repeated measures ANOVA. **Results:** All trials took place during evening practices over the course of 5 days. Average wet bulb globe temperature (23.8 ± 2.4°C) was similar across all days (P = 0.823). Average TGI across 4 practices was 38.0 ± 0.3°C while maximum TGI was 38.4 ± 0.3 °C (range: 37.5 to 39.6°C, n = 14). Average practice HR was 118 ± 11 bpm, while HRmax was 148 ± 13 bpm. Participants arrived to practices with Ucol of 3 ± 1 (range: 1 to 7) and USG of 1.018 ± 0.007 (range: 1.001 to 1.033). Post-practice USG (1.022 ± 0.007) was significantly higher than pre-practice across all days (P < 0.001) and ranged from 1.006 to 1.037. The average sweat rate across 4 practices was 0.6 mL/hr with a range of 0.2 to 1.1 L/hr for 2-hr practice. Average %BML was -0.3 ± 0.4% with a range of (-1.4 to + 1.9%). Thirst and thermal sensations across the 4 practice days were moderate (4 ± 1 and 5 ± 1, respectively), while RPE averages across days was 11 ± 1 with a range from 6 to 15 (out of 20). **Conclusions:** This is a unique group of athletes whose hydration practices and thermoregulatory responses to practice had not yet been examined. Female football players tended to have similar physiological responses to male football tackle activities according to their heart rate and body temperature measures. Perceptual measures revealed that participants considered these practices to be of moderate intensity. Although participants seemed to adequately match their sweat losses with fluid consumed during practice, there was considerable variability in hydration indices and hydration practices, with some participants experiencing hypohydration and others overestimating their fluid needs. Athletic trainers working with this patient population should emphasize the need for hydration education and establish individualized hydration regimens.

Collegiate Ice Hockey Athletic Trainers' Hydration Practices and Knowledge of Fluid Recommendations and Factors Influencing Hydration

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Context: Due to playing in cool environments, ice hockey athletes may not be considered at risk for dehydration. Intensive equipment, high intensities, body type, and high sweat rates may predispose these athletes to hypohydration. Therefore, it is imperative athletic trainers (ATs) in these settings utilize appropriate hydration practices. **Objective:** To determine current hydration strategies of ATs working men's and women's collegiate ice hockey and to examine AT's knowledge of fluid recommendations and effects of sodium, caffeine, and alcohol on hydration status. **Design:** Mixed-methods, qualitative-quantitative survey. **Setting:** NCAA Division I and III men's and women's ice hockey teams. **Patients or Other Participants:** Ninety-four ATs (males = 53, females = 41; response rate = 53.11% [94/177]) ranging in years of experience (<1yr to >15yrs) and role (graduate assistant to full time). **Interventions:** Fifteen-question survey housed on a host website (SurveyMonkey). **Main Outcome Measures:** Participants completed demographic questions and questions regarding: fluid and electrolyte availability in various team environments (e.g., practice, dining, bus, etc.), hydration education strategies, implementation of hydration status measures, knowledge of the National Athletic Trainers' Association position statement on fluid replacement, and knowledge of sodium, caffeine, and alcohol on hydration. **Results:** Majority of ATs (61.7%) did not measure hydration status. Of those who measured, urine color was most common (31.9%) and no ATs reported using urine specific gravity. Most ATs (95.7%) reported they educated athletes about proper hydration and consequences of dehydration. Twenty-five percent of ATs did not have electrolyte supplements available for athletes. When asked if they felt they had adequate access to hydration/electrolyte items there was a significant difference between Division I who reported "yes" compared to Division III (88% vs 46%, $P < 0.001$). Twenty-three percent of ATs reported athletes had access to coffee before/after games. No ATs reported athletes having access to energy drinks pre/post or during activity or when traveling. Regarding knowledge, 76.6% correctly chose the recommendation on fluid replacement before activity. All ATs chose at least 1 correct answer for fluid consumption recommendations during activity. Most ATs (75.5%) chose "I do not know" for sodium recommendations. Caffeine questions were based on regular consumption of a moderate amount of caffeine. Most ATs were incorrect regarding caffeine increasing urine output (78.7%), dehydrating an individual (71.3%), and delaying fluid recovery (57.5%). Most ATs were correct regarding alcohol increasing urine output (88.3%), dehydrating a hydrated individual (78.7%), and delaying fluid recovery (84%). **Conclusions:** While most ATs educated athletes on hydration, few monitored hydration status. Monitoring hydration status is encouraged to prevent dehydration and subsequent health and performance decrements. We identified disparity between Division I and III regarding access to hydration/electrolyte items. ATs were less knowledgeable about caffeine's effects on hydration and sodium supplementation recommendations, suggesting these topics may be an area for educational opportunities.

The Effect of Sodium Supplementation Using High and Low Sodium Concentration Fluids on Serum Electrolytes, Plasma Volume, and Aldosterone in Collegiate Football Players During Preseason

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Context: Many football players lose significant sodium during preseason due to heavy sweating, especially those with high sweat sodium concentrations. This leads to hypovolemic hyponatremia which can affect health and performance. **Objective:** To supplement two groups of collegiate football players with fluids containing either 300mg Na+·L-1 or 1500 mg Na+·L-1 and measure serum electrolytes, osmolality (Sosm), aldosterone, and changes in plasma volume (% ΔPV) and body weight during preseason. **Design:** Observational cohort. **Setting:** Preseason of one collegiate football team. **Patients or Other Participants:** Six players in the low sodium group (LowNa+) (age = 22 ± .9 y, mass = 107 ± 24.7 kg, height = 187 ± 2.1 cm and BSA = 2.3 ± .33 m2·kg-1) and six players in the high sodium group (HighNa+) (age = 21.5 ± .5 y, mass = 106.4 ± 23 kg, height = 187.3 ± 4.9 cm and BSA = 2.3 ± .25 m2·kg-1) participated. **Interventions:** Beginning the morning of day 5, on days with 1 practice LowNa+ consumed 600mg·d-1 and HighNa+ consumed 3000mg·d-1 of sodium in 2L of drink. On days with 2 practices, LowNa+ consumed 900mg·d-1 and HighNa+ consumed 4500mg·d-1 of sodium in 3L of drink. The fluids were identical in all other ingredients (neither contained K+) and taste so players were blinded to their treatment. Blood was drawn via 21g needle in the morning of day1 for baseline measures and in the mornings of days 5, 7 and 9 of training camp. Whole blood was analyzed for Hb, Hct, serum was analyzed for electrolytes (ion-selective electrode) and osmolality

by osmometry. Four ml of serum was refrigerated and later analyzed for aldosterone. Players recorded body weight in dry shorts before and after all practices. **Main Outcome Measures:** Serum Na+, K+ Cl-, osmolality, aldosterone, and %ΔPV and body mass. **Results:** Physical characteristics were not different between groups. Serum Na+ did not change across days in LowNa+ but in HighNa+ was significantly (P = .03) higher on day7 (140.7 ± 1.8 mmol·L-1) and day9 (141 ± .41mmol·L-1) compared to baseline (138 ± 1.3 mmol·L-1). %ΔPV did not change across days in LowNa+ but in HighNa+ PV expanded significantly (P = .002) and was +11 ± 7.4% on day5, and +18 ± 14% on day9. There were no group differences in serum Cl- but both increased across days (P < .001). Serum Cl- was higher on day7 (103.3 ± 2.0 mmol·L-1) and day9 (103 ± 1.2 mmol·L-1) compared to baseline (100.5 ± 1.2 mmol·L-1). In both groups Sosm changed across days (P = .007) and was higher on day5 (289.2 ± 4.1 mOsm·kg-1) compared to baseline (284 ± 4.4 mOsm·kg-1) but lower on day7 (284.3.2 ± 3.9 mOsm·kg-1) and day9 (283.3 ± 3.5 mOsm·kg-1) compared to day5. Serum K+, aldosterone and body weight were not different between groups or across days. **Conclusions:** Important findings were an increase in serum Na+ and PV across days only in players who consumed the high sodium drink. Both drinks increased serum Cl- but did not change serum K+, and assisted in maintaining body weight and decreasing serum osmolality indicating morning euhydration, which are all beneficial in football players during preseason.

Football Coaches Knowledge Regarding the Risk Factors, Symptoms, and Management of Sports Related Concussions

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Context: Due to the high number of Sport Related Concussions (SRC) that occur in football, it is crucial for football coaches to recognize the signs, symptoms, and sequalae for these injuries. In recent years, there have been concerted education efforts, including state legislative actions, directed at Wisconsin football coaches regarding the risk factors, recognition, and management of SRC. The extent of success of these efforts has not yet been evaluated. **Objective:** To determine Wisconsin (WI) high school football coaches' knowledge regarding risk factors, symptoms, management of SRC, knowledge of current WI legislation and the Wisconsin Interscholastic Athletic Association (WIAA) SRC guidelines. **Design:** Cross-sectional. **Patients or Other Participants:** Members of the Wisconsin Football Coaches Association (WFCA) were invited to participate in person (paper version) at the association's annual meeting or online through e-mail solicitation. A convenience sample of 701 of 1411 coaches (49.68%) completed the quiz; n = 104 (14.8%) youth/middle school coaches (YMC), n = 292 (41.7%) sub-varsity coaches [high school assistant, junior varsity and freshman head coaches] (SVC), and n = 305 (43.5%) head varsity coaches (HVC). **Interventions:** Subjects were asked to report their coaching level, years' of coaching experience, and highest level of education completed. They also completed a ten-item quiz that asked questions regarding risk factors, recognition, management recommendations, WI laws, and WIAA guidelines regarding SRC. **Main Outcome Measures:** Independent variables included coaching level, years' of coaching experience, and highest level of education completed. The dependent variable was the quiz score (correct number of responses recorded). Descriptive statistics were calculated as Mean ± SD. Kruskal-Wallis tests ($p < 0.05$) were used to determine if the quiz scores differed for each independent variable. **Results:** Three hundred three subjects (43.2%) held a graduate degree, 277 (40%) held a bachelor's degree, 59 (8%) held an associate's degree, and 62 (9%) held a high school diploma. One hundred and twenty-nine (18%) had coached for <5 years, 137 (20%) coached 5-10 years, 139 (20%) coached 11-15 years, 97 (14%) coached 16-20 years, and 198 (29%) coached >20 years. The mean quiz score for all respondents was 8.1 ± 1.3. The scores for YMC coaches (7.8 + 1.6) were lower ($p = 0.003$) than the scores for SVC (8.2 + 1.1) and HVC (8.2 + 1.7). There was no difference in the scores for the coaches based on years of experience ($p = 0.741$), education level ($p = 0.398$) or coaching level ($p = 0.093$). **Conclusions:** With the exception of YMC, football coaches in the Wisconsin demonstrated good knowledge (>80% quiz score) regarding risk factors, recognition, management recommendations, understanding of WI state laws, and of WIAA guidelines pertaining to SRC. Coaches' education level, coaching level and coaching experience do not appear to influence knowledge of SRC. ATs working with YMC coaches may consider initiating educational programs to increase coaches understanding of SRC.

Effect of Viewing a Concussion Education Video Followed by In-Person Reinforcement on Parents' Concussion Knowledge

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Context: Parents of young athletes are often the key individuals responsible for seeking care following their child's concussion. They are key stakeholders in understanding the culture concerning concussion in youth sport. Few studies have examined the effects of publicly available educational materials and reinforcement strategies on improving parents' concussion knowledge. **Objective:** To examine the effect on parents' concussion knowledge of 1) viewing publicly available concussion education videos (general concussion and sport-specific videos) and 2) viewing concussion education videos combined with in-person verbal reinforcement of the video messages. **Design:** Cluster-randomized trial. **Setting:** Classroom/meeting room. **Patients or Other Participants:** A convenience sample of North Carolina and Arizona parents (n = 213; age = 44.1 (6.5 years; 131 females) whose children participated in middle school or youth club football, boys/girls soccer, boys/girls lacrosse, and/or boys/girls ice hockey. **Interventions:** Parents were cluster-randomized by their child's team to two study arms: 1) video with in-person reinforcement (IPR) or 2) video with no in-person reinforcement (NoIPR). A pre-validated concussion survey was completed prior to, and immediately following, the educational session (time). Kappa agreement was 0.6-0.9 for all survey questions. Participants completed informed consent prior to any research activities. **Main Outcome Measures:** The main outcome was knowledge score. Knowledge score was the total correct of 29 knowledge questions (higher = more knowledge). A mixed model analysis of covariance

(controlling for state of residence) was used to examine the interaction between our two independent variables on knowledge score. An a priori alpha level of 0.05 was used. **Results:** Of the 213 parents, 155 (54 IPR, 91 NoIPR) completed the intervention and all knowledge questions. There were no age differences between the intervention groups (IPR: 43.7 ± 6.0 years vs. NoIPR: 43.7 ± 7.0 years; t146 = 0.044; P = 0.965), exposure to concussion education (IPR: 15.9% vs. NoIPR: 15.9% with previous education; $\chi 2(1) = 0.0$; P = 0.995), previous concussion history (IPR: 22.6% vs. NoIPR: 33.3% with at least one previous concussion; $\chi 2(1) = 2.1$; P = 0.151) or sex (IPR: 67.2% vs. NoIPR: 58.2% female; $\chi 2(1) = 1.3$; P = 0.259). There was no significant interaction effect (intervention arm x time) on parental knowledge, as there was no difference in post-intervention improvement between study arms (IPR knowledge mean improvement: 0.8 ± 2.3 vs. NoIPR knowledge mean improvement: 0.7 ± 2.2; F1,152 = 0.183; P = 0.670). Additionally, there was no main effect of either intervention on parental knowledge (pre-intervention knowledge mean = 23.4 ± 2.5 vs. post-intervention knowledge mean = 24.2 ± 2.5; F1,152 = 2.181; P = 0.142). **Conclusions:** The publicly available videos, regardless of reinforcement, did not immediately improve overall concussion knowledge among parents. This study highlights the need for more directed educational efforts to improve youth sport parents' concussion knowledge. Concussion education mandates should be more specific and should include enhanced educational efforts to improve knowledge. These enhancements may include involvement of parent stakeholders in the development of educational programs. Athletic trainers should consider these factors when educating parents about concussion. This study was funded in part by the National Operating Committee on Standards for Athletic Equipment.

REACT: Testing the Effectiveness of a Poster Education Program on Sport-Related Concussion Knowledge and Attitudes in High School Football Players

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Context: Football players encounter many concussion facts, rules, testimonials, and tales of tragedies throughout their careers. The communications that sport-related concussions (SRC) are a risk associated with contact sports, are serious injuries, and increase the risk of a life-threatening injury with premature return to activity are common knowledge to athletes, coaches, and athletic trainers thanks in part to the development and use of concussion education programs. **Objective:** To test the effectiveness of an educational poster program at influencing the knowledge about and attitudes toward SRC in a cohort of high school football players. **Design:** Randomized control trial. **Setting:** High school. **Patients or Other Participants:** 394 interscholastic football players from 12 schools; ranging in age from 13-18 years (15.9 ± 1.2 yr.). Participants at six schools were randomly assigned to the poster group, while the others served as controls (no posters). **Interventions:** The Rosenbaum Concussion Knowledge and Attitudes Survey – Student Version (RoCKAS-ST) was used to measure concussion knowledge (Concussion Knowledge Index [CKI]) and attitudes (Concussion Attitudes Index [CAI]) and gauge the effectiveness of the concussion education poster intervention program. A total of 7 REACT posters were displayed at life-path points in the 6 schools throughout the entire season. Two posters had the entire REACT educational message displayed, while the others had the individual letters of the acronym displayed: Recognize, Encourage, Apply, Communicate, and Think. The RoCKAS-ST was completed pre and post in the poster group and post only in the non-poster group. **Main Outcome Measures:** The dependent variables included CAI and CKI scores (higher scores better); the independent variable was group status (poster vs. control). Dependent samples t-tests were computed to compare the pre and post-season CKI and CAI scores within the poster group. Independent samples t-tests were used to compare the post-season CKI and CAI scores between the groups. **Results:** Range: CKI 6-24; CAI 8-75. Surprisingly, there were no significant differences (t = 1.138, p = .256) in CKI scores pre (18.69 ± 2.98) to post (18.39 ± 3.49) season in the poster group. Unexpectedly, there were no significant differences (t = .991, p = .322) in CKI scores between the two groups post-season (18.39 ± 3.49 vs.18.73 ± 3.28). There was a significant difference (t = 4.096, p = .000) in the CAI scores pre (55.04 ± 8.28) to post (52.52 ± 8.43) season in the poster group. There was a significant difference (t = 2.083, p = .038) in the CAI scores between the two groups post-season (52.52 ± 8.43 vs.54.21 ± 7.45). **Conclusions:** Contrary to what we hypothesized, our REACT poster campaign was ineffective in changing SRC-related knowledge and attitudes. We contend that the disconnect between our poster theme and the RoCKAS-ST survey instrument used to measure outcomes, as well as an ineffective poster design were most likely the cause of our findings.

Athletic Trainers' Perceptions of Their Role and Responsibilities Regarding Academic Accommodations as Part of the Concussion Management Process in the Secondary School Setting

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Context: Athletic trainers (ATs) play a vital role in concussion management for student-athletes following a sport-related concussion, yet little is known about their actual involvement in the implementation of academic accommodations (AA) as part of the concussion management plan. To date, little research has been done to evaluate the process of initiating AA, along with the roles and responsibilities of each member of the concussion management team. **Objective:** To qualitatively investigate ATs' perceived roles and responsibilities throughout the implementation of AA. **Design:** The consensual qualitative research tradition was used for this study. **Setting:** Individual phone interviews were conducted with all participants. **Patients or Other Participants:** 16 ATs employed in the secondary school setting (8 females, 8 males; age = 39.6 ± 7.9 years; athletic training experience = 15.1 ± 5.6 years), representing 12 states, were interviewed. Criterion sampling was utilized to recruit participants. **Data Collection and Analysis:** A semi-structured interview protocol was used to allow for flexibility of the data collected. Once interviews were transcribed, data were analyzed and coded into themes and categories. Final themes and categories were determined via consensus of a four-person research team. Each researcher independently coded the data and created a preliminary codebook. The research team then met as a group to discuss and finalize a consensus codebook that richly captured the data. To decrease researcher bias, triangulation occurred through participant member checking, the inclusion of multiple researchers, and the inclusion of internal and external auditors. **Results:** ATs perceived several components as essential for their responsibilities within the AA process. Specifically, participants' discussed their understanding and perceptions of AA as well as their perceptions of their own role in the AA process. ATs also perceived they had a role in both the initiation and facilitation of AA for student-athletes following a sport-related concussion in the secondary school setting. Conversely, some participants discussed their perceptions that an AT should not have a role in the implementation of AA as part of the concussion management process. If participants felt they had a role in the process, they frequently suggested the need for further education. If they did not feel they should be involved, they cited not feeling that it was within their scope of practice as the reason. **Conclusions:** While ATs show disagreement regarding their perceived level of involvement in the AA process, it highlights the variations in current practices. ATs either want to be involved in the implementation of AA but feel further education is needed, or they do not want to be involved because they feel that it is not in their area of expertise. In order to create cohesive concussion management and AA teams, it is vital that ATs understand their individual and collaborative roles in the secondary school setting. Funded by the National Athletic Trainers' Association Research and Education Foundation Masters Grant Program.

Athletic Trainers' Return-to-Learn and Academic Support Recommendations Following Adolescent Concussion

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Context: Following concussion student-athletes may require cognitive rest and academic support upon return to school. Athletic trainers (ATs) employed in secondary schools are uniquely positioned to provide medical care and collaborate with school professionals throughout the concussion management process. However, little is known regarding the academic support provided and existence of a return-to-learn policy in secondary schools. **Objective:** To examine ATs' recommendations for cognitive rest and academic adjustments, and whether employment characteristics predict existence of a return-to-learn policy. **Design:** Cross-sectional. **Setting:** Web-based survey. **Patients or Other Participants:** We emailed 3,941 ATs employed within secondary schools and analyzed 1,124 (28.5%) completed surveys. Most participants were employed full-time (752/1,114 [67.5%]), within public schools (911/1,117 [81.6%]), and paid primarily through a school district (512/1,070 [47.9%]) or individual school (190/1,070 [17.8%]). **Interventions:** The validated survey was part of a larger study and was comprised of multiple components assessing concussion management policy development, academic support, and communication with school professionals. Responses were not required for each item; therefore, we reported completed responses. **Main Outcome Measures:** Dependent variables were participant responses to questions regarding cognitive rest and academic support after concussion. ATs' recommendations and involvement in academic interventions were analyzed with descriptive statistics. Binary logistic regression analysis ($p < .05$) was used to assess if employment characteristics

predicted existence of a return-to-learn policy. **Results:** ATs mostly recommended complete (e.g., no reading, school work, television, 492/1087 [45.3%]) or situational (i.e., limitation of activities based upon symptoms, 391/1087 [36.0%]) cognitive rest. Common academic adjustments after concussion included: postponing assignment due dates (789/954 [82.7%]), rest breaks (765/954 [80.2%]), and partial attendance (740/954 [77.6%]). ATs reported being the primary individual responsible for monitoring health (764/1,037 [73.7%]) and academic progression (359/1,011 [35.5%]) after concussion. Overall, 84.1% of ATs (915/1,088) recommended a gradual return-to-learn, but only 43.7% (435/995) reported having a written return-to-learn policy. Factors that significantly increased the likelihood of having a return-to-learn policy were: frequent communication with teachers (odds ratio [OR] = 2.1; 95% confidence interval [CI] = 1.51, 3.1), presence of two or more ATs to provide patient care (OR = 1.6; CI = 1.1, 2.3], primary salary via school/district (OR = 1.5; CI = 1.0, 2.3), and full-time employment status (OR = 1.6; CI = 1.0, 2.4). **Conclusions:** To promote the best patient care throughout the concussion management process, schools should consider direct full-time employment of ATs. While ATs self-identified as the primary person to provide medical care for the student-athlete following concussion, school professionals may be better suited to identify appropriate academic adjustments and monitor academic progress. Because collaboration is necessary to ensure full return-to-learn prior to return-to-play, future research should explore school professionals' involvement with academic adjustments and communication with ATs throughout the concussion management process.

Physicians' Familiarity and Perceptions of Academic Accommodations for Adolescent Athletes Following Sport-Related Concussion

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Context: Cognitive rest is an integral aspect of concussion management and often prescribed by a physician. However, not all physicians have associations with a secondary school, relationships with athletic trainers (AT) or follow best practices for concussion management. Little is known regarding the familiarity and perceptions of academic accommodations (AA) among team physicians (TP) and community-based physicians not associated with a secondary school (non-TP). **Objective:** To determine whether a physicians' association with a secondary school influences familiarity and perceptions of AA for adolescent athletes following a sport-related concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 94 physicians (4.7% response rate) from a convenience sample of physician members of the (58 males, 18 females, 18 missing, age=46.7±11.4). **Interventions:** Participants were solicited via email to complete the Physicians' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-PHYS) survey. The BAKPAC-PHYS consisted of several multipart questions to assess physicians' familiarity and perceptions regarding AA, 504 plans and Individualized Education Programs (IEP). The independent variable included physician association (TP, non-TP). **Main Outcome Measures:** The dependent variables were participants' responses to the AA questions. Descriptive statistics were utilized to describe overall familiarity and perceptions and Mann Whitney U tests ($P < .05$) were used to determine group differences. **Results:** 80.4% of TPs (n = 45) have had adolescent patients under their care receive AA following a concussion, while only 33.3% of non-TPs (n = 12) had patients that received AA following a concussion; 16.7% of non-TPs (n = 6) were not aware if their patients received AA. TPs were moderately familiar with AA (3.24/4.0 ± 0.79, $P < .001$), and minimally-to-moderately familiar with 504 plans (2.49/4.0 ± .0.97, $P < .001$). However, non-TPs were only minimally familiar with AA (2.11/4.0 ± 0.85) and not familiar with 504 plans (1.37/4.0 ± 0.74). There was no significant group difference regarding familiarity with IEPs ($P = .065$); both groups were minimally-to-moderately familiar (TP = 2.90/4.0 ± .94, non-TP = 2.52/4.0 ± .89). TPs agreed that ATs should have a role in the implementation of AA (3.43/4.0 ± 0.73, $P = .00$), while non-TPs disagreed-to-agreed (2.96/4.0 ± .0.81). Furthermore, TPs agreed that adolescent athletes with active concussions should be eligible to receive AA (3.16/4.0 ± 0.83, $P = .036$), while non-TPs disagreed-to-agreed (2.78/4.0 ± 0.75). **Conclusions:** These results indicated physicians with secondary school associations had a greater familiarity and perception of AA compared to physicians without secondary school associations. More specifically with respect to the use of AA, TPs have a more favorable perception and belief of AT involvement with the care of student-athletes following a sport-related concussion. These beliefs may be the result of the close working relationship between ATs and TPs, and familiarity with each discipline's role in concussion management. This information should be utilized to provide education about AA to community physicians. In addition, ATs should seek a more effective communication strategy to connect with other physicians involved in student-athlete care.

Knowing isn't Always Doing: High School Coaches' Knowledge Regarding Sports-Related Concussions

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Context: Recent legislation in most states has mandated concussion education for high school coaches in order to prepare them to recognize a concussion and remove student-athletes from play for further evaluation. There is little research available that demonstrates whether concussion education is effective in meeting these goals. **Objective:** To determine high school coaches' knowledge regarding concussion recognition and management. **Design:** A mixed method design emphasizing quantitative methods. **Setting:** Surveys were distributed electronically using Survey Monkey. Interviews were conducted individually in-person or by telephone. **Patients or Other Participants:** Massachusetts' public high school coaches of any sport with at least 1 season of coaching were recruited. One hundred and four participants completed the on-line survey. Twelve coaches completed interviews. **Interventions:** A survey was designed based on three surveys from prior concussion education research. A semi-structured interview guide was created for the purposes of this study. Qualitative data was analyzed using a general inductive approach. Trustworthiness was ensured using stakeholder checks for accuracy; memos summarizing key observations; and transcripts were reviewed by a researcher not involved in the initial data collection. Independent variables included formal concussion training, informal modes of education used by coaches to obtain concussion knowledge, and the number of times they completed mandated formal concussion trainings. Descriptive statistics were utilized to analyze quantitative data. **Main Outcome Measures:** A "concussion knowledge" scale was created to assess coaches' knowledge of concussion recognition of signs and symptoms, and management. **Results:** Confusion (94.3%), headache (94.3%), dizziness (91.4%), and blurred vision (90.5%) were identified by the majority of coaches as indicators of a concussion. Most coaches associated loss of consciousness (86.7%), nausea (81.9%) and amnesia (75.2%) as primary indicators of a concussion. Less than half (41.9%) of the participants recognized sleep disturbances as a symptom. Approximately 10% of the coaches associated non-concussion symptoms as primary indicators of a concussion. Over 90% of coaches correctly identified concussion management strategies in typical concussion scenarios. However, when posed with atypical scenarios, only 57% of participants appropriately removed athletes from play. **Conclusions:** This study shows that while high school coaches are knowledgeable about basic concussion recognition information, but their responses reveal that coaches have difficulty distinguishing concussion symptoms from other injuries and lack sufficient understanding to ensure proper care. Coaches' concussion management decisions show that as symptoms of a concussion become less obvious, coaches become less likely to remove a student-athlete from play and refer them to a qualified medical professional. These findings demonstrate a lack of effectiveness of current concussion education to adequately change coaching behaviors to ensure implementation by coaches of the recommended concussion management guidelines. This study shows the need for improved concussion education and access to athletic trainers to provide appropriate and immediate concussion management.

Current Practices in Collegiate Concussion Management

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Context: Concussion identification and management are important processes with direct impacts on athlete health. There have been few current, comprehensive descriptions of concussion management practices at U.S. colleges. **Objective:** Examine and describe routine practices in concussion management of clinicians at NCAA member-schools and the extent to which practices align with best practice guidelines. **Design:** Cross-sectional study of NCAA sports medicine clinicians. **Setting:** Electronically-administered survey September-October 2013. **Patients or Other Participants:** Initial email was sent to 2935 NCAA sports medicine clinicians at all 1066 NCAA member schools. Of those, 866 clinicians answered questions relevant to this analysis (30% overall response rate; 756 athletic trainers, 102 physicians, 8 other clinicians). Participants represented 527 NCAA member-schools (49.4%) in all 50 states. **Interventions:** Survey administered electronically after pilot testing for content and clarity. Independent variables: position on the sports medicine staff. **Main Outcome Measures:** Participants were asked: whether their sports medicine team obtained a concussion history from athletes prior to the start of the season (yes all athletes, yes contact/high-risk sport athletes only, no); whether any teams at their school completed a pre-season

baseline assessment (yes, no, not sure); what their concussion diagnosis and recovery monitoring process entailed (select all that apply from list of responses drawn from best practice guidelines); what occurs in the 24-hours following an athlete's concussion diagnosis (select all that apply from list of responses drawn from NCAA guidelines). Descriptive statistics are provided. Chi-squared tests of independence were used to assess the relationship between the use of a test at baseline (yes, no) to its use in post-injury management (yes, no) with z-scores of > (1.97(reported as significant. **Results:** The majority of respondents indicated that they obtained a concussion history from all athletes (90.7%), with fewer indicating a concussion history is obtained from some athletes (7.6%). A small minority (1.7%) indicated that they did not obtain a concussion history. The majority of respondents (96.1%) indicated that athletes at their school complete pre-season baseline testing. The top selections for the tests included in the preseason baseline were ImPACT or similar computerized neuropsychological testing (83.5%), and the Balance Error Scoring System (28.5%). The most commonly used tools for concussion diagnosis and management were symptom checklists (89.9%) and ImPACT or similar computerized neuropsychological testing (79.5%). There was a significant association between the use of a tool at baseline and the same tool's use at follow up ($P < .001$) for nearly all tools. In the 24-hour period after an athlete's concussion diagnosis, most but not all (98.9%) respondents indicated that concussed athletes are prohibited from resuming participation in practices or games. **Conclusions:** Most participating clinicians report following best practice recommendations for concussion management. Not all respondents, however, report doing so, presenting an important opportunity for improvement.

The Impact of Employment Model on Athletic Trainers' Concussion Management Practices in the Secondary School Setting

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Context: Employment model may influence clinical practice in the secondary school setting. Those employed directly by the school may be more closely associated with the school and have better administrative support. Those in outreach positions may have less school affiliation but ties to external entities that may assist with referral or other resources. It is unclear whether employment model impacts athletic trainers' (AT) concussion management practices in secondary schools. **Objective:** To determine differences in concussion management practices between ATs in a direct versus outreach employment model. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 851 clinicians (25.9% response rate) from a convenience sample of ATs that were currently practicing in the secondary school setting (308 males, 376 females, 167 missing, age = 37.28 ± 10.13). **Interventions:** 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 consisted of several multipart questions to assess ATs' current concussion management practices regarding policy, standing orders, baseline and follow-up testing and clearing athletes to return-to-play. The independent variable was employment model (direct AT, outreach AT). **Main Outcome Measures:** The dependent variables were participants' responses to the concussion management questions. Descriptive statistics were utilized to describe overall practices and separate Mann Whitney U tests ($P < .05$) were used to identify group differences. **Results:** Respondents included 582 direct ATs and 198 outreach ATs. Significant group differences were found regarding having a written concussion policy at the secondary school ($U = 54618.0$, $P = .037$) and conducting baseline concussion assessment testing ($U = 52431.0$, $P = .005$). 91% of direct ATs (n = 530/582) reported having a written concussion policy for their secondary school, while only 85% of outreach ATs (n = 170/198) reported having a policy. Interestingly, only 79% of direct ATs (n = 462/582) conducted baseline assessment testing at the secondary school compared to 88% of outreach ATs (n = 175/198). The most common factors reported by ATs that do not conduct baseline concussion assessment testing were money (direct AT = 69.2%, n = 83/120; outreach AT = 82.6%, n = 19/23), time (direct AT = 65.0%, n = 78/120; outreach AT = 60.9%, n = 14/23), and limited personnel (direct AT = 31.7%, n = 38/120; outreach AT = 43.5%, n = 10/23). Direct ATs were significantly more familiar of Individualized Education Plans (IEP) (2.41/4.0 ± 1.3, $P < .001$) and 504 plans (2.13/4.0 ± 1.3, $P < .001$) than outreach ATs (1.98/4.0 ± 1.1; 1.52/4.0 ± .97). No significant group differences were found for having standing orders from a directing physician ($P = .30$), conducting post-concussion assessment testing ($P = .50$), return-to-play clearance of student-athletes ($P = .11$), and physician referral ($P = .39$). **Conclusions:** Concussion management practices differ by employment model. Those employed directly by the school are more likely to have a written concussion policy as well as a greater familiarity of academic accommodations compared to outreach ATs. However, regardless of employment model, ATs reported several barriers that limit their ability to implement baseline testing.

Physicians' Concussion Management and Referral Patterns for Adolescent Athletes Following Sport-Related Concussion

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Context: While athletic trainers (AT) are often responsible for concussion management within a secondary school, they work closely with their team physician (TP) as well as community-based physicians (non-TP) who manage the concussion outside of the school setting. A physician's knowledge and familiarity of concussion management is important for proper communication with the AT, yet little is known about the current concussion management and referral patterns of physicians associated with secondary schools. **Objective:** To determine whether physicians' association with a secondary school influences their concussion management and referral patterns for adolescent athletes. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 94 physicians (4.7% response rate) from a convenience sample of physician members of the American Academy of Family Physician's National Research Network and American Osteopathic Academy of Sports Medicine (58 males, 18 females, 18 missing, age = 46.7 ± 11.4). **Interventions:** Participants were solicited via email to complete the Physicians' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-PHYS) survey. The BAKPAC-PHYS consisted of several multipart questions to assess physicians' current concussion management practices regarding baseline and follow-up testing, as well as their referral patterns and established relationships with other healthcare providers. The independent variable included physician association (TP, non-TP). **Main Outcome Measures:** The dependent variables were participants' responses to the BAKPAC-PHYS questions. Descriptive statistics were utilized to describe overall practices and Mann Whitney U tests ($P < .05$) were used to determine group differences. **Results:** On average, TPs (n = 56) managed 38.9 ± 48.1 concussions per year while non-TPs (n = 36) managed 3.1 ± 4.3. A significant group difference was found regarding baseline concussion assessment testing ($P = .031$); 77.8% of TPs (n = 28) did not offer baseline testing in their practice, while 58.3% of non-TPs (n = 21) did not. There was no significant difference regarding post-concussion testing ($P = .182$). Regardless of physician association, the most commonly used concussion assessments tools were computerized neurocognitive tests (28.7%, n = 27), sideline assessments (25.5%, n = 24), and balance assessments (22.3%, n = 21). TPs most commonly reported having an established relationship with ATs (85.7%, n = 48), physical therapists (73.2%, n = 41), and neurologists (64.3%, n = 36). Of those TPs with an established relationship with an AT, 45.8% (n = 22/48) always and 18.8% (n = 9/48) almost always referred concussed adolescents to ATs. While non-TPs also most commonly had an established relationship with physical therapists (41.7%, n = 15) and neurologists (50.0%, n = 18), only 22.2% (n = 8) of non-TPs reported having an established relationship with an AT. **Conclusions:** Our results suggest that TPs have better established relationships with a variety of healthcare providers and are more likely to include ATs in their referrals. ATs should continue to strengthen their relationships with their TP and seek out opportunities to educate and collaborate with community physicians who are not associated with their secondary school to build stronger interprofessional concussion management teams.

The Effect of Knee Joint Angle on NMES-Induced Torque Production

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Context: Neuromuscular electrical stimulation (NMES) is frequently used to strengthen muscles during post-surgical knee rehabilitation. We have observed differences in the knee position typically used during research versus clinical practice, which warranted a comparison. The required training intensity for strength gains is often referred to as a percentage of the maximum voluntary isometric contraction (%MVIC). To better understand NMES-induced training intensity at a clinically relevant knee angle, a comparison of the %MVIC at the two joint angles was needed. To make a fair comparison, it was necessary to calculate and compare both an absolute and relative %MVIC. **Objective:** To compare knee extension force production with the knee in a mechanically advantaged position (60° flexion), which has been commonly used during research, to the force produced with the knee in a potentially more clinically relevant position (15° flexion) during NMES-induced contractions of the quadriceps. We hypothesized that force production would be significantly greater at 60° of knee flexion but differences would be negated for the relative %MVIC. **Design:** Randomized counterbalanced study. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen healthy female participants (21.5 ± 2.4 yr, 67.7 ± 7.7 kg, 162.4 ± 5.3 cm) completed the study. **Interventions:** After two familiarization sessions, participants performed MVIC and NMES-induced isometric knee extension on a dynamometer at 60° and 15° of knee flexion. Russian current was delivered through two channels with an Intelect® Legend XT (Chattanooga Group, Inc., Hixon, TN) via four electrodes affixed over the femoral nerve and motor points of the superficial quadriceps muscles. For each participant, the same maximum comfortable amplitude was used at 60° and 15°. Dependent t-tests were used to analyze dependent variables, peak torque, absolute %MVIC and relative %MVIC. **Main Outcome Measures:** Normalized peak torque during NMES-induced isometric contractions of the quadriceps was measured. Absolute %MVIC was calculated by dividing NMES-induced torque at each angle by MVIC at 60°. Relative %MVIC was calculated by dividing NMES-induced torque at each angle by MVIC at the respective angle. **Results:** Normalized NMES peak torque at 60° (1.13 ± 0.74 Nm/kg) was significantly greater ($t_{15} = 3.694$, $p < 0.001$, $d = 0.924$) than at 15° (0.55 ± 0.19 Nm/kg). Absolute %MVIC at 60° (53.5 ± 32.3 %MVIC) was significantly greater ($t_{15} = 4.062$, $p < 0.001$, $d = 1.015$) than at 15° (26.4 ± 9.7 %MVIC). There was no significant difference ($t_{15} = -1.029$, $p = 0.320$, $d = 0.257$) between relative %MVIC at 60° (53.5 ± 32.3 %MVIC) and 15° (59.2 ± 21.2 %MVIC). **Conclusions:** Based on the relationship between training intensity and strength gains, unless contraindicated, we recommend 60° rather 15°. However, because training intensity is typically determined by a %MVIC, absolute and relative %MVIC should be considered. Differences that we observed with the absolute %MVIC were negated when comparing the relative %MVIC. Consequently, if training intensity threshold is joint angle specific then training at 15° may be as effective since our results showed no difference in relative %MVIC.

Assessment of Patient Comfort During NMES-Induced Quadriceps Contractions at Two Knee-Joint Angles

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Context: Effectiveness of neuromuscular electrical stimulation (NMES) is largely dependent on the force of the NMES-induced contraction which is reported as a percentage of the maximum isometric voluntary contraction (%MVIC). This training intensity is limited by patient tolerance to NMES amplitude. In a previous study comparing NMES training intensities at different knee joint angles, several participants reported greater discomfort with lesser knee flexion angles which prompted this investigation. **Objective:** To compare level of discomfort in participants completing NMES-induced isometric quadriceps contractions at 60° and 15° of knee flexion during a fixed NMES amplitude. We hypothesized that participants would experience greater discomfort at 15°. **Design:** Randomized counterbalanced study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty participants (10 males, 10 females, 21.3 ± 2.1 yr, 75.6 ± 15.3 kg, 163.4 ± 24.9 cm) completed the study. **Interventions:** Participants reported to the research laboratory on two occasions separated by 72 hours. Participants completed a warm-up on each day that included cycling, dynamic quadriceps stretching and isometric knee extension exercises. Day one was used to identify the NMES amplitude to be used for testing on day two. Participants were positioned on a dynamometer with knee flexed to 15° and performed three MVIC separated by two minutes rest. The largest peak torque was used to determine the target %MVIC. Next, NMES was delivered via four electrodes affixed to motor points on a

shaved and cleansed right thigh. Motor points of the proximal and distal vastus lateralis, rectus femoris and vastus medialis oblique were located with a pen electrode. The NMES amplitude was gradually increased until NMES-induced force reached the target range of 30-40% MVIC, which was based on previous research. On day two motor points were identified at 60° and 15° of knee flexion with the pen electrode. Participants received a 15 second bout of NMES at the pre-determined amplitude from day one at each joint angle with test order counterbalanced. Russian current was delivered with an Intelect® Legend XT (Chattanooga Group, Inc., Hixon, TN) using the following parameters to deliver NMES: 60 bps frequency, 10% duty cycle, 5 second ramped amplitude. Immediately following NMES, participants rated their perceived level of discomfort on a 100 mm visual analog scale (VAS). Between trials electrodes were repositioned over the motor points for the alternate knee angle. A dependent t-test was used to analyze the dependent variable. **Main Outcome Measures:** VAS scores measured in mm at 60° and 15°. **Results:** The mean VAS score at 15° (47.1 ± 21.3 mm) was significantly greater ($t19 = 3.413$, $p = 0.003$, $d = 0.764$) than at 60° (32.1 ± 22.8 mm). **Conclusions:** To assist in maximizing NMES-induced training intensity a knee angle of 60° is recommended over a knee angle of 15°, because this will allow greater patient comfort. Greater comfort should enable a greater training intensity with improved benefits.

The Effect of Acclimation and Knee-Joint Angle on Tolerance to NMES Amplitude

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Context: Neuromuscular electrical stimulation (NMES) is frequently used in rehabilitation settings. Patient tolerance has been identified as a limiting factor in NMES effectiveness. A variety of factors including patient acclimation have been shown to influence patient tolerance. Anecdotal evidence suggests joint angle may also influence patient tolerance. However, there is currently a dearth of evidence addressing this topic. **Objective:** To determine if knee joint angle (60° versus 15°) and participant acclimation from day one to day two significantly influence tolerance to NMES amplitude. We hypothesized that tolerance to NMES amplitude would be significantly greater at 60° of knee flexion and significantly greater on day two. **Design:** Randomized counterbalanced study. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen healthy female participants (21.3 ± 2.4 yr, 66.8 ± 7.6 kg, 162.5 ± 5.3 cm) completed the study. **Interventions:** Participants performed NMES-induced isometric knee extension using self-selected maximum comfortable stimulation amplitude at 60° and 15° of knee flexion on two days separated by 48-72 hours. On both days subjects received 3 repetitions of NMES at each joint angle and were permitted to increase intensity to insure that maximum comfortable amplitude was used for each repetition. Russian current was delivered through two channels with an Intelect® Legend XT (Chattanooga Group, Inc., Hixon, TN) via four electrodes affixed to a shaved right thigh over the femoral nerve and motor points of the superficial quadriceps. Dependent t-tests were used to analyze dependent variables, total tolerated amplitude at each angle and each day. **Main Outcome Measures:** Total comfortable stimulation amplitude tolerated by participants at each joint angle was determined by adding the amplitudes used during the final repetition on day one and two. Total comfortable stimulation amplitude tolerated by participants during day one and two was determined by adding the amplitudes used during the final repetition at 60° and 15°. **Results:** The summed tolerated amplitude at 60° (119.0 ± 25.5 mA) was significantly greater ($t15 = 6.109$, $p < 0.001$, $d = 1.527$) than the summed tolerated amplitude at 15° (107.0 ± 22.7 mA). The summed tolerated amplitude for day two (122.6 ± 23.4 mA) was significantly greater ($t15 = 6.481$, $p < 0.001$, $d = 1.620$) than day one (103.4 ± 25.6 mA). **Conclusions:** As expected, patient tolerance to NMES stimulation amplitude increased with exposure to electrical current. This is an important finding for clinicians because tolerance to stimulation amplitude is a limiting factor for torque production, and sufficient torque production is essential for positive rehabilitation outcomes when using NMES. In addition, knee flexion angle may influence patient tolerance to NMES. We believe that participants experienced discomfort at lower stimulation amplitude at 15° because contraction of the already shortened muscle provided a cramping sensation. However, this is speculative and should be clarified with further research assessing the relationship between knee joint angle and tolerance to NMES.

The Acute Effects of Russian Stimulation on Peak Torque in the Elbow Joint

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Context: Russian stimulation is a type of electrical stimulation therapy that is used for muscle reeducation. The objective of this therapy is to increase a muscle's ability to generate force by causing the muscle to contract until it reaches tetany, thereby obtaining a complete contraction of the muscle fibers. The key to muscle reeducation is that the patient actively contracts the muscle during the Russian stimulation therapy. Research studies have shown that Russian stimulation coupled with contraction helps the patient to regain control of the muscle group faster than without Russian assistance. **Objective:** The primary aim of this study was to examine the effect of Russian stimulation therapy on peak torque at the elbow joint. We hypothesized that the addition of Russian stimulation to the elbow flexor muscles would increase peak torque at the elbow joint. **Design:** Repeated measures. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** Twenty healthy active males (age 20.70 ± 3.01 years, weight 82.27 ± 2.78 kg, height 204.67 ± 28.98 cm) volunteered to participate in the study. **Interventions:** Isometric peak flexion torque was measured by a Biodex Isokinetic Dynamometer before and during Russian stimulation therapy being applied to the elbow flexors of the dominant arm. Patients performed 3 repetitions of unilateral isometric contractions for 10 seconds at a 45° and 90° angle of elbow flexion. A 3-minute resting period then occurred after which Russian stimulation was applied to each participant and the same isometric tests were repeated. Russian stimulation settings included: 0.5 second ramp, 10/10 duty cycle, and 2.5 minutes treatment time. Electrode pads were placed at the start of the short head of the biceps and 1 inch above the distal biceps tendon on the lateral side. **Main Outcome Measures:** Isometric peak torque at 45° and 90° of elbow flexion in ft-lbs. **Results:** The results revealed a significant difference in elbow peak torque at the 45° test angle from pre to post-test measures with a mean decrease in peak torque of 10.03 ± 9.33 ft-lbs, t-value = 4.81 ($p < 0.0001$). A significant difference in elbow peak torque at the 90° test angle from pre to post-test measures was also identified with a mean decrease in peak torque of 5.73 ± 4.98 ft-lbs, t-value = 5.15 ($p < 0.0001$). **Conclusions:** This study was designed to determine the effect Russian stimulation had on peak torque at the elbow joint. Our results revealed that Russian stimulation significantly decreased the torque applied at the elbow joint. These findings are in conflict to previous research that has reported Russian stimulation producing greater force in the excited muscle than voluntary recruitment. Further research is warranted to determine why Russian stimulation decreased isometric peak torque at the elbow joint and how this may effect muscle reeducation of the elbow flexors.

Patterned Electrical Neuromuscular Stimulation Improves Hip Muscle Activation and Pain in Individuals with Patellofemoral Pain

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Context: Individuals with patellofemoral pain (PFP) often present with altered lower extremity (LE) neuromuscular function. LE muscle activation impairments may be an explanation for pain and poor performance during functional tasks. Patterned Electrical Neuromuscular Stimulation (PENS) is a precisely timed electrical stimulation treatment developed from healthy individuals' electromyography (EMG) activity to re-educate optimal firing patterns. **Objective:** To examine the effect of a 15-minute PENS treatment on LE muscle activation and pain levels during a lateral step-down task (LSDT). **Design:** Double-blinded randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-one physically active individuals with PFP participated (15F/6M, Age = 26.1 ± 7.9 years; Height = 173.7 ± 8.3 cm; Mass = 75.5 ± 18.3 kg). Participants had to have 3 months of non-traumatic peri- or retro-patellar pain during running, stair ambulation, kneeling, squatting, jumping or prolonged sitting. Participants were excluded with previous knee injury/surgery, other form of anterior knee pain, or contraindications to electrical stimulation. **Interventions:** Participants were randomly allocated to the PENS or sham treatment. The PENS group received a 15-minute strong motor stimulus delivered from an asymmetrical, biphasic square wave stimulation (50Hz frequency and 70μsec phase duration). The Sham group received a 15-minute minimal stimulus (1mA) subsensory treatment. **Main Outcome Measures:** Normalized surface electromyography amplitudes (root mean square area) for the medial gastrocnemius(MG),

vastus lateralis(VL), vastus medialis oblique(VMO), biceps femoris(BF), adductor longus(AL) and gluteus medius(GMed) were collected during 5 LSDT. Pain during the task was also collected with a visual analog scale (VAS). All measures were performed pre- and post-intervention. All data was analyzed using a repeated-measure ANOVA. Cohen's d effect sizes with 95% confident intervals were calculated. **Results:** No baseline differences between groups were identified($p > .05$). A main effect for time was observed for MG (pre = 0.25 ± 0.17, post = 0.39 ± 0.26, $p = .013$) and GMed (pre = 0.27 ± 0.18, post = 0.45 ± 0.22, $p < .001$). A significant group-by-time interaction for the GMed was found (PENS: pre = 0.26 ± 0.19, post = 0.52 ± 0.22 vs. sham: pre = 0.29 ± 0.19, post 0.37 ± 0.19, $p = 0.023$). A large effect size was found for GMed amplitude change scores in favor of the PENS group 0.88 (0.01, 1.78). A significant difference in VAS was identified between PENS: pre = 3.4 ± 2.4, post = 1.1 ± 0.8 vs. sham: pre = 3.9 ± 1.7, post = 3.3 ± 2.0, $p = 0.023$. The effect size on change score for VAS between PENS and sham was 1.07 (0.15, 1.98). **Conclusions:** Participants in the PENS group had a significant increase in GMed muscle activation during a LSDT and a large effect on pain reduction. These findings suggest that a single treatment of PENS may be an alternative intervention for clinicians to improve hip muscle activation. Long-term benefits of this modality should be examined if improvements in muscle activation and pain reduction can alter functional activity kinematics in those with PFP.

Effect of Patterned Electrical Neuromuscular Stimulation on Lower Extremity Kinematics in Individuals With Patellofemoral Pain

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Context: Patellofemoral pain (PFP) accounts for approximately 25% of lower extremity pathologies present in the sports medicine setting. Individuals with PFP demonstrate altered biomechanics during a single leg squat (SLS). Conservative management strategies lack successful resolution at improving SLS biomechanics. Patterned Electrical Neuromuscular Stimulation (PENS) is a novel intervention which delivers a precisely timed electrical stimulation to the lower extremity muscles, mimicking proper firing patterns derived from healthy individuals. **Objective:** To determine the effects of a single PENS treatment on lower extremity kinematics during a SLS task in individuals with PFP. **Design:** Double-Blind Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-one physically active individuals with PFP participated (15F/6M, Age = 26.1 ± 7.9 years; Height = 173.7 ± 8.3 cm; Mass = 75.5 ± 18.3 kg). Participants had 3 months of non-traumatic peri- or retro-patellar pain during running, stair ambulation, kneeling, squatting, jumping or prolonged sitting. Exclusion criteria were previous knee injury or surgery, other source of anterior knee pain, or contraindications to electrical stimulation. **Interventions:** Subjects were randomly allocated into a PENS or sham treatment group. PENS group received a 15-minute strong motor response treatment (asymmetrical, biphasic square wave, 50Hz frequency and 70μsec phase duration) with electrodes over the gluteus medius, vastus medialis oblique, adductor group and hamstrings. The sham group received an identical electrode placement with a 15-minute sub-sensory treatment (1mA). **Main Outcome Measures:** Three-dimensional ankle, knee, hip and trunk kinematics were assessed during peak knee flexion and at 25% increments of knee flexion within both the ascending and descending components. Pre and post intervention visual analog scale (VAS) scores for pain during the SLS were also collected. All data was analyzed using a one-way repeated-measure ANOVA. Cohen's d effect sizes(ES) with 95% confidence intervals were calculated for mean VAS changes between groups. **Results:** No significant baseline differences were found between groups. A significant group-by-time interaction for knee flexion was found: (PENS: Pre: 59.4° ± 17.4°, Post: 62.7° ± 21.9°, sham: Pre: 60.6° ± 18.9°, Post: 57.0° ± 16.3°, $F = 6.89$, $p = 0.017$). The PENS group also had significantly increased knee flexion at all increments during the SLS task. A significant reduction in SLS VAS scores was found (PENS: pre = 2.7 ± 1.9, post = 0.9 ± 0.7 vs. sham: pre = 3.2 ± 1.6, post = 2.8 ± 1.9, $F = 4.4$, $p = 0.041$). VAS change score was identified between groups in favor of PENS (ES = 0.99 (0.09, 1.9). **Conclusions:** Following a single PENS treatment there was improved knee flexion during a SLS. A clinically significant decrease in pain occurred in the PENS group. Clinicians may be able to decrease pain by performing PENS before SLS exercises in patients with PFP. This modality may also enable patients to perform rehabilitative exercises with increased comfort and facilitate progression of care.

Patterned Electrical Nerve Stimulation Improves Quadricep Strength and Power at High Isokinetic Speeds

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Context: Patterned Electrical Nerve Stimulation (PENS) allows for activation of the quadriceps and hamstrings in patterns that mimic natural motion. Previous work demonstrated no immediate effects of one PENS treatment on quadriceps function; however, little is known about the training effects. **Objective:** The purpose of the study was to investigate the effects of twelve PENS treatments on quadriceps torque, power, and work during two isokinetic speeds. **Design:** 2x3 (group x time) between-within repeated measures design. Group included PENS and sham microcurrent (SMC). Time was Day 1, Day 6, and Day 12. **Setting:** Research Laboratory. **Patients or Other Participants:** Nineteen subjects without knee injuries (within 6 months) volunteered. Subjects were not engaged in organized weight training programs and were randomly assigned to either PENS (n=10; 4 men, 6 women, age = 22.1 ± 0.8 yrs) or SMC group (n = 9; 5 men, 5 women, age = 24.6 ± 2 years). **Interventions:** Test days included day 1 before 1st treatment, day 6 before 6th treatment, and day 12 within 24 hours after last treatment. Subjects reported for 12 treatment sessions where two 3x5 inch electrode pads were placed on the quadriceps and two 2x4 inch electrode pads were placed on the hamstring. Fifteen minutes of passive PENS or SMC protocols were delivered using OmniStimFx2. PENS is a triphasic sinusoidal wave with pulse duration of 70μsec at 40Hz and we used an intensity that produced a comfortable yet visible contraction. The SMC was described as a sub-sensory microcurrent but was a sham treatment (no stimulation delivered). Testing was done on a Biodex® and included two isokinetic speeds (90°/s and 180°/s). **Main Outcome Measures:** Dependent variables included peak torque (90PT, 180PT) and peak power (90PP, 180PP) and work (90WORK, 180WORK). **Results:** Analyses were completed using separate linear mixed model repeated measures and Sidak post-hoc assessments ($\alpha = 0.05$). There were no significant differences between group and time for 90PT, 90PP, 90WORK ($p > 0.05$). There were significant group x time interactions for all 180°/sec variables ($p < 0.05$). Within the PENS group only, Day 6 and Day 12 were significantly greater than Day 1 for 180PP ($p < 0.02$), 180PT ($p < 0.03$) and 180WORK ($p < 0.02$) but Day 12 was not greater than Day 6 ($p > 0.05$). At Day 6 the PENS group demonstrated increases from Day 1 of 9.7 ± 2.4 N (peak torque), 31.5 ± 7.4 W (peak power), and 13.9 ± 2.7 J (work). **Conclusions:** Our results support the positive effects of 6-12 sessions of PENS treatments on muscle function at high speeds. We believe this occurred as a result of more efficient recruitment of large motor units. We used healthy normal subjects for this assessment but believe that patients experiencing quadriceps inhibition would especially benefit from at least 6 treatments of PENS as a part of strength therapy.

Free Communications, Rapid Fire Poster Presentations: Athletic Training Student Professional Development and Career Advancement

Friday, June 26, 2015, 1:30PM-2:45PM, Room 125/126; Moderator: William Pitney, EdD, ATC, FNATA

Final-Term Professional Athletic Training Students' Perceived Abilities to Implement the Core Healthcare Competencies into Clinical Practice

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Context: As final-term professional athletic training students prepare to transition to practice, it is necessary to ensure they are competent to provide patient care in an evidence-based manner, which promotes interprofessional collaboration, incorporates healthcare informatics, and supports quality improvement initiatives. Currently, only a few of these areas, set forth by the Institute of Medicine for all healthcare professionals, are required in professional athletic training programs (ATP). Therefore, it is difficult to identify whether students are able to transition to practice with the skills and abilities to provide impactful patient care. **Objective:** To determine final-term ATP students' perceived abilities to implement healthcare competencies into their clinical practice. **Design:** Cross-sectional. **Setting:** Self-reported paper survey. **Patients or Other Participants:** 1,501 participants (575 male, 896 females, 30 missing, age = 22.6 (2.5) from a convenience sample of 1,783 2013-2014 final-term ATP students (84.2% response rate) enrolled in 167 participating ATPs. **Interventions:** The survey consisted of one section for each identified healthcare 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 section included concept statements (range:8-18) that directly relate to each competency. Participants rated their ability to incorporate concepts of each competency within clinical practice on a 4-point Likert scale of strongly disagree (1), disagree (2), agree (3), strongly agree (4). Reliability of the abilities scale was established prior to data collection (α=.955). **Main Outcome Measures:** Composite ability scores were achieved by tabulating all values and then averaging the score back to the Likert scale. Higher scores indicated participants perceived themselves to have greater ability implementing the competencies in clinical practice. Descriptive statistics (mean(SD) were utilized to describe overall perceived abilities per competency. **Results:** While participants generally agreed they had the ability to implement the competencies into their clinical practice (QI = 3.41/4.0 ± .35, PROF = 3.53/4.0 ± .30, HCI = 3.04/4.0 ± .44, IPECP = 3.24/4.0 ± .46, EBP = 3.36/4.0 ± .36, PCC = 3.30/4.0 ± .41), there were some concepts of HCI, IPECP and PCC where they disagreed. Participants disagreed they had the ability to understand the differences between electronic medical records (EMR) and electronic health records (2.43/4.0 ± .78). They disagreed-to-agreed with their ability to use computerized patient records to develop clinical questions (2.80/4.0 ± .82), work within a true collaborative practice (2.65/4.0 ± .85), utilize EMR information to make clinical decisions (2.58/4.0 ± .80), utilize information from patient surveys to assess the quality of care provided (2.79/4.0 ± .84), and provide patients with access to real-time electronic information regarding their care (2.66/4.0 ± .85). **Conclusions:** These findings provide a better understanding of ATP students' perceived abilities to implement the healthcare competencies into clinical practice. As students prepare to transition to practice, it is important educators' emphasize the benefits of HCI for clinical practice and demonstrate how to successfully incorporate real-time electronic information to support the clinical decision-making process. Funded by the National Athletic Trainers' Association Research and Education Foundation.

The Comparison of Professional Undergraduate and Entry-Level Master Athletic Training Students' Perceived Preparation Levels of the Six Healthcare Competencies

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Context: The Institute of Medicine recommended that healthcare professionals be educated to deliver patient care by using evidence-based practice, healthcare informatics, quality improvement, and working in interdisciplinary teams. Currently, very few of these areas are required in the educational competencies for professional athletic training programs, and only recently became required at the post-professional level. **Objective:** To compare perceived levels of preparation within competency areas between students enrolled in professional undergraduate (UG) and entry-level masters (ELM) Commission on Accreditation of Athletic Training Education (CAATE) athletic training programs (ATP). **Design:** Cross-sectional. **Setting:** Self-reported paper survey. **Patients or Other Participants:** 1501 participants (1301 UG: age = 22.27 ± 2.15 yrs, 498 males, 803 females; 170 ELM: age = 25.25 ± 3.16 yrs, 77 males, 93 females; 30 missing) from a convenience sample of 1783 final-term athletic training students (84.2% response rate) enrolled in 167 participating ATPs. **Interventions:** Participants completed the survey in the spring of 2014. The survey consisted of a section for each competency: quality improvement (QI), professionalism (PROF), healthcare informatics (HCI), interprofessional education and collaborative practice (IPECP), evidence-based practice (EBP), and patient-centered care (PCC). Within each competency, concepts (range: 8-18) were described that related to the definition of the competency. Participants rated their perceived level of preparation from their ATP for each concept of each competency on a 4-point Likert scale of not prepared (1), minimally prepared (2), moderately prepared (3), and fully prepared

(4). Reliability of the preparation scale was established prior to data collection and was extremely high (α = .971). **Main Outcome Measures:** Composite preparation scores were calculated by adding all values and then averaging the scores back to the Likert scale. Higher scores indicated participants' perceived higher levels of preparation in each competency. The independent variable was ATP type (UG, ELM) and dependent variables were participants' responses. Between-group differences were assessed with Mann-Whitney U tests (P < .05). **Results:** Overall, participants perceived they were "moderately prepared" in the competency areas (QI = 3.39/4.0 ± .42, PROF = 3.47/4.0 ± .40, HCI = 3.02/4.0 ± .55, IPECP = 3.27/4.0 ± .53, EBP = 3.41/4.0 ± .44, PCC = 3.34/4.0 ± .46). Significant differences were found between UG and ELM students with ELM exhibiting higher perceived preparation for QI (UG = 3.38/4.0 ± .41, ELM = 3.47/4.0 ± .38, U = 92392.50, P = .007), PROF (UG = 3.46/4.0 ± .40, ELM = 3.53/4.0 ± .38, U = 94972.0, P = .03), IPECP (UG = 3.26/4.0 ± .53, ELM = 3.36/4.0 ± .52, U = 95689.50, P = .027), EBP (UG = 3.39/4.0 ± .44, ELM = 3.55/4.0 ± .39, U = 83028.0, P < .001), and PCC (UG = 3.33/4.0 ± .46, ELM = 3.42/4.0 ± .46, U = 93499.50, P = .011). There was no significant difference for HI (UG = 3.01/4.0 ± .55, ELM = 3.09/4.0 ± .51, U = 100939.50, P = .113). **Conclusions:** Final-term students in ELM ATPs perceive themselves as more prepared in five of the six competency areas when compared to final-term students in UG ATPs. Students rated preparation in healthcare informatics lowest among all competencies. Using information technology to manage clinical data and to access the most recent evidence can aid in providing optimal patient care. Education programs should work to improve students' preparation in all competency areas, but particular emphasis should be placed on integrating healthcare informatics into didactic and clinical curricula. Funded by the National Athletic Trainers' Association Research and Education Foundation.

Accuracy and Reliability of Peer Assessment of Clinical Skills and Professional Behaviors Among Undergraduate Athletic Training Students

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Context: Peer assessment is used widely in medical education as a preparatory tool for students to prepare them for work as healthcare professionals. Athletic training students learn some of the same skill-set as medical students. Initial research in peer assessment in athletic training education shows promise for further development. **Objective:** To identify if undergraduate athletic training students can accurately and reliably assess their peers on clinical skills and professional behaviors. **Design:** Quasi-experimental between- and within- groups. **Setting:** Medical exam office. **Patients or Other Participants:** Convenience sample of junior (n = 9) and senior athletic training students (n = 10) and their classroom and clinical faculty (instructors [n = 9]) at a CAATE-accredited program. Years of clinical experience for the juniors was 0.5 years, 1.5 years for the seniors, and averaged 16.4 ± 5.3 for the instructors. **Interventions:** Independent variables were group assignment, clinical skill (Biceps Femoris Manual Muscle Test [BFMMT], Lachman Test, Kleiger Test, Noble's Compression Test, Thompson Test), clinical skill subscale (patient position, clinical position, test performeance), and professional behaviors summative score. Participants concurrently assessed live clinical skills performance of a junior or senior student. Each student group's scores were compared to instructor group scores to determine accuracy of student scores. Each student group's scores were compared within-group to determine reliability of student scores. Accuracy and reliability of skills and subscales were measured using Cohen's kappa coefficient. Weighted Cohen's kappa coefficient was used for professional behaviors measures. Instrument was adapted, with permission from an athletic training textbook designed for clinical skills documentation and was field-tested prior to use in study. **Main Outcome Measures:** Yes/No dichotomous scores used for clinical skills and subscales. 5-point Likert scale for professional behaviors score. **Results:** Seniors were accurate (P < .05) for all clinical skills (percent agreement 70.0%, 89.7%, κ = .3735, .5540, P < .001, .037), subscales (71.1%, 97.8%, κ = .2577, .7887, P < .001, .019), and professional behaviors (48.6%, κ = .2559, P = .008). Seniors were reliable for BFMMT ω (76%, κ = .4286, P = .003), Thompson Test (93.3%, κ = .6296, P = .014), test performance (93.3%, κ = .3407, P = .002), and professional behaviors (54.5%, κ = .4094, P < .001). ω Juniors were accurate for the BFMMT (82.8%, κ = .5589, P < .001), Thompson Test (92.9%, κ = .7296, P < .001), Kleiger Test (71.4%, κ = .2593, P = .041), Noble's Compression Test (83.9%, κ = -.0862, P = .005) patient position (96.8%, κ = .7835, P < .001), test performance (77.1%, κ = .3236, P < .001). Juniors were reliable for BFMMT (77.5%, κ = .3793, P = .030), Noble's Compression Test (90.6%, κ = .5200, P = .039), patient position (92.6%, κ = .6250, P = .016), and test performance (78.8%, κ = .3295, P = .023). **Conclusions:** Students assess the clinical skills of their peers on par with instructors during live skills demonstration. Year in school may affect ability to assess professional behaviors.

Prediction Modeling for Graduate Athletic Training Programs - BOC Success

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Context: Several recent changes in athletic training education have been implemented and more are expected in the future, specifically a greater emphasis on first-time BOC exam pass rates as an outcome measure for accredited professional athletic training programs. This study may provide a framework to assist Graduate Athletic Training Program (GATP) faculty in identifying students who are likely to pass the BOC exam on their first-attempt. **Objective:** Our purpose was to develop a prediction model to identify factors associated with eligibility and first-attempt success on the BOC examination for students enrolled in a professional GATP. **Design:** A cohort design was used for this research. **Setting:** This study was conducted at a university with a GATP. **Patients or Other Participants:** A record review of 106 students who applied to a GATP, were accepted, and remained as a part of the program for at least the first year was used. **Interventions:** A total of 39 potential predictors were identified following a record review of subjects' application and academic records. Receiver Operating Characteristic (ROC) analyses yielded cut-points for the continuous and multi-level discrete predictor variables. Univariable analysis using a 2 x 2 cross-tabulation table to calculate the sensitivity (Sn), specificity (Sp), odds ratio (OR), relative frequency of success (RFS) and Fisher's Exact Test (one-sided) found 5 variables to consider for multi-variable analysis. Logistic regression produced a three-factor model for predicting first-attempt success on the BOC exam (graduate GPA [gGPA], percentile rank of GRE-quantitative score [GREq], and percentile rank of GRE-verbal score [GREv]), were found to have the strongest potential for predicting first-attempt success on the BOC exam. **Main Outcome Measures:** First-attempt passage of the BOC exam defined success for this study. **Results:** Descriptive data included gGPA (3.59 [± 0.38]), uGPA (3.27 [± 0.29]), percentile rank of GREq (25.63 [± 17.13]), percentile rank of GREv (37.57 [± 19.14]). The three-factor model established a student with ≥ 2 predictors had a Sn of 0.80, a Sp of 0.62, an OR of 6.31 and a RFS of 1.66 for first-attempt success on the BOC exam, and correctly predicted 87.7% of first-attempt pass success. **Conclusions:** Recent changes in the CAATE accreditation standards mandate all programs must publish student outcome data on their web site home pages including the percentage of students who have passed the BOC exam on the first-attempt. Programs that do not have a three-year aggregate first-time pass rate ≥ 70% are considered in non-compliance, making passing the BOC exam on the first-attempt a primary outcome of importance for any athletic training curriculum. The prediction model created uses readily, accessible, past, academic performance data. The associated statistics were very strong to predict who might be likely to pass the BOC exam on their first-attempt.

Board of Certification Examination: Candidate Confidence and Preparation

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Context: Athletic Training (AT) accreditation requirements have placed an increased emphasis on the Board of Certification (BOC) examination. Understanding how candidates prepare for the exam will help programs direct and advise candidates. **Objective:** The primary purpose was to explore confidence before and after taking the examination. Secondarily we explored how candidates prepare for the examination. **Design:** Set of pre-post qualitative online survey instruments. **Setting:** Instruments were distributed to examination candidates via email. **Patients or Other Participants:** All BOC examination candidates were solicited via email for participation. Of those solicited, 176 (Male = 71 and Female = 105) completed both the pre-examination and post-examination instruments. In three BOC testing windows (June, August, October 2014), 2363 candidates were contacted for a response rate of 7%. **Interventions:** Online survey instruments were developed utilizing a sample of convenience to identify the various activities candidates utilize to prepare for the exam. The instruments consisted of several demographics (age, gender, degree program), multiple-selection questions with the various activities previously identified, and a Likert rating scale (1-5) question about confidence. The pre-examination instrument asked the candidates to select which activities they utilized and their confidence before taking the examination. The post-examination instrument asked them rate their confidence of having passed the examination before knowing the results. Face validity of the instrument was established by the critical review of three AT program directors and three exam candidates. Reliability analysis revealed an acceptable level ($\alpha = .705$). **Main Outcome Measures:** The primary dependent variable was confidence pre-examination and

post-examination. Other dependent variables were the activities utilized to prepare (pre-examination). Data was collected online and analyzed with SPSS 20 (IBM Inc., Chicago, IL). Basic descriptive statistics were calculated. A t-test was used to compare means. **Results:** Pre-examination confidence (M = 4.51 ± 1.18) was significantly higher (P < .001, df = 172) than post-examination confidence (M = 4.17 ± 1.36). The most common activities were Review Text Books from AT Classes (82%), Review AT Class Notes (82%), Review Arnheim Principles of Athletic Training (77%), and Produce Self-Made Study Guides (51%). Of the materials made available by the BOC the most widely utilized were the BOC Sample Exam Questions (73%) and the BOC Self-Assessment Exams (49%). Commercially available examination preparation texts were utilized by 53% of the participants. The most commonly utilized were AT Exam Review: A student Guide (26%) and Study Guide for the BOC (23%). **Conclusions:** Confidence decreased after taking the examination before knowing the results. This could be explained by the Dreyfus Conscious Competency Model. Following the examination candidates were conscious of the things they didn't previously understand. Follow-up study will focus on those activities that were viewed as a hindrance to preparing for the exam.

An Analysis of BOC Exam First-Attempt Pass Rates and Descriptive Characteristics of Professional Athletic Training Programs

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Context: Currently there is a significant discussion in the field related to whether professional education in athletic training should occur solely at the graduate level, eliminating undergraduate professional preparation. Overall evidence to support this decision is lacking. Specifically there are minimal studies evaluating the relationship of Board of Certification examination (BOC exam) first-attempt pass rates and descriptive characteristics between professional bachelor's athletic training programs (PB-ATP) and professional master's athletic training programs (PM-ATP). **Objective:** 1) To determine how the BOC exam first-attempt pass rates compare between PM-ATP and PB-ATP; and 2) to determine differences in descriptive characteristics between PM-ATP and PB-ATP program directors (PDs), faculty, and athletic training students (ATSs). **Design:** Web-based, cross-sectional survey. **Setting:** A web-based survey. **Patients or Other Participants:** We recruited PDs from all professional athletic training programs to participate in the study. One hundred and thirty-three PDs (121 PB-ATP, 12 PM-ATP, 36% response rate) from each of the ten NATA districts participated in the study. **Interventions:** We collected 3-year aggregated BOC exam first-attempt pass rates for all programs from the Commission on Accreditation of Athletic Training Education website. We used a web-based survey (Qualtrics, Provo, UT) called the Athletic Training Program and Program Director Survey (ATPPDS) to collect descriptive characteristic data of all professional programs. The ATPPDS was developed exclusively for this study and was field-tested with three experienced PDs to verify its content validity. There were two independent variables in this study: PM-ATP and PB-ATP . **Main Outcome Measures:** Dependent variables include: 3-year aggregated BOC exam first-attempt pass rates, PD characteristics, faculty characteristics, and ATSs' characteristics. An independent t-test analysis evaluated descriptive characteristic data collected about PDs, faculty, and ATSs, as well as to evaluate differences in the 3-year aggregated BOC exam first-attempt pass rates between PM-ATP and PB-ATP. There are considerably more PB-ATP than PM-ATP. Subsequently we needed to account for this in the statistical analysis. To create a random sample of PB-ATP the function 'sample' was used in R (v3.0.2; Vienna, Austria). Sampling was done without replacement so duplicates were avoided. **Results:** PM-ATPs had a significantly higher BOC exam first-attempt pass rate than PB-ATP (p=.01). The PM-ATP had a 91% pass rate while the PB-ATP only had a 79% pass rate. We identified a significant difference between the PM-ATP and PB-ATP for the number of ATSs (PB-ATP = 35.5 vs PM-ATP = 21.3; p = .02) and graduating cohort average GPA (PB-ATP = 3.3 vs PM-ATP = 3.6; p = .01). **Conclusions:** PM-ATP students were more successful in passing their BOC exam on the first-attempt compared to PB-ATP students. Based on our findings, PM-ATP better prepare students to pass the BOC exam. These findings could provide support to the current education reform discussions on eliminating PB-ATP route-to-certification.

A Retrospective Recall of Athletic Training Efficacy Sources Among Certified Entry Level Masters and Undergraduate Program Graduates

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Context: Recently certified Athletic Trainers (AT) retrospectively account their degree of efficacy in five clinical domains, the source of that efficacy and the learning contexts in which it was developed. **Objective:** To compare domain-specific efficacy characteristics of graduates from entry level masters (ELM) and undergraduate athletic training programs (ATP). **Design:** Descriptive study. **Setting:** Questionnaire administered through multiple universities with CAATE accredited ATPs. **Patients or Other Participants:** 74 (25 male, 48 female, 1 unidentified) first year BOC certified athletic trainers (Age = 23.2 + 6.2 years). **Intervention(s):** The Confidence in Athletic Training Education Questionnaire (CATEQ), 59 questions based on the domains from the 2010 BOC Role Delineation Study. Participants rated efficacy in their ability to perform 5 clinical skills, then identified the respective source of efficacy and specified the learning context in which they developed the skill (classroom, practice lab, clinical site). **Main Outcome Measure(s):** CATEQ. **Results:** Independent t-tests indicated Males were older, placed at more clinical sites, and reported higher efficacy in Evaluation and Treatment domains than females ($P < 0.05$); no differences between program type for any of the efficacy domains, but ELM AT's reported higher athlete to AT, athlete to preceptor, and student AT to preceptor ratios compared to undergraduate AT's ($P < .05$). Across learning contexts, AT's identified the clinical site as the place where they gained the most efficacy (58.9%). Across BOC domains, the most prevalent sources of efficacy were: performance accomplishments (27.1%), physiological states (20.8%), and vicarious experience (20.6%). Within each BOC domain the most frequently cited sources of efficacy were: 1. clinical site: vicarious experience for Prevention (21.4%); 2. practice lab: performance accomplishments for evaluation (23.4%), Emergency Care (14.4%), and Treatment & Rehabilitation (26.5%), 3. classroom: verbal persuasion for Administration (16.1%). In reference to the site where the most confidence was gained correlation were evident; moderate positive between number of athletes at the site and: number of preceptors, other student ATs, athlete:student AT ratio, and athlete:preceptor ratio ($r = 0.52$, $r = 0.49$, $r = 0.63$, $r = 0.68$; $P < 0.001$); positive high between other AT students and preceptors ($r = 0.82$, $P < 0.001$); weak positive between AT student:preceptor ratio and number of AT students ($r = 0.34$, $P < 0.01$); moderate negative between athlete: AT student ratio and AT:preceptor ratio ($r = -0.30$, $P < 0.01$). **Conclusions:** ATs in both programs identified clinical sites as central to developing efficacy despite the variability in athlete-preceptor-AT ratios. Taken together with the prominence of performance accomplishments as the source of efficacy, these findings support that both programs produce similar levels of domain specific efficacy among their graduates supporting ELM program transitions. Providing quality clinical experiences will be key to confident athletic trainers. Subsequent studies should examine these relationships relative to performance.

Athletic Training Student Perceptions of Their Professional Development

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Context: Alternative methods that gather input from students regarding their field experiences and professional development can be valuable sources of information. **Objective:** The purpose of this study was to examine student perceptions of their field experience and professional growth. **Design:** Qualitative case study. **Setting:** Undergraduate athletic training program in a small private university in the Midwest. **Patients or Other Participants:** Twenty-five athletic training students that completed a field experience as part of the athletic training program. Participants were recruited for three years of the program and included sophomore, junior and senior students. **Data Collection and Analysis:** Students completed a reflection at the end of every semester that examined three areas: 1) most anxiety provoking/ stressful situation, 2) suggestion for/advice to future students, and 3) growth and professional development. The first two were explored through written reflection and the third was explored through a creative approach. Creative approaches included drawing, painting, photos, collage or scrap book page that depict how the students viewed themselves at the time and in ten years. Data was analyzed by qualitatively coding for themes using deductive content analysis. Peer debriefing and member checking ensured trustworthiness. **Results:** Stressful situations usually revolved around a life or limb threatening emergency situation. Some students reported negative feelings because they were unprepared or did not have the proper equipment. Other students reported positive feelings because they were able to use skills they have not applied before and the outcome was positive. Advice to students revolved

around the following three themes: 1) take initiative and practice skills whenever possible, 2) other students and preceptors are there to help/don't be afraid to ask for help, and 3) review class material frequently so you are prepared for any situation. The creative reflection on professional growth varied greatly. Many of the students currently viewed themselves as overwhelmed and busy. Several athletic training students are also athletes and a few showed the conflict between athletics and athletic training. Interestingly, these students almost always viewed themselves as an athletic trainer in ten years and not an athlete. Another subset of athletic training students thought they would be working with a specific professional team in ten years. Sophomore students reported wanting to be an athletic trainer for a professional sports team more often than senior students. Senior students were more likely to reflect on their personal lives as well as their professional life. **Conclusions:** Reflections are one way to gauge the clinical field experiences for athletic training students. Information from this study has helped to prepare students for entering the field experience for the first time. The reflections also allowed for a dialogue about professional development with the students and what is important for their future.

Free Communications, Rapid Fire Poster Presentations: Balance and Screening Measures

Friday, June 26, 2015, 3:15PM-4:45PM, Room 125/126; Moderator: Jennifer Earl-Boehm, PhD, ATC, FNATA

Identifying Sport and Gender Differences In the Lower Extremity Functional Test (LEFT)

Kelley K, Poel D, Cornell D, Gnacinski S, Hess C, O'Connor M, Zander R, Arvinen-Barrow M, Truebenbach C, Earl-Boehm J: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Identifying athletes who may be at risk of injury is an important role of athletic trainers. Using a battery of baseline performance tests may allow athletes and athletic trainers to identify factors that could be improved to reduce risk of injury. One such physical performance test is the lower extremity functional test (LEFT) for agility. It has been found to be useful in predicting lower extremity injuries across a wide variety of sports. It has shown high reliability, however current research neglects to consider gender and sport as they relate to performance. These factors would be important when using the LEFT as a screening test. **Objective:** To determine if differences exist among athletes from different sports, and between genders on LEFT performance. **Design:** Cross sectional. **Setting:** University recreational facility. **Patients or Other Participants:** A total of 222 Division I collegiate athletes took part in a larger study investigating sport injury risk and performance. Of those, 179 completed the agility test. (91 male, 88 female; age 19.77 ± 1.41 yrs, height = 176.59 ± 15.47 cm, weight = 74.75 ± 14.47 kg) Athletes had no history of lower extremity pathology within the past year. **Interventions:** Trials were performed by athletes from the following sports: basketball, soccer, baseball, volleyball, cross-country, track and field, and volleyball. The LEFT is a diamond shaped agility drill around which participants performed multi-directional sprinting movements (i.e. shuffling, backpedal, carioca etc.). Participants were allowed one practice trial at half speed and observed at least one trial prior to data collection. Participants were instructed to perform the test as quickly as possible. The test was repeated if multiple errors were made. Each participant performed 1 timed trial. **Main Outcome Measures:** An ANOVA was performed with the dependent variable as time to completion (seconds). The independent variables were gender and sport. Tukey's Post Hoc test was used ($p < 0.05$). **Results:** There were significant differences among sports ($f(5, 146) = 2.31$, $p = .047$) and between genders ($f(1,146) = 91.6$, $p = .00$), however there was no significant interaction ($f(3,146) = 2.146$, $p = .097$). Soccer (97.9 ± 9.3) was faster than cross country (104.8 ± 8.9, $p = .001$) and volleyball (107.0 ± 5.7, $p = .000$). Baseball (95.1 ± 7.1) was faster than track and field (101.6 ± 10.9, $p = .008$), basketball (101.9 ± 6.3, $p = .008$) cross country (104.8 ± 8.9, $p = .000$), and volleyball (107.0 ± 5.7, $p = .000$). Males (94.3 ± 6.4) were faster than females (106.9 ± 7.3) **Conclusions:** The physical and performance demands of different sports explains the differences seen in agility performance. In further studies involving the LEFT as an injury screening tool it seems prudent to consider sport and gender specificity relative to performances on the LEFT. This may indicate greater accuracy when predicting injury risk.

The Association Between Quality of Movement and Dynamic Stability in Uninjured High School Softball Players

Dierks TA, Nittoli VC, Schwipps AR, Foster AE: St. Vincent Sports Performance, Indianapolis, IN, and Indiana University, Indianapolis, IN

Context: Clinicians routinely screen athletes to assess injury risk and establish uninjured baseline data. Two common tests are the anterior reach component of the SEBT for dynamic postural stability, and the lateral step down (LSD) for movement quality. However, despite similar movement patterns, the contribution of movement quality to performing the SEBT, and the influence of core endurance as a fundamental component to performing both of these tests remains largely unknown in high school athletes. **Objective:** To examine the association between quality of movement, dynamic stability, and core endurance in uninjured high school softball players. **Design:** Cross-sectional. **Setting:** High school athletic training facility. **Patients or Other Participants:** Seventeen uninjured female softball players (age: 15.8 ± 1.3 years; height: 1.62 ± 0.07 m; weight: 62.9 ± 9.9 kg; all right side dominant). **Interventions:** This is an ongoing study involving a retrospective review of early season baseline data on the functional status of softball players in an uninjured state. Players were bilaterally assessed for dynamic postural stability (normalized SEBT anterior reach distance) and movement quality during both the LSD and SEBT (LSD scoring criteria). Core endurance was assessed as hold times bilaterally for the gluteal bridge, side plank, and modified wall sit, in addition to trunk flexion hold and horizontal trunk hold. **Main Outcome Measures:** Correlations between SEBT, LSD, and core endurance measures (Pearson, Spearman's rank), as well as paired t-test for differences in SEBT and LSD

movement quality scores and side-to-side symmetry ($p < 0.05$). **Results:** Mean SEBT movement quality was categorically better bilaterally than the LSD (right: 1.8 ± 0.9 vs. 2.4 ± 1.0; left: 1.6 ± 0.9 vs. 2.5 ± 0.6). Players were symmetric during each test, with no side-to-side differences and strong bilateral correlations (SEBT r = 0.77; LSD r = 0.68). SEBT movement quality on the left side (left leg stance) was correlated with that during left side LSD (left leg stance; r = 0.61); however, no correlation was found for the right (r = 0.17). SEBT reach distance was farther on the left side than the right (left = 62.2 ± 4.8%; right = 60.8 ± 4.6%), but were correlated bilaterally (r = 0.91). Surprisingly, the SEBT reach distance was not correlated with SEBT movement quality (right r = -0.01, left r = -0.17), but was correlated with right side LSD (r = -0.51; left r = -0.30). Unexpectedly, no core endurance tests were correlated with movement quality, but all were correlated bilaterally (r = 0.83 to 0.90). **Conclusions:** Early results indicate that for right side dominate softball players, left SEBT movement quality is related to that of left LSD, while right SEBT reach distance is related to right LSD movement quality. However, SEBT may be a lower intensity task considering the lower movement quality scores, and there appears to be no association with static core endurance tests. Future studies are needed to determine if side dominance influences movement quality associations and if this is related to injury risk.

Lower Extremity Movement Profiles of Incoming Division I Collegiate Athletes

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Context: A disparity exists between the rates of male and female lower extremity injuries. Abnormal biomechanical patterns increase the risks of non-contact lower extremity injuries and are commonly displayed by females. These abnormal biomechanics may contribute to the sex disparity. Movement assessments can identify abnormal biomechanics. It is unknown what biomechanical differences exist between incoming NCAA Division I male and female student-athletes during an overhead (OHS) and single leg squat (SLS). Identifying individuals with abnormal biomechanics will allow for the development of targeted injury prevention programs to reduce injury risks. **Objective:** To determine biomechanical differences between male and female student-athletes during baseline movement assessments. **Design:** Cohort. **Setting:** Research laboratory. **Patients or Other Participants:** One-hundred twenty-three incoming NCAA Division I varsity athletes (males = 65: height = 181.0 ± 8.2 cm, mass = 88.9 ± 19.7 kg, age = 18.3 ± 0.7 yrs; females = 58: height = 167.5 ± 7.2 cm, mass = 61.6 ± 11.6 kg, age = 18.4 ± 1.2 yrs). A representative sample of sex and sports was included. Participants were free of injury at the time of assessment. **Interventions:** Testing was completed as part of the athletes' pre-participation physical examinations. Movement errors during the OHS and SLS were assessed by a certified athletic trainer. Separate chi-square tests of independence were performed to examine difference in proportions of males and females displaying each movement error during the OHS and SLS ($\alpha \leq 0.05$). **Main Outcome Measures:** Movement errors included: feet flattening/turning out, heels lifting off the ground, knee valgus/varus motion, knee flexion angle <60º, asymmetrical hip/weight-shift, hip hike/drop, low-back arching/rounding, uncontrolled trunk motion, arms falling forward, and loss of balance. **Results:** The proportions of males and females displaying each error during the movement assessments differed between the sexes. During the OHS a greater proportion of males displayed knee varus motion ($\chi 2$ (1, N = 123) = 7.60, P = 0.006; males = 0.46, females = 0.22), low-back rounding ($\chi 2$ (1, N = 123) = 7.84, P = 0.005; males = 0.20, females = 0.03), and heels lifting off the ground ($\chi 2$ (1, N = 123) = 4.07, P = 0.044; males = 0.14, females = 0.03); a greater proportion of females displayed low-back arching ($\chi 2$ (1, N = 123) = 4.74, P = 0.029; males = 0.23, females = 0.41). During the SLS a greater proportion of males displayed feet flattening ($\chi 2$ (1, N = 123) = 4.34, P = 0.037; males = 0.58, females = 0.40), loss of balance ($\chi 2$ (1, N = 123) = 5.61, P = 0.018; males = 0.68, females = 0.47), and low-back rounding ($\chi 2$ (1, N = 123) = 13.23, P < 0.000; males = 0.28, females = 0.03); a greater proportion of females displayed knee valgus motion ($\chi 2$ (1, N = 123) = 5.14, P = 0.023; males = 0.65, females = 0.83). No other differences existed between the sexes. **Conclusions:** Incoming male and female collegiate athletes exhibit different biomechanical patterns during an OHS and SLS. In general, a larger proportion of males displayed movement errors than females. These observations benefit sports medicine professionals who are unable to screen every incoming student-athlete, in developing team based injury prevention programs. Specialized injury prevention programs can effectively reduce lower extremity injury rates. Reducing injury rates will mitigate the negative short- and long-term effects of injury while increasing physical fitness and performance.

Balance Error Scoring System Baseline Normative Values for Five Contact Sports in High School Athletics

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Context: Current consensus statements recommend postural stability assessments as one component of a multifaceted concussion management program. The Balance Error Scoring System (BESS) is an inexpensive postural stability assessment recommended for athletic trainers (AT) in both sideline and clinical use, as administration is simple and quick. Optimally BESS requires comparison with individual baseline measures. However, the resources and time needed to perform baseline assessments on high school populations can be problematic. Therefore, establishing population specific norms for age, gender, and sport would provide AT with improved data when baseline assessments are not available. **Objective:** The purpose of this study was to develop population specific BESS norms for five gender mutual high school contact sports (Basketball, Judo, Soccer, Volleyball and Wrestling). **Design:** Retrospective cross-sectional study. **Setting:** Controlled environment free of external stimuli in 67 participating high schools. Baseline concussion testing was implemented in 2010 as part of a statewide concussion management program. **Patients or Other Participants:** De-identified data from baseline BESS tests from the 2011-2014 school years for 3,238 [age = 14.49 ± 1.36 years old (y/o), females (F) n = 1,812, males (M) n = 1,426] high school athletes free of injury and not currently in a balance or postural stability training program. **Interventions:** Baseline BESS testing for all contact sport athletes was administered in a setting of eight participants per group. Baseline BESS scores were video recorded and scored by four ATs (ICC=.945) prior to the competitive season. **Main Outcome Measures:** Total error score on the BESS was compared using univariate analysis of variance by gender (M, F), age (13 y/o n = 214, 14 y/o n = 1051, 15 y/o n = 655, 16 y/o n = 868, 17 y/o n = 417 and 18 y/o n = 33) and five contact sports (Basketball n = 1221, Judo n = 48, Soccer n = 1568, Volleyball n = 291 and Wrestling n = 110). Mean, standard deviation (SD), and 95% confidence intervals were reported. **Results:** There was a significant (F4 = 2.493, p = .041, power = .714) difference between sports with Volleyball (11.63 ± 6.22 CI = 10.95-12.32) and Wrestling (15.51 ± 5.40 CI = 14.40-16.63) demonstrating the largest difference. There was a significant (F1 = 17.872, p = .000, power = .988) difference between Males (13.22 ± 6.23 CI = 12.91-13.53) and Females (12.32 ± 5.79 CI = 12.05-12.60). No significant (F5 = .996, p = .419, power = .360) differences were found for the six ages. **Conclusions:** In our sample of athletes significant differences were found between gender and sport but not age, which contradicts previous analysis performed within the same population, that found significance between three age groups. The current study had a larger n size for all age groups, which may account for the differences. Accordingly, BESS baseline scores are more sensitive to gender and sport differences rather than age; therefore they may only need be collected once in an individual's high school matriculation. Being equipped with sport and gender specific normative data, ATs will be able to make the best decision in diagnosing and making return to play decisions regarding concussions.

Responsiveness of the Self-Efficacy of Balance Scale (SEBS) and the Relationship Between the SEBS and Measures of Self-Reported Function and Objective Measures of Balance in High School Female Basketball Players

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Context: Research suggests that injury risk reduction is not feasible without behavioral change. The Self-Efficacy of Balance Scale (SEBS) was created to capture information regarding balance confidence. Linking behavioral change, based on the beliefs of an individual, the SEBS represents a quantifiable psychological component, currently lacking in the literature, to potentially aid in injury risk assessment of the lower extremity. The SEBS has demonstrated reliability and validity for measuring balance self-efficacy in a young, active population. **Objective:** Determine responsiveness of the SEBS over the course of a 15-week season and its relationship with self-reported function and objective balance measures in female high school basketball players. **Design:** Cohort. **Setting:** Field Setting. **Patients or Other Participants:** 54 female basketball athletes (age = 15.8 ± 1.3 years, height = 178.3 cm ± 48.9, mass = 65.9 kg ± 11.6) from four high schools. **Interventions:** Participants completed preseason screening, completing the SEBS (Chronbach's alpha = 0.95, ICC = 0.76), Functional Ankle Ability Measure-Sport (FAAM-S) and Knee Injury and Osteoarthritis Outcome Score-Sport subscale (KOOS-S) surveys, before participating in the static balance assessment, measured by Time to Boundary (TTB), and the Balance Error Scoring System (BESS). Following the high school basketball season, participants completed post-testing, which consisted of the same pre-test procedures. **Main Outcome**

Measures: The independent variable was time. The dependent variables were scores from the SEBS, FAAM-S, KOOS-S, TTB, and BESS. Separate repeated measures ANOVAs were used to compare across time, for dependent variables to assess scale responsiveness, and change over time. Spearman's rank correlation coefficients were used to assess the relationship between the SEBS and FAAM-S, and KOOS-S, as well as measures of TTB, and BESS scores. **Results:** A main effect for time was found for the KOOS-S ([MeanPRE = 90 ± 15, MeanPOST = 94 ± 10] F = 18.3 p = 0.01), and the SEBS ([MeanPRE = 86 ± 12, MeanPOST = 90 ± 11], F = 18.3, $p \leq 0.001$). There was a significant, positive relationship between the SEBS and the FAAM-S ($r = 0.34$, $p \leq 0.001$), and between the SEBS and the KOOS-S ($r = 0.32$ $p \leq 0.05$) at pre-test, and between the SEBS and FAAM-S ($r = 0.37$, $p \leq 0.001$) and the SEBS and KOOS-S ($r = 0.48$, $p \leq 0.001$) at post-test. A significant, positive relationship between the SEBS and the mean of TTB Anteroposterior minima ($r = 0.30$, $p = 0.02$) was detected at pre-test, and the mean of TTB Mediolateral minima ($r = 0.30$, $p = 0.03$) at post-test. **Conclusions:** The SEBS was responsive to change when a functional change was noted across all participants. The relationship between SEBS and self-reported measures of lower extremity function indicates that the SEBS is providing additional information about balance that current lower extremity self-report functional measures are not. This suggests that the SEBS represents a quantifiable psychological component, which could to be influential in determining risk of lower extremity injury in the future.

Comparison of iLESS Scores by Gender in Healthy High School Age Athletes: The FPPE Project

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Context: The Impression Landing Error Scoring System (iLESS) system utilizes a general and immediate clinician assessment of jump-landing technique to identify potentially injurious joint motion during drop jump landings. This system uses a dichotomous high risk or low risk rating to identify landing injury risk factors in knee flexion and knee valgus at initial contact and peak knee flexion. The Functional Pre-participation Physical Evaluation (FPPE) project is a nationwide preseason screening assessment aimed at assessing high school athletes' lower extremity (LE) musculoskeletal injury risk. **Objective:** Determine if males score differently than females on the iLESS. **Design:** Cross-Sectional Study. **Setting:** High school athletic training facilities. **Patients or Other Participants:** 2406 high school football, basketball, soccer and lacrosse athletes (1581 male/ 825 female, 15.7 ± 1.3 y, 1.72 ± 0.11 m, 68.9 ± 15.3 kg). **Intervention:** Prior to the start of their respective seasons, athletes performed the iLESS as part of a functional performance assessment. The iLESS test was rated 0 for low risk and 1 for high risk by the Certified Athletic Trainer based on the performance of each drop vertical jump. High risk characteristics include knee valgus or decreased knee flexion at initial contact or peak knee flexion. Each athlete performed 3 jumps and the scores were summed for a possible score of 0 to 3. **Main Outcome Measures:** Outcomes of the iLESS were dichotomized into summed scores below 2 (low risk landing) and summed scores above 2 (high risk landing). A chi-square analysis was conducted to determine if males and females score differently with significance set at p<=.05 a priori. **Results:** The occurrence of iLESS scores between male and female high school athletes were significantly different ($\chi^2 = 74.21$, $p < .001$). Males had a significantly greater percentage of low risk landings (60.0%), while females had an opposite result with (58.4%) reporting high risk landings. **Conclusions:** Female high school athletes have a significantly greater percentage of high risk jump landings as compared to their male counterparts while performing drop vertical jumps. It is important to understand the differences between gender performance on iLESS performance and drop vertical jump performance as pre-participation physical exams attempt to determine the functional tests that best predict musculoskeletal injury risk in high school age athletic populations.

Balance Error Scoring System Baseline Normative Values for High School Football

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Context: Present concussion statements recommend postural stability assessments as one component of a multifaceted concussion management program. The Balance Error Scoring System (BESS) is a rapid, easy to administer, and inexpensive postural stability assessment recommended for athletic trainers (AT) in both sideline and clinical use. During the fall competitive season, the high school AT may have several collision and contact teams simultaneously to manage, including football and soccer. Having adequate resources and time needed to perform baseline assessments on a large high school population can be problematic for the AT. Therefore, establishing population specific norms by age would provide improved options for using the BESS for concussion assessment when baseline assessments are not available. **Objective:** To develop population specific BESS norms for high school football players. **Design:** Retrospective cross-sectional study. **Setting:** The State of Hawaii has implemented a comprehensive concussion management program, which included BESS baseline testing since 2010. **Patients or Other Participants:** De-identified data from baseline BESS tests from the 2010-2014 school years for 1,481 [age = 15.18 ± 1.17 years old (y/o)] high school athletes, free of injury and not currently in a balance or postural stability training program. **Interventions:** All student athletes in collision and contact sports from 67 participating high schools were administered baseline BESS testing. Testing was video recorded and scored by four ATs (ICC= 0.945) prior to the competitive season. **Main Outcome Measures:** Total error score on the BESS was compared using univariate analysis of variance between six age groups (13 y/o n = 103, 14 y/o n = 372, 15 y/o n = 360, 16 y/o n = 467, 17 y/o n = 160, 18 y/o n = 19) that participated in football. Mean BESS error scores and 95% confidence intervals were reported. **Results:** There was a significant (F5 = 2.326, p = .041, power = .752) difference between ages with the largest difference between 17 and 18 year olds (12.66; CI = 9.35-15.99) followed by 16 to 18 year olds (12.97; CI = 9.76-16.17). Thirteen year olds scored significantly higher than 16 year olds (18.03; CI = 16.54-19.52) and 17 year olds (18.31; CI = 16.60-20.06). **Conclusions:** In our sample of high school athletes, there were significant differences between BESS scores with respect to the six age groups. Limitations due to the unequal distribution of athletes in each age group, especially in the 17 and 18 year old age groups may have effected the results of the present study. However, these finding are similar to our previous study, which found significantly higher BESS error scores in the lowest age group (13-14 y/o) compared to the two older groups (15-16y/o and 17-18y/o). The results of this study may assist the AT who does not have baseline measures in utilizing the BESS to assess their football players' recovery following concussion.

Event Specific Normative SEBT Scores in Track and Field Athletes

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Context: The Star Excursion Balance Test (SEBT) is a valid and reliable dynamic balance tool that is particularly sensitive in predicting lower extremity injuries. However, performance has not been extensively examined in track and field athletes and normative data for this group is lacking. Incidence rates of injury in track and field at the youth and collegiate levels are high and vary by track event. Specifically, sprinters suffer from acute muscle strains (often leading to long recovery periods) while other groups are prone to chronic injuries. Given these factors, evaluation of screening methods for identifying risk factors in this population is warranted. **Objective:** To determine normative dynamic balance measures in track and field athletes, and to examine differences among event groups. **Design:** Cross-sectional study. Setting: Athletic training room. **Patients or Other Participants:** Forty-seven NCAA Division I track and field athletes (25 male, 22 female, 20.8 ± 1.2 years, 176.3 ± 9.3 cm, 71.3 ± 15.7 kg) of various event groups (sprints, distance, jumps, throws) volunteered for this study. **Interventions:** Participants completed three trials of the SEBT in the anteromedial, medial, and posteromedial reach directions by maintaining balance on one leg while simultaneously touching down with the contralateral limb. Testing was randomized for leg order and reach direction. Raw data were normalized to leg length and trials were averaged prior to data analysis. **Main Outcome Measures:** SEBT reach distances were recorded to the nearest centimeter. Descriptive statistics were used to establish event-specific normative values. A series of one-way ANOVAs and post-hoc comparisons were used to

compare the reach directions for each of the four event groups. **Results:** Event specific means of the groups were 95.0 ± 7.1, 95.6 ± 5.4, 98.5 ± 5.8 for sprints; 95.8 ± 11.1, 100.3 ± 10.6, 108.3 ± 11.7 for jumps; 92.9 ± 6.1, 96.2 ± 6.4, 102.2 ± 7.0 for distance; 95.2 ± 7.3, 101.8 ± 6.9, 106.4 ± 7.1 for throws in the anteromedial, medial, and posteromedial reach directions, respectively. The overall ANOVA showed statistically significant differences between event groups in the posteromedial ($F = 6.85$, $P < .001$) and medial directions ($F = 3.57$, $P = .017$). Post hoc analyses revealed that reach distances were significantly lower for sprinters in the posteromedial direction compared to jumps ($P = .016$) and throwers ($P = .007$), and compared to throwers in the medial direction ($P = .038$). **Conclusions:** The normative values we established are useful when implementing the SEBT for screening or rehabilitation measures in track and field athletes of different event groups. The sprints group had significantly lower reach distances in directions that involve abduction (medial and posteromedial) when compared to other groups that utilize more unilateral strategies in sport. Potential explanations for our results, such as decreased gluteal activation or core stability, should be further examined as risk factors that may be linked to sprinters higher incidence of acute injuries. Future prospective studies examining prediction of such injury risk using the SEBT in this population is warranted.

Comparison of Functional Movement Patterns Between Gender and Sport

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Context: Poor movement patterns and altered neuromuscular control may increase injury risk in athletes. Injury risk appears to differ between males and females and across sport participation. Understanding these influences on functional movement patterns may help clinicians develop assessments that are sensitive to gender and sport participation. **Objective:** To compare functional movement patterns during drop vertical jumps and dynamic balance between genders and across sport participation. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** A total of 78 healthy (51 males, age: 20 ± 2 years, height: 181.37 ± 6.71, mass: 84.68 ± 16.72 kg; 27 females, age: 21 ± 3 years, height: 166.21 ± 13.11 cm, mass: 64.02 ± 15.65 kg) recreationally active or varsity intercollegiate D1 athletes (recreational female: n = 19, recreational male: n = 5, football: n = 6, men's track: n = 12, women's track: n = 3, men's soccer: n = 6, women's soccer: n = 5, men's lacrosse: n = 22) participated in this study. **Interventions:** Drop vertical jump and star excursion balance test (SEBT). **Main Outcome Measures:** The number of errors during a drop vertical jump using the landing error scoring system (LESS) criteria were scored on video by a single assessor, and the composite normalized reach distances of the anterior, posterior medial and posterior lateral directions during the SEBT were measured in real-time. Independent t-tests were used for gender comparisons, ANOVA was used to compare between sports with simple contrasts as post-hoc tests. **Results:** Overall, males had more landing errors (males: 7 ± 3, females: 6 ± 2 errors, $p = 0.037$). No differences were observed between genders for the composite normalized SEBT reach distance (males: 2.40 ± 0.21, females: 2.44 ± 0.17, $p = 0.445$). Landing errors ($p = 0.026$) and composite SEBT scores ($p = 0.011$) were significantly different among sports (LESS: recreational female: 5 ± 2 errors, recreational male: 4 ± 3 errors, football: 9 ± 3 errors, men's track: 7 ± 4 errors, women's track: 7 ± 2 errors, men's soccer: 6 ± 2 errors, women's soccer: 7 ± 2 errors men's lacrosse: 7 ± 3 errors; composite SEBT: recreational female: 2.47 ± 0.16, recreational male: 2.60 ± 0.16 football: 2.43 ± 0.12, men's track: 2.42 ± 0.26, women's track: 2.17 ± 0.17, men's soccer: 2.47 ± 0.13, women's soccer: 2.46 ± 0.09, men's lacrosse: 2.31 ± 0.19). Football players had more errors than recreational females ($p = 0.003$), recreational males ($p = 0.006$) and men's soccer players ($p = 0.026$). Men's lacrosse players also had more errors than both recreational females ($p = 0.009$) and recreational males ($p = 0.030$). Women's track athletes had a shorter composite normalized SEBT reach distance compared to recreational females ($p = 0.010$), recreational males ($p = 0.002$), men's track ($p = 0.037$), men's soccer ($p = 0.024$), and women's soccer ($p = 0.032$) players. Men's lacrosse also had shorter composite SEBT reach distances compared to both recreational females ($p = 0.008$) and recreational males ($p = 0.002$). **Conclusions:** The current findings suggest males exhibit more landing errors, which is contrary to current literature. Sport-specific differences in landing errors and SEBT reach distances have possible implications into identifying injury risk or for identifying inherent characteristics of sports participation that may enhance movement quality during landing or dynamic balance performance.

The Influence of Creatine, Carbohydrate, and Creatine Plus Carbohydrate Supplementation on Anaerobic Activity in Adolescent Athletes: A Systemic Review

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Context: Creatine (Cr) is a popular supplementation used during anaerobic activities to increase performance. Although Cr is popular among high-intensity athletes; CHO supplementation may increase anaerobic performance more than Cr supplementation without the added side effects of weight gain and cost. **Objective:** Systematically review the literature to determine if creatine supplementation, carbohydrate supplementation and/or a combination of creatine and carbohydrate (Cr + CHO) increases performance during anaerobic activity. **Data Sources:** Relevant articles were identified from the following electronic databases: PubMed and Medline from January 2004 to September 2014 using the following search phrases: "creatine supplementation AND carbohydrate supplementation NOT protein", "creatine AND anaerobic", "carbohydrate supplementation AND anaerobic", and "creatine with carbohydrate supplementation" resulting in 145 studies. **Study Selection:** Studies were included if they met the following criteria: (1) full report, peer-reviewed randomized controlled trials, (2) healthy adolescent athletes, ages 15-22 who engaged in physical activity on a regular basis, (3) written in English, (4) available abstract, and (5) included key outcomes measuring increased anaerobic performance (ie., anaerobic work capacity (AWC), vertical jump and one repetition maximum tests for upper and/or lower body (1-RM). **Data Extraction:** Two reviewers independently assessed and graded each study on the Physiotherapy Evidence Database (PEDro) scale. Data of interest were subjects, intervention, descriptive data (means, SDs), group differences and confidence intervals (when available), and effect size (calculated when possible) of the main outcome measures. **Data Synthesis:** Four studies met the inclusion criteria, all full reports. PEDro scores ranged from 6-9 points (maximum score = 10), average of 7.25 ± 1.25. Mean subject age range was 20.52 ± 2.12 (range = 17-35) and all engaged in physical activity on a regular basis. All studies included at least one key outcome measuring increased anaerobic performance: vertical jump (n = 2), AWC (n = 1), and 1-RM (n = 1). Results revealed two significant interactions and one within-group effect. In one study subjects who ingested Cr and Cr + CHO compared to CHO experienced significant ($p \leq .05$) increases in AWC of 9.4% (d = .358) and 30.7% (d = .476), respectively. A second study examining 100-kcal, 250 k-cal, and Cr to a placebo found all 3 groups receiving supplementation improved their ability to maintain vertical jump height. The 250-kcal and Cr groups outperformed the 100-kcal and placebo, with the benefits in the 250 k-cal being observed 1 jump earlier than in the Cr subjects. **Conclusions:** Results demonstrate inconsistent finings between Cr, CHO, and Cr + CHO relative to increased anaerobic activity. However, Cr and Cr + CHO did demonstrate a slight advantage over CHO, specifically with lower CHO supplementation. However, within-group results suggest that Cr and CHO have the potential to improve anaerobic performance. These findings; however, should be interpreted cautiously as differences in study methodologies, outcome measures, populations, supplementation regiments, and time frames all varied.

Influence of Static Lower Extremity Alignment on Lower Extremity Kinematics Across Functional Tasks

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Context: Altered static lower extremity alignment (LEA) is thought to contribute to dynamic malalignment, increasing the risk of knee injuries. LEA has been shown to influence dynamic alignment during a slow, controlled task. However, the observed relationships may not be consistent across functional tasks commonly occurring during sport where injury rates are greater. **Objective:** To examine the relationship between LEA and lower extremity kinematics across a jump landing (JL) task, a single-leg landing (SLL) task, and a jump-cut task (JC). **Design:** Descriptive laboratory. **Setting:** Research laboratory. **Patients or Other Participants:** Forty participants (20 females, 20 males: 21.6 ± 1.9 yrs, 173.3 ± 9.0 cm, 79.0 ± 12.3 kg) volunteered to participate. **Interventions:** Pelvic angle (PA), femoral anteversion (FA), genu recurvatum (GR), tibial torsion (TT), navicular drop (ND), hip internal rotation (HIR), and external rotation (HER) range of motion, were measured on the dominant stance limb by a clinician with known reliability (ICC2,k>0.87). Three-dimensional kinematics were assessed using an electromagnetic motion analysis system during a JL task from a 30cm box set 50% of participant's height away from a force plate, a SLL task from a height of 45cm, and a JC task from a 30cm box set 2/3 of participant's height away with a side-step cut (60°) upon landing. **Main Outcome Measures:** LEA values were averaged over the three measures. Peak frontal and transverse plane hip and knee joint angles [initial contact (GRF>10N) to peak knee flexion] were averaged over five trials for each functional task.

Step-wise linear regressions determined the extent to which LEA measures predicted lower extremity kinematics for each functional task, in males and females. **Results:** In females, less HER range of motion (32.6 ± 5.3°) predicted greater knee valgus during the JL (-8.1 ± 4.1°, R2 = 0.367, P = 0.005), the JC (-8.2 ± 3.9°, R2 = 0.560, P < 0.001), and SLL (-7.5 ± 4.6°, R2 = 0.321, P = 0.009). Greater TT (15.9 ± 3.8°) predicted greater knee internal rotation during the JC (3.7 ± 7.9°, R2 = 0.198, P = 0.049), and less knee external rotation during the SLL (-6.9 ± 8.7°, R2 = 0.252, P = 0.024). In males, greater GR (2.9 ± 3.3°) predicted greater knee external rotation during the JL (-6.9 ± 7.7°, R2 = 0.220, P = 0.037) and JC (-4.3 ± 9.1°, R2 = 0.298, P = 0.013), and less knee internal rotation during the JC (8.7 ± 9.0°, R2 = 0.313, P = 0.010). Greater PA (7.4 ± 4.5°) predicted greater hip internal rotation during the JL (15.4 ± 15.2°, R2 = 0.247, P = 0.026) and JC (13.3 ± 11.5°, R2 = 0.289, P = 0.014). Greater TT (16.4 ± 4.7°) predicted less knee internal rotation during the JL (11.4 ± 12.6°, R2 = 0.287, P = 0.015). **Conclusions:** HER range of motion was the only consistent predictor of lower extremity kinematics across functional tasks and was specific to females. Other LEA variables did not predict lower extremity kinematics, or were not consistent across functional tasks. Understanding these task-specific relationships is an important step toward identifying the most relevant factors that increase risk of knee injuries.

Development of a New Jump-Landing Protocol for Dynamic Stability in High-Level Athletes

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Context: Dynamic stability is a means to assess ankle stability. Current jump-landing protocols identify differences in recreational individuals, but have not elicited differences in high-level athletes. **Objective:** To develop a new jump-landing protocol to identify differences in high-level athletes. **Design:** Case-control study. **Setting:** Movement Analysis Lab. **Patients or Other Participants:** 61 Division I collegiate athletes (32 females, 29 males; age = 19.9 ± 1.2 yrs; height = 176.6 ± 9.5 cm; mass = 74.10.8 kg) were separated into healthy, coper, and unstable groups based on the Cumberland Ankle Instability Tool and their ankle injury history. **Interventions:** Two jumping tasks from the forward and lateral directions were executed barefooted onto the force plate. For the forward jump, participants took two preparatory steps, jumped to 50% of their pre-recorded maximum vertical jump, and landed single-legged on the force plate. For the lateral jump, participants took two side shuffle steps and jumped to 50% of their pre-recorded maximum vertical jump, again landing single-legged on 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. Three trials were collected for each jump in a randomized order. **Main Outcome Measures:** A one-way ANOVA with Tukey post hoc test was used to identify differences in time-to-stability (TTS) in the forward and lateral jumps among groups. **Results:** For the forward jump, the healthy group had a TTS of 1.19 ± 0.37s, the coper group 1.13 ± 0.49s, and the unstable group 1.58 ± 0.62s. For the lateral jump, the healthy group had a TTS of 1.14 ± 0.37s, the coper group 1.15 ± 0.39s, and the unstable group 1.55 ± 0.63s. Significant differences in TTS were found in both forward and lateral jumps at P = 0.014 and P = 0.013, respectively. The post hoc analyses revealed that the unstable group had a significantly slower TTS than the healthy and coper groups (P = 0.050, P = 0.019, respectively for the forward jump; P = 0.026, P = 0.028, respectively for the lateral jump). No differences were detected between healthy and coper groups at P = 0.918 for the forward jump and P = 1.000 for the lateral jump. **Conclusions:** This jump-landing protocol sufficiently detects differences in TTS among the healthy, coper, and unstable groups of high-level athletes. Previous jump-landing protocols identified poor stability measures in the unstable group of recreational individuals, but not of high-level athletes. Previous protocols utilized either a vertical displacement or multi-directional jumps, but did not incorporate them together. However, this new jump-landing protocol integrated the two into a more sport-specific movement. The more dynamic movement used in this protocol is likely what exposed the stability impairments of the unstable group of high-level athletes. Perhaps, this new jump-landing protocol better taxes the sensorimotor system of high-level athletes, giving clinicians the ability to identify those at risk of injury and implement interventions to reduce these risks.

Influence of Hip Strength and Range of Motion on Landing Kinematics Across Maturation Groups in Youth Athletes

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Context: Changes in landing patterns through maturation are suggested to contribute to increased risk of knee injuries in youth athletes. However, factors contributing to altered landing kinematics throughout maturation are unknown. Hip range of motion (ROM) and strength are known to influence landing kinematics. It is unknown if these factors contribute to maturational changes in landing kinematics. **Objective:** To determine if hip strength and ROM are associated with lower extremity kinematics during a jump landing (JL) task, across stages of maturation. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** One hundred and four (41M, 63F) youth athletes (13.4 ± 3.1 yrs, 159.0 ± 16.2 cm, 52.1 ± 17.0 kg) volunteered to participate. **Interventions:** The validated Pubertal Maturational Observational Scale (PMOS) determined maturation stage. Isometric strength of the hip external rotators (HER), abductors (HABD), and extensors (HEXT) was evaluated by testers with known reliability (ICC > 0.80), using a handheld dynamometer. Passive hip internal rotation (HIR), HER, and HABD ROM were measured with a digital inclinometer. Three-dimensional hip and knee kinematics were assessed using an electromagnetic motion analysis system during a JL task from a 30-cm high box set 50% of their height away from a force plate platform. **Main Outcome Measures:** Participants were classified into groups: pre-pubertal (10M, 15F: PMOS < 2), pubertal (11M, 10F: PMOS = 2-5), and post-pubertal (20M, 38F: PMOS > 5). Peak isometric hip strength was normalized to body weight (%BW), while ROM was recorded to the nearest degree. Frontal and transverse plane hip and knee joint angles at initial contact (IC) (GRF > 10N), peak joint angles (IC to peak knee flexion), and joint excursions (peak minus IC) during the deceleration phase of the JL tasks were used for analysis. Separate step-wise, multiple linear regressions determined the extent to which hip strength and ROM predicted hip and knee kinematics during the JL task. **Results:** Pre-pubertal group: less HER strength (0.22 ± 0.04% BW) predicted (R^2 = 0.185, P = 0.032) greater HIR (-4.6 ± 13.3°) at IC, less HEXT strength (0.42 ± 0.14% BW) predicted (R^2 = 0.214, P = 0.020) greater knee IR (5.2 ± 11.6°) at IC, less HABD (0.21 ± 0.05% BW) and HEXT strength combined to predict (R^2 = 0.309, P = 0.017) greater peak knee IR (-8.1 ± 6.9°), and less HER (5.2 ± 11.6°) ROM predicted (R^2 = 0.175, P = 0.037) greater knee IR (7.9 ± 9.3°) displacement. In the post-pubertal group, less HER (36.0 ± 12.6°) ROM predicted greater knee ER at IC (R^2 = 0.161, P = 0.002, -3.7 ± 10.1°) and peak knee ER (R^2 = 0.187, P = 0.001, 8.0 ± 12.3°), greater HIR (45.8 ± 7.8°) ROM predicted less HADD at IC (R^2 = 0.077, P = 0.035, -7.9 ± 7.8°) and peak HADD (R^2 = 0.131, P = 0.005, -1.7 ± 8.8°), but greater HIR displacement (R^2 = 0.134, P = 0.005, 12.7 ± 8.8°), less HABD strength (0.23 ± 0.05% BW) predicted (R^2 = 0.184, P = 0.001) greater peak knee ER (-9.2 ± 9.2°). **Conclusions:** In pre-pubertal athletes, hip strength has more of an influence on landing kinematics, while hip ROM has more of an influence in the post-pubertal athletes. These changes through maturation should be considered when developing youth injury prevention programs.

Effect of Reduced Gravitational Load Running on Lower Limb Kinematics

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Context: There is a lack of research in the athletic population on the effects of an anti-gravity treadmill, which is also known in the literature as a lower body positive pressure treadmill. It is unknown whether lower extremity (LE) kinematics are altered during a bout of running in an anti-gravity environment. **Objective:** We aimed to determine the effect of gravitational loads (GL) on LE gait kinematics during various running velocities. We hypothesized that running at decreased GL would lead to altered biomechanics. **Design:** Single group cohort design. **Setting:** Exercise Physiology Laboratory and Athletic Training Services Clinic. **Patients or Other Participants:** Fourteen male recreational runners (age = 23.1 ± 1.9 y, height = 181.8 ± 6.7 cm, mass = 83.5 ± 9.7 kg), with no current LE injuries. Participants reported a minimum of 200 min per week of running. **Interventions:** During the first session, participants completed a VO2max test in the Exercise Science Laboratory. From this test, we calculated running velocity at 60, 70, and 80% VO2max for subsequent tests. During the second session, participants completed 15 randomized running trials (5x3) on the Alter G® treadmill under five different GL and three different velocities (1-min trials with 3-min rest). We recorded electrogoniometry (EG) from the knee and ankle joints using a Delsys® Wireless TrignoTM System. Additionally, we used Tekscan F-scan® in-shoe to record plantar pressure, identify onset of stride cycle and synchronize with joint kinematics. We recorded all data during the last 30sec of each 1-min trial and averaged 10 consecutive stride cycles. **Main Outcome Measures:** We used EG to determine angle at initial contact, toe-off, peak angle in stance phase, and ROM during the stance phase. We used plantar pressure data to determine glide time, stride frequency, stride duration, ground contact time (GCT), and normalized GCT. We used a 2-factor repeated measures ANOVA to quantify statistical differences, with significance set at $P < 0.05$ α-priori. **Results:** Reduced GL significantly increased stride duration ($F = 50.3$; $P < 0.001$; $d = 0.93$) and reduced stride frequency ($F = 50.5$; $P < 0.001$; $d = 0.90$). Despite the stride duration increasing, ground contact time was significantly reduced ($F = 43.4$; $P < 0.001$; $d = 0.87$). In addition, normalized GCT was significantly reduced ($F = 21.1$; $P < 0.001$; $d = 1.38$), indicating an increase in glide time as GL was diminished. Reduced GL also resulted in significant reductions in peak knee flexion ($F = 51.3$; $P < 0.001$; $d = 0.78$) and dorsiflexion ($F = 24.6$; $P < 0.001$; $d = 0.99$) and reduced the overall knee ($F = 33.0$; $P < 0.001$; $d = 1.08$) and ankle ROM ($F = 20.8$; $P < 0.001$; $d = 0.73$) during the stance phase. **Conclusions:** Running with reduced GL in the Alter G® treadmill alters LE gait kinematics resulting in reduced joint ROM at the ankle and knee. In addition, reduced GL alters the stride characteristics resulting in greater glide time, as observed by increasing stride duration but reduced GCT. Clinicians must be aware of LE kinematic alterations to provide safe and effective parameters for rehabilitation involving the Alter G® treadmill. .

Test-Retest Reliability of the King-Devick Tool in a Pediatric Sample

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Context: Athletic Trainers need accurate and reliable tools which aid in diagnosing sport concussion and monitoring patient recovery post-injury in lieu of a gold standard. The King-Devick (KD) serves as a gross screening for cognitive visual processing which is a common impairment post-concussion. Early KD research among children (<8years) revealed a strong learning effect. However, recent research using the KD over time in collegiate and professional athletes suggests more stability in concussion assessment for this age group. Test-retest reliability of the KD has not yet been established for use in a pediatric population. **Objective:** Within a pediatric sample: (1) examine the test-retest reliability of the King-Devick over time; (2) investigate the effect of gender on the test-retest reliability of the King-Devick over time; and (3) investigate the effect of age on the test-retest reliability of the King-Devick over time. **Design:** Repeated Measures Design. **Setting:** Secondary School. **Patients or Other Participants:** Sixty-eight healthy children with no reported learning disabilities completed all three testing sessions including 41 boys (age = 15.4 ± 1.9 yr, ht = 168.8 ± 39.8 cm, wt = 71.2 ± 30.8 kg) and 27 girls (age = 15.4 ± 1.9 yr, ht = 154.4 ± 45.4 cm, wt = 57.0 ± 28.8 kg). **Interventions:** Participants completed the KD/Version 1 at each of three testing sessions (Day 1, 30 days later and 45 days from baseline). **Main Outcome Measures:** Trained testers recorded the total time a child took to complete reading all four cards as well as errors committed while reading. Time and errors were recorded for each child at each testing session. Repeatability coefficients (CR) were calculated and linear mixed models were used to test for changes in testing

times as well as age and gender differences over the 3 visits. **Results:** The KD demonstrated a low level of repeatability(CR =± 8.76 seconds) among all participants. Significant improvements were observed between visits 1 and 2 (4.3 ± 0.5 seconds, mean ± SE, $p < 0.001$) and also between visits 2 and 3 (2.4 ± 0.5 seconds, $p < 0.001$) for a total improvement of 6.7 seconds over 3 tests. No significant gender by visit interactions were observed indicating that while the test was not reliable, the changes were similar between genders. Similarly, no age by visit interactions was observed which indicates that while participants <15yo took longer on average to complete the test they improved similarly to children > 16yo. **Conclusions:** Providers using the KD for initial recognition and serial reassessment of concussion in youth (12-18yo) should use caution when using the KD to diagnose concussions and make return to play decisions due to the poor test-retest reliability demonstrated in this study. This study was limited to the utilization of KD/Version 1 over the testing time frames. Further research should determine if alternating Version 1 and 2 over time would improve the test-retest reliability and decrease the learning effect over time.

Certified Athletic Trainers' Knowledge of Posterolateral Corner Injuries

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Context: Posterolateral corner (PLC) knee injuries are often complex and frequently overlooked. Diagnosis of PLC injuries may be difficult when symptoms are masked by those of cruciate ligament injury. Failure to diagnose and appropriately treat underlying PLC injury can increase the risk of an individual experiencing graft failure after reconstruction of a concomitantly injured cruciate ligament. **Objective:** Our purpose was to identify a knowledge gap in the Athletic Training population by comparing pre-test perceived knowledge to actual knowledge of PLC injury assessment and to determine the effect of taking a test on perceived knowledge. The relationship between perceived and actual knowledge helps us to identify a knowledge gap, or a discrepancy between what we think we know and what we actually know. Further, the act of taking a test is theorized to initiate self-directed and life-long learning values in respondents. **Design:** Cross-sectional design. **Setting:** Web-based educational assessment. **Patients or Other Participants:** We recruited certified athletic trainers from the National Athletic Trainers' Association (n = 289; age = 37 ± 10 y; male n = 111, female n = 121; years of experience = 14 ± 16 y) that practice within the college/university (n = 131), secondary school (n = 73), clinic (n = 40), physician extender (n = 22), and other (n = 23) settings. Forty-seven percent of respondents completed the instrument in its entirety (137/289 = 47.4% completion rate). **Interventions:** Participants completed a questionnaire with three components: pre and post-perceived knowledge assessment, and an actual knowledge assessment. We adapted the perceived knowledge assessment tools (PKAT) from a previously validated instrument. We constructed a 25 item actual knowledge assessment tool (AKAT) and it was reviewed by an expert on orthopedic injury assessment. **Main Outcome Measures:** We analyzed the pre- and post-PKAT and AKAT with descriptive statistics on the total scores. We used a Pearson correlation to assess the relationship between AKAT and pre-PKAT and we used a paired t-test to determine the effect of taking the AKAT on PKAT. Partial data were included for all comparisons. **Results:** We identified a poor, but significant relationship ($r = 0.195$, $p = 0.003$) between the pre-PKAT and the AKAT. We also identified a significant decrease (8.5%, $t137 = 7.784$, $p < 0.001$) in pre (4.4 ± 0.8) and post-PKAT (4.0 ± 1.0) after taking the AKAT (8.6 ± 4.6, 34.4 ± 18.5%). **Conclusions:** Our findings suggest that a knowledge gap exists in the certified athletic trainer population regarding PLC and knee injury assessment. We were also able to identify that perceived knowledge of athletic trainers regarding PLC and knee injury assessment ability decreased following the completion of our AKAT, suggesting some recognition of that knowledge gap. However, participants still maintained that they "somewhat agreed" with feelings of knowledge and expertise regarding PLC injuries. This is inconsistent with participant performance on the AKAT and has potential to negatively impact patient care, particularly considering the likelihood of graft failure when not recognized and treated in conjunction with cruciate ligament reconstructions.

Examining the Benefits of Prior Heat Exposure on Race Day Performance Using a Heat Stress Score Ratio

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Context: Heat acclimatization (HA) induces favorable adaptations for runners that reduce exertional heat illness and enhance aerobic performance in the heat. However, heat acclimatization status is difficult to accurately describe in the field. No indices to our knowledge have assessed the benefits of previous heat exposure on road race performance. **Objective:** To investigate the effects of prior heat exposure, estimated by a novel heat stress score (HSS), on event finish time (FT), heart rate (HR), and gastrointestinal temperature (TGI) during a warm weather race. **Design:** Observational field study. **Setting:** The 2014 11.3km Falmouth Road Race in Falmouth, MA. **Patients or Other Participants:** Sixteen men (mean ± SD; age, 39.6 ± 11.7 y; body mass, 76.3 ± 8.5 kg; body fat, 18.6 ± 5.6%) and 16 women (age, 36.2 ± 10.1 y; body mass, 59.8 ± 7.1 kg; body fat, 19.1 ± 5.4%) runners participated in the study. **Interventions:** Participants logged their training mode, location, and duration for 14 days before the event. Ambient temperatures during the workouts were recorded retrospectively using Weather Underground. An estimated fixed temperature of 20˚C was used for indoor workouts. The HSS [ambient temp (˚C) x time (min)] for the event (HSSE) as well as the average training sessions (HSST) was calculated. The heat stress score ratio (HSSR) was calculated as the ratio between HSSE to HSST or [event day ambient temperature (˚C) x exercise duration (minutes)] to [average training environmental temperature (˚C) x average exercise duration (minutes)]. A HSSR ≤ 1.0 indicated training heat stress was equivalent or greater to that of race day. Relative performance was calculated as the percent off of predicted pace (km·min -1) from actual pace (km·min -1). An ingestible thermistor was ingested six to ten hours to the start of the event and a HR monitor fitted immediately prior. TGI and HR were recorded before and immediately after the race. FT was collected from the official race website. Pearson product correlations analyzed the relationship between HSSR, performance, and physiological variables. A t-test analyzed HSSR, FT, and relative performance. **Main Outcome Measures:** TGI, HR, and race FT, and relative performance. **Results:** The average HSSR was 1.46 ± 0.55. HSSR did not correlate with post event TGI ($r = 0.020$, $p = 0.918$) and HR ($r = 0.132$, $p = 0.528$), however lower HSSR were correlated with faster FT ($n = 32$, $r = 0.795$, $p < 0.0001$) and relative performance ($n = 32$, $r = 0.554$, $p = 0.003$). Five runners (33%) experienced heat stress similar to race day (HSS ≤ 1.0, 0.68 ± 0.12) and had FT that was on average 12.52 minutes faster ($p < 0.001$) than subjects with HSS > 1.0. Relative performance was also 13.5% greater ($p = 0.003$). **Conclusions:** Subjects with a HSSR ≤ 1.0 had faster FT and improved relative performance. Our findings indicate that the HSSR may be a potential index to examine event day preparedness for runners training for warm weather road races, though further investigation is warranted.

Persistent Deficits in Postural Control Despite Balance Error Scoring System Recovery

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Context: Impaired postural control is a cardinal symptom of concussion and is commonly assessed with the Balance Error Scoring System (BESS). The BESS scores will typically return to baseline in 3-5 days, however, a potential practice effect could limit the interpretation of the results. Gait termination (GT) is a dynamic tool that has been successful in identifying postural control impairments that may linger beyond traditional measures of recovery. **Objective:** To compare post-concussion gait termination performance on the day BESS score achieved baseline values to healthy baseline performance. **Design:** Prospective Longitudinal. **Setting:** Research laboratory. **Patients or Other Participants:** Fifteen NCAA Division I student-athletes (8 females; height = 175.6 ± 8.4 cm, weight = 84.7 ± 21.2 kg, age = 1A9.0 ± 1.3 years) with diagnosed sports-related concussions. **Interventions:** All participants completed five planned GT trials during pre-season baseline testing (BL) and the day BESS score returned to baseline (BESS Day). All trials were conducted using a GaitRITE portable walkway system and four 400mm x 600mm force plates. The participants walked down the GaitRITE at a self-selected speed before performing the penultimate and termination steps of planned GT on the force plates. The data were compared using a two-sample t-test **Main Outcome Measures:** The dependent variables were center of pressure (CoP) displacement, CoP velocity and gait velocity (GV). The CoP displacements and velocities were calculated in both the mediolateral (ML) and anteroposterior (AP) directions on the force plate during the three phases of GT CoP (S1, S2, S3), which correspond to the locomotor, single-leg stance and postural adjustment phases. The GaitRITE recorded the gait velocities during each trial. **Results:** The mean time for the BESS score to return to baseline was 3.1 ± 1.7 days. There was no difference in gait velocity between baseline and BESS day (BL: 1.45 ± 0.19 m/s, BESS Day: 1.39 ± 0.19 m/s, p = 0.652). There was a significant difference in the CoP displacement during S1AP (BL: 59.5 ± 10.9 cm, BESS Day: 47.0 ± 25.7 cm, p = 0.000) and S2AP (BL: 9.0 ± 6.7 cm, BESS Day: 19.5 ± 19.0 cm, p = 0.000). There were also significant differences in the S2APV (BL: 199.2 ± 171.5 cm/s, BESS Day: 422.6 ± 429.2 cm/s, p = 0.000) and S3APV (BL: 39.6 ± 21.7 cm/s, BESS Day: 54.5 ± 62.2 cm/s, p = 0.049). There were no significant differences found in the ML displacements or velocities. **Conclusions:** On the day the BESS score returned to baseline, an altered movement strategy was identified during planned GT. These results were independent of gait velocity, suggesting residual impairments in postural control. Clinicians should consider the potential for these lingering deficits despite apparent recovery on the BESS test.

Biomechanical Risk Factors for Lower Extremity Overuse Injury Related to Fatigue

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Context: Lower extremity overuse injuries (LEOI), including tibial stress fractures (TSF) and iliotibial band syndrome, present insidiously with a mechanism of injury and pain attributed to repetitive activity. Biomechanical variance in running gait has been previously linked to increased LEOI risk, but these measures are primarily taken in a rested state, despite activities commonly linked to LEOI being highly fatiguing. **Objective:** The purpose of the current study was to evaluate changes, following fatiguing exercise compared to rested state, in biomechanical variables previously linked to LEOI. We hypothesized that fatigue would increase the magnitude of variables previously associated with injury development. **Design:** Pretest-Posttest. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-one cadets (7 females, Age: 21.09 ± 2.76 yrs, Height: 1.75 ± 0.1 m, Mass: 71.57 ± 13.46 kg, Body fat: 14.13 ± 8.86%), from the University's Army ROTC unit undergoing standardized physical fitness training volunteered to participate. Cadets who were medically limited from physical fitness training were excluded. **Interventions:** Three-dimensional lower-extremity kinematics (240Hz) and kinetics (960Hz) were collected for three trials, bilaterally while running at 4.0 m/s ± 10% in both rested and fatigued states. Rested state gait trials were collected, followed immediately by an exhaustive treadmill protocol (graded exercise test, three-minute walking recovery, and run to voluntary exhaustion performed in succession) to elicit fatigue. Fatigued state gait trials were initiated within 6:09 ± 1:41 minutes following the treadmill protocol. **Main Outcome Measures:** Biomechanical variables previously associated with

LEOI were of primary interest, including vertical ground reaction force, loading rate, free moment (FM), knee flexion, and vertical stiffness (Kvert). Preliminary findings related to differences in bilateral Kvert resulted in trials being separated according to Kvert at baseline measurements and repeated measures ANOVAs were performed on the less-stiff limbs (LS) and more-stiff limbs (MS) independently to evaluate differences in variables from a rested to fatigued state. **Results:** Comparison of LS limbs revealed significant ($p < 0.01$) increases in Kvert (pre: 52.21 ± 6.10 kN/m, post: 56.46 ± 7.58 kN/m) and loading rate (pre: 13064.63 ± 2627.40 N/s, post: 134949.37 ± 2884.39 N/s), and a significant decrease in knee flexion excursion (pre: 30.13 ± 4.44°, post: 28.36 ± 4.00°). Comparison of MS limbs revealed no change in Kvert ($p = 0.14$). Significant ($p < 0.01$) bilateral increases were found for knee internal rotation velocity (LS-pre: 365.13 ± 165.83°·s^{-1}, post: 414.98 ± 154.19°·s^{-1}, MS-pre: 522.80 ± 217.78°·s^{-1}, post: 597.25 ± 297.71°·s^{-1}) and FM (LS-pre: 6.07 ± 2.77-3 Nm·kg, post: 7.51 ± 2.68-3 Nm·kg, MS-pre: 6.28 ± 2.48-3 Nm·kg, post: 7.82 ± 2.80-3 Nm·kg). **Conclusions:** An increased risk for LEOI may become evident in a fatigued state due to an increase in magnitude of LEOI related biomechanical variables that are not apparent in a rested state. Changes in force modulation represented by changes in Kvert may signify increased risk for LEOI in a fatigued state though limbs may respond differently within individuals. Significant increases in FM and loading rate are of particular concern due to their previous association with TSF. Increased knee internal rotation velocity may increase strain on the iliotibial band.

No Evidence of Altered White Matter Integrity Following Sport-Related Concussion

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Context: Identifying neuroimaging biomarkers of acute concussive injury is a major goal towards improving diagnosis and prognosis of sport-related concussion. Diffusion tensor imaging has enabled in-vivo visualization of neuroanatomical alterations following moderate to severe traumatic brain injury. However, there are many conflicting and contradictory findings acutely following sport-related concussion. **Objective:** To examine white matter structural integrity following sport-related concussion in college football players and uninjured matched controls. Given the diffuse nature of concussive injury, we hypothesized the concussed group would have reduced white matter integrity as reflected by decreased fractional anisotropy (FA) and increased mean diffusivity (MD) globally and within the corpus callosum and cingula long-association fibers. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** Division I collegiate football players were diagnosed with a sport-related concussion (n = 10; age = 20.0 ± 0.9 years; concussion history = 0.5 ± 0.9). They completed magnetic resonance brain imaging within 72h post-injury. Sixteen non-concussed football players served as controls and were matched on sex, age, position, and previous concussion history. **Interventions:** Both T1 and 54-direction diffusion-weighted magnetic resonance brain images were collected using a 3T Siemens scanner with voxel size of 1mm3. Voxelwise statistical analyses of FA and MD data were carried out using Tract-Based Spatial Statistics and Monte Carlo permutation inference. Additionally, mean FA and MD were compared using region of interest (ROI) analyses of the corpus callosum and the right and left cingula. The ROIs were drawn using the Jülich histological atlas. **Main Outcome Measures:** Voxelwise FA and MD values were compared along a common white matter tract skeleton using cluster-corrected, permuted independent samples t-tests (1,000 permutations, a priori $P = 0.05 \pm 0.0138$). Mean FA (unitless measure) and MD values (measured in 10-3mm2/s) within the corpus collosum and right and left cingula were compared using independent samples t-tests. **Results:** No clusters were significantly different between groups for either FA or MD along the white matter skeleton (corrected $P > 0.05$). The ROI analysis revealed no differences in FA in the following three examined structures: Corpus callosum FA (concussed 0.69 ± 0.05, controls 0.68 ± 0.07; $t24 = 0.36$; $P = 0.73$); Right cingulum FA (concussed 0.66 ± 0.06, controls 0.66 ± 0.08; $t24 = -0.01$; $P = 0.99$); Left cingulum FA (concussed 0.62 ± 0.06, controls 0.63 ± 0.08; $t24 = -0.37$; $P = 0.71$). Likewise, no differences were observed for MD on the following: Corpus callosum MD (concussed 0.76 ± 0.02, controls 0.76 ± 0.02; $t24 = -0.43$; $P = 0.67$); Right cingulum MD (concussed 0.75 ± 0.02, controls 0.75 ± 0.03; $t24 = -0.95$; $P = 0.35$); and Left cingulum MD (concussed 0.75 ± 0.03, controls 0.76 ± 0.03; $t24 = -0.11$; $P = 0.91$). **Conclusions:** We found no evidence of altered white matter integrity following sport-related concussion. These results corroborate recent findings in non-sports concussion, and reinforce that concussion is a functional—not structural—injury. While conventional neuroimaging remains useful for ruling out more serious and emergent neurological damage, diffusion tensor imaging may not add diagnostic or prognostic benefit in the management of acute sport-related concussion.

Increased Acute Lower Extremity Musculoskeletal Injury Rates Following Concussion

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Context: Sport-related concussion results in measurable neurocognitive and static postural control deficits. Additional dynamic postural control deficits during gait have been reported to persist beyond an athlete's return to participation following concussion. Thus, incomplete brain trauma recovery may increase the athlete's risk of acute lower extremity musculoskeletal injury. **Objective:** To investigate acute lower extremity musculoskeletal injury rates before and after concussion in concussed and matched control athletes. **Design:** Cross-sectional. **Setting:** Clinical research center. **Patients or Other Participants:** Concussed college athletes (n = 41; age = 19.98 ± 1.23 years) were physician diagnosed. Non-injured college athletes (n = 54; age = 20.41 ± 1.25 years) were matched to concussed individuals on sport, sex, competition exposure, and age. **Interventions:** Acute lower extremity musculoskeletal injury data were collected for a 2-year window (up to 365 days prior to and after the physician diagnosed concussion) using institutional electronic medical records. Control participants' 2-year windows for exposure and injury data were anchored to their injury match's concussion injury date. **Main Outcome Measures:** Injury rates were calculated for the pre-injury and post-injury time periods for both study cohorts. Athlete-exposure (AE) was defined as days of available injury record data. Injury rate ratios (IRR) were calculated to determine differences for our comparisons. **Results:** The concussed group was 1.97 times more likely to suffer an acute lower extremity musculoskeletal injury post-concussion (3.34/1000AE) than prior to concussion (1.70/1000AE; IRR 95% CI: -2.89 to -0.40; P = 0.010), and 1.57 times more likely to suffer an acute lower extremity musculoskeletal injury following concussion (3.34/1000AE) than their uninjured match cohort (2.12/1000AE; IRR 95% CI: 0.01 to 2.43; P = 0.049). The IRR between the 2 study years in the control group (pre: 2.56/1000AE; post: 2.12/1000AE; IRR 95% CI: -0.64 to 1.51; P = 0.435) and the IRR (IRR 95% -1.97 to 0.26; P = 0.134) between the concussed (1.70/1000AE) and control match athletes (2.56/1000AE) prior to concussion were not significant. **Conclusions:** The increased acute lower extremity musculoskeletal injury rates following concussion suggest normal functional movement and dynamic postural control may not be fully restored when concussed athletes return to play. Previous literature has detailed dynamic postural control deficits in standard gait following return to play after concussion as well as increased motor evoked potential latency and decreased amplitude. These findings suggest the brain may be unable to coordinate movement as it did prior to the concussion. This motor control deficit may become more pronounced with the dynamic movements required for sport. In combination with our finding of increased acute lower extremity musculoskeletal injury rates following concussion, this underscores functional movement and dynamic postural control assessments may be a valuable addition to the concussion injury assessment protocol employed by athletic trainers and other medical professionals.

Exploring Barriers to the Successful Socialization of Athletic Training Doctoral Students into Future Faculty Roles

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Context: Current discourse in the field regarding future directions of athletic training (AT) education includes recommendations to intentionally explore doctoral education. Little is known about the experiences of AT doctoral students and their prospective role outside of patient care which typically includes teaching, research and service roles in higher education. Professional socialization research demonstrates successful transition into the workforce is facilitated by role preparation. Barriers to this transition however, are unknown for ATs pursuing doctoral education. **Objective:** Investigate barriers to AT doctoral students' socialization as future faculty and misconceptions that may exist in this preparation. {Banerjee, 2004 #30} **Design:** Qualitative study. **Setting:** Universities with AT doctoral students. **Patients or Other Participants:** We recruited 28 (19 females, 9 males) doctoral students with one full year of study completed. The average age of participants was 28 ± 3 years. Most participants had teaching (N = 8) or research (N=9) assistantships. Others (N = 5) reported splitting teaching and research responsibilities, clinical (N = 4), or administrative (N-1) responsibilities. **Data Collection and Analysis:** One of three researchers completed individual telephone interviews following a semistructured script. We discontinued recruitment upon data saturation and coded data following a systematic general inductive analysis approach. Peer review and multiple analyst triangulation were completed for credibility purposes. **Results:** While participants reported teaching, research, and service as three primary faculty roles, research was identified as "academic currency" for faculty success. Participants did not clearly understand faculty expectations relative to teaching and service and many characterized strong content knowledge and/or clinical experience as preparation for future teaching roles. Barriers included a lack of exposure to formal pedagogical training as most assistantships, coursework and mentoring was specific to research. Participants had little knowledge of educational standards in the field and administrative duties that may accompany an athletic training faculty position. In some instances, this limitation was due to the absence of a professional program in AT at their current institution. Another barrier to role preparation for some doctoral students included minimal mentoring relative to faculty service expectations. A dichotomy existed between those who identified service as a cultural expectation in their institutional environment compared to environments in which little attention was given to service. **Conclusions:** Intentional exposure during the doctoral experience to teaching and service expectations as well as the administrative nuances of AT education may facilitate socialization of future AT faculty into academic roles. Doctoral students should take the initiative to seek out a variety of meaningful teaching and service opportunities to balance research experiences. Faculty advisors and administrators should consider avenues to integrate pedagogical training and intentional mentoring specific to teaching, service, and administrative tasks to facilitate doctoral student preparation for future faculty roles more comprehensively.

The Association Between Perceived Difficulty of Locating Spinal Palpation Landmarks and Palpation Accuracy for Entry Level Athletic Training Clinicians

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Context: Palpation of spinal anatomical landmarks is generally poor, however the effects of perceived difficulty of palpation and accuracy have not been established. **Objective:** To examine the relationship between perceived level of difficulty and identification of a landmark. The secondary objective was to determine the intra-rater reliability of anatomical palpation for each tester. **Design:** Quasi-experimental pre-post test. **Setting:** Laboratory **Patients or Other Participants:** Twenty physically active adults (age = 22.65 ± 2.89 yrs, height = 166.44 ± 9.24 cm, mass = 66.96 ± 14.62 kg, BMI = 23.98 ± 3.40) participated. Four novice Athletic Trainers (ATs)(certified < 2 yrs) served as the testers of interest. **Interventions:** Participants completed a medical screening questionnaire and were measured for height and weight, which was used to calculate BMI. Participants were prone on a plinth and two experts (ATs certified > 10 yrs.) independently palpated each participant and then agreed on the center of the most prominent projection of each spinal anatomical landmark (L4, right and left PSIS). The experts marked each point with an ultraviolet (UV) pen and transferred the markings onto contact paper using a UV light. The contact paper was removed and placed onto a transparency. The participant's back was cleaned with rubbing alcohol pads and the four testers began the first trial. Testers were randomly allocated to one of four participants. The testers received no preliminary training for palpation but received verbal instruction to utilize any palpation technique they preferred, as long as the participant remains prone and stationary. Testers were instructed

to locate and mark the center of each bony landmark. The testers followed the same procedure as the experts for marking and transferring marks. The testers palpated their respective participant and then rotated to the next participant. After palpating each participant the process was repeated for Trial 2. Following Trial 2, testers were asked to rate, on a Likert scale, their perceived level of difficulty for each participant. **Main Outcome Measures:** The independent variables were tester (AT1, AT2, AT3, AT4) and time (Trial 1, Trial 2); dependent variables included perceived level of difficulty (scale of 1 to 5) and distance from the expert marking (mm) for L4 and PSIS palpations. Spearman correlations examined the relationship between distance from the expert and perceived difficulty. Intra-class correlation coefficients (ICC2,1) and standard error of measurement(SEM) were calculated to examine the intrarater reliability of each rater. **Results:** The correlation between distance from the expert and perceived difficulty was weak for L4 ($r = 0.10$, $p = 0.41$) and left PSIS ($r = 0.21$, $p = 0.07$), but moderate for the right PSIS ($r = 0.49$, $p < 0.001$). Intratester reliability ranged from ICC2,1 = 0.48 (SEM = 8.00 mm) -0.88 (SEM = 5.07 mm) for L4, ICC2,1 = 0.42 (SEM = 5.86 mm) -0.76 (SEM = 5.93 mm) for the right PSIS, and ICC2,1 = 0.53 (SEM = 6.68 mm) -0.75 (SEM = 5.19 mm) for the left PSIS. **Conclusions:** Perceived difficulty was only associated with one landmark, and generally does not seem to be a factor in accurately palpating spinal landmarks. Intratester correlations were fair-to-good and indicate a level of consistency within the examiners.

Effects of an Educational Intervention on Accuracy of Spinal Palpation Landmarks for Entry Level Athletic Training Clinicians

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Context: Research has indicated that those in healthcare professions demonstrate poor reliability of palpation, but have shown improvement with the inclusion of anatomical information. **Objective:** Assess the effects of a spinal palpation educational intervention (SPEI) on the ability for novice athletic trainers (ATs) to accurately palpate the L4 spinous process and right and left posterior superior iliac spine (PSIS). **Design:** Quasi-experimental pre-post test design. **Setting:** Laboratory **Patients or Other Participants:** 20 physically active adults (age = 22.65 ± 2.89 yrs, height = 166.44 ± 9.24 cm, mass = 66.96 ± 14.62 kg, BMI = 23.98 ± 3.40) participated. Four novice ATs (certified < 2 yrs) served as the testers of interest and were randomly assigned to one of two groups; a control group (CON) or an experimental group (EXP). **Interventions:** Participants were prone on a plinth and two experts (ATs certified >10 yrs.) independently palpated each participant and then agreed on the center of the most prominent projection of each spinal anatomical landmark (L4, right and left PSIS). Experts utilized the same technique that was implemented in the SPEI. The experts marked each point with an ultraviolet (UV) pen and transferred the markings onto contact paper, and the contact paper was removed and placed onto a transparency. Testers were randomly allocated to one of four subjects and instructed to use any palpation technique they preferred to locate the landmarks center, as long as the participant remains prone and stationary.. The testers followed the same procedure as the experts for marking and transferring marks. After palpating each participant the process was repeated for Trial 2. The testers assigned to the EXP group reported to one educational intervention session which took place within 1 week following session 1, and the CON group received no additional training/practice. All four testers reported for a second session within 1 week following initial testing procedures, and followed the same procedures as previously described for landmark identification. **Main Outcome Measures:** The independent variables were group (EXP, CON) and session (1, 2) and the dependent variable included distance from the expert marking in millimeters (mm). Dependent t-tests were performed to compare average distance from expert markings between sessions for each group. Alpha was set a priori at $P < 0.05$. **Results:** ATs in the control group had a significant decrease in distance from expert markings between sessions in L4 ($p = .005$) (pre: 20.4 ± 12.1; post: 14.0 ± 7.97), LPSIS ($p = .049$) (pre: 20.6 ± 10.5; post: 16.6 ± 8.94), and RPSIS ($p = .005$) (pre: 21.0 ± 9.28; post: 15.9 ± 6.97). The intervention group demonstrated a significant decrease in distance from expert markings between sessions in L4 ($p = .026$) (pre: 18.3 ± 12.4; post: 13.1 ± 7.62). **Conclusions:** The experimental and control groups improved over time for L4, however the control group improved for the other markings as well. Our control group had larger pretest distance scores and therefore may have had more chance for improvement. The impact of locating marks multiple times seems to increase accuracy over time.

Effects of an Interprofessional Living Learning Community With Athletic Training, Dietetics, Exercise Science, and Nursing Students

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Context: Many athletic trainers will work with other healthcare professionals. A living learning community (LLC) may help prepare students for future interprofessional practice and improve their first year experience. **Objective:** The purpose of this study was to examine student perceptions of their participation in a living learning community during their freshman year. **Design:** Qualitative case study. **Setting:** Undergraduate college of nursing and health sciences in a small private university in the Midwest. **Patients or Other Participants:** Twenty-one athletic training, dietetics, exercise and nursing students participated in a living learning community. They lived in the same dorm, took three classes together and participated in monthly sessions that were educational, service or social. **Data Collection and Analysis:** Students completed a survey at the end of their freshman year. The survey examined their perceptions of their satisfaction with the LLC, university experiences, learning experiences, residential experiences, teamwork, career and self-understanding. Survey results were analyzed using frequency counts for Likert questions. Open ended questions were analyzed by qualitatively coding for themes using deductive content analysis. Peer debriefing and member checking ensured trustworthiness. **Results:** Sixteen of the 21 students completed all of the activities associated with the LLC. Fourteen of the 16 completed the survey (87.5%); overall perceptions were positive for each category. 100% of the students were satisfied with the LLC and would recommend joining the LLC to a friend or perspective students. In regards to interprofessional collaboration, 100% felt that the LLC increased their ability to interact students in other healthcare professionals, 93.9% (13/14) felt the LLC helped increase their understanding of other healthcare professionals, and 85.7% (12/14) thought the LLC helped increase their knowledge of issues and problems facing other healthcare providers. Themes that emerged from the open ended questions about benefits of the LLC include getting to know students in their majors right away, professors that cared, earlier exposure to professional issues and unique experiences that other freshman did not have (through educational sessions). The students in the LLC had a retention rate of 95.24% (20/21) and 90.48% (19/21) remained in the College of Nursing and Health Sciences; the university had a retention rate of 76.8% for the freshman class. **Conclusions:** Living learning communities are a way to increase interprofessional collaboration and improve the first year experience. The students in this study had positive experiences and there may be long term benefits when they are practicing professional. In addition, there are potential benefits to the university, including greater student satisfaction and a higher retention rate.

Engaging Athletic Training Students in a Flipped Classroom Results in Superior Learning and Comprehension Levels

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Context: The flipped classroom (FLIP) is an instructional approach that has become prevalent in higher education. This approach allows for the opportunity to utilize higher order thinking skills through active learning strategies during a face to face class on a regular basis after students have gained their first exposure to content on their own. While previous literature supports the positive student and faculty subjective perceptions of the FLIP approach, it remains unclear whether the FLIP approach allows for better content comprehension in comparison to traditional (TRAD) lecture methods as objectively measured through exam item comprehension. **Objective:** To compare comprehension performance on FLIP content to TRAD content. **Design:** Prospective Cohort. **Setting:** A standard athletic training education laboratory. **Patients or Other Participants:** Twenty-four sophomore level athletic training students (9 males, 15 females) enrolled in a pathology and evaluation course within an accredited athletic training education program. **Interventions:** The independent variable was question content type (FLIP or TRAD). Course content for one semester was divided in half and the instructor taught half of the content using a FLIP approach and the other half using a TRAD approach. Comprehension was assessed through written examinations. Using bloom's taxonomy as a guide the FLIP exams questions were written to include the same root words and to ask the same overall general concept as the matched TRAD control question items. Dependent t-tests were utilized to compare item comprehension between FLIP and TRAD classroom content. Statistical significance was defined as $p \leq 0.05$ and means (M) and standard deviations (SD) are reported. **Main Outcome Measures:** Dependent variables were item comprehension for two

exams and overall item comprehension. Descriptive and inferential statistics were conducted on exam items that students completed throughout the course. **Results:** Students performed significantly better in FLIP (M = 23.83, SD = 2.97) item comprehension in comparison to TRAD (M = 19.25, SD = 2.691) content ($t(23) = -7.51$, $p < 0.001$) for exam 1. Students also performed significantly better in FLIP (M = 24.88, SD = 3.30) item comprehension in comparison to TRAD (M = 22.92, SD = 3.322) content ($t(23) = -2.77$, $p = 0.011$) for exam 2. Overall item comprehension was significantly better for FLIP (M = 48.71, SD = 4.768) content in comparison to TRAD (M = 42.17, SD = 5.088) content ($t(23) = -6.45$, $p < 0.001$). **Conclusions:** FLIP classroom methods resulted in better item comprehension than TRAD classroom. The value of FLIP instructional approach should continue to be investigated within athletic training education curricula.

Perceptions of Preceptors' Utilization of Evidence-Based Practice

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Context: The field of athletic training is constantly evolving. Utilization of evidence-based practice (EBP) when providing patient care has become a focus for athletic trainers and athletic training educators. Athletic training programs are required to instruct students not only in evidence-based techniques, but also the steps associated with utilizing evidence properly when making clinical decisions regarding patient care. Including EBP in curriculums is mandatory now as it helps provide optimal patient care. However, the question remains whether these concepts and practices are being reinforced during clinical education. **Objective:** To explore perspectives on preceptors' acceptance and usage of EBP in their health care practices. **Design:** Qualitative methods using asynchronous online interviewing. **Setting:** Three separate Commission on Accreditation of Athletic Training Education accredited undergraduate athletic training programs. **Patients or Other Participants:** Ten preceptors with an average of 5 ± 3.5 years of experience as preceptors and 10 athletic training students (8 seniors, 2 juniors). Six preceptors worked at one of the 3 host institutions while 4 were from off-campus sites. Twelve athletic training students were in clinical education at one of the 3 host institutions while 8 were completing an off-campus rotation. **Data Collection and Analysis:** All participants journaled responses to a series of open ended questions using Question Pro™. We analyzed data via a general inductive approach in order to uncover the most dominant themes. Data analysis was distinctive using a general inductive approach. Trustworthiness of the data was established by researcher triangulation, peer review, and stakeholder checks. **Results:** Preceptors remarked that they embraced the use of evidence in clinical practice to inform decisions. Preceptors utilization of EBP to enhance patient care serves as an indicator that EBP competencies are being reinforced during clinical education in both on- and off campus sites. Difficult clinical cases often served as the catalyst for searching for additional information in textbooks and journal articles. Preceptors utilized a patient-centered approach and possessed a willingness to obtain additional knowledge in order to improve patient outcomes. Athletic training students agreed that their preceptors embraced EBP through researching topics as well as considering patient preference and prior experience when making clinical decisions. The majority of instances where EBP was utilized were decisions regarding treatment protocols and rehabilitation. **Conclusions:** The results of the study are encouraging as both athletic training students and preceptors agree that there is a focus on using EBP to guide clinical decision-making. Athletic training students and preceptors discussed utilizing current research, patient preference, and prior clinical experience when making clinical decisions indicating that EBP concepts are being reinforced on some level throughout clinical education. While EBP dominated decisions for therapeutic intervention, it remains uncertain as to how evidence is infused into the other domains of athletic training practice.

Experiences of Clinical Education Coordinators in Selecting Clinical Education Experiences Within the Confines of the Accreditation Standard: A Qualitative Study

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Context: Some students who pursue and complete programs in Athletic Training (AT) choose to pursue other careers. The clinical education experience has been identified as one of the reasons why students choose to pursue professions other than Athletic Training. Ideally, the Clinical Education Coordinator (CEC) has the ability to select experiences that are the best fit for educational needs and career goals of students. Information regarding the role of the existing accreditation Standard 50 as to how it affects the CECs' process for placing students in effective and productive clinical education experiences is lacking. **Objective:** To explore the methods and processes by which CECs select athletic training student clinical placement in professional athletic training programs, and how the accreditation Standard influences the placement. **Design:** Semi-structured phone interviews. **Setting:** Educational Institution. **Patients or Other Participants:** Seven CECs of Professional Graduate AT programs (3 females, 4 males) with 3 or more years of CEC experience volunteered. The range of experience was 3-14 years. **Data Collection and Analysis:** All phone interviews were conducted by the same researcher, digitally recorded with the consent of the participant, and transcribed verbatim. Member checks were performed to verify accuracy of transcripts. Data was etic coded and reviewed through comparative pattern analysis. Data credibility was further maintained using field notes and inter-coder reliability following a peer coding process. Data saturation guided participant recruitment. **Results:** Two main categories were identified: 1) Required Considerations based on the Standard and 2) Additional Considerations external to the Standard, with additional themes identified within these categories. The requirements of the accreditation Standard were repeatedly identified as the primary guiding factor for placement selection. Additional themes within this category included the advanced planning needed to fulfill the requirements, and the benefits and limitations of the Standard. Participants expounded on ways in which their process went beyond the requirements of the Standard, and subsequently additional themes within this category dealt with the importance of student-preceptor personality matches, requests, and the influence of the previous edition of the Standard. **Conclusions:** Our findings indicate that CECs often go beyond that which is prescribed in the accreditation Standard when selecting students' clinical education placements. The Standard was identified as having certain benefits, such as requiring a wide range of patient populations, but also limitations, in that other important considerations, such as preceptor-student personality match, are not always incorporated in lieu of meeting Standard requirements. Future accreditation standards may need to allow greater flexibility for CECs to clinically place students based on their personalities, educational needs, and future career goals.

Understanding El Salvador's Sports Medicine Services for Elite Amateur Athletes Through a Quality Assessment Model

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Context: A sports medicine (SM) team is designed to work collaboratively to provide athlete healthcare, but the development of an Olympic SM team is specific to each nation. A quality assessment model can be applied to assess the structure, process and outcomes of a SM team. **Objective:** To describe SM services to elite amateur Salvadoran athletes. The Donabedian Model of Quality Assurance provided the framework for the description and the perspectives of the El Salvador Olympic team were used to assess the quality of care provided to elite athletes. **Design:** This exploratory qualitative study used three forms of data: observations individual interviews and the focus group. Observations and interviews were used to describe the structure, process and outcomes of the sports medicine services for elite amateur Salvadoran athletes while a focus group was used for member checking. **Setting:** Fieldnotes were taken during the observation of healthcare during two instances 1.) during a 15-day international games competition in Peru and 2.) in Salvadoran athletic healthcare facilities. Face to face interviews were conducted in El Salvador. The focus group interview occurred via Skype. **Patients or Other Participants:** Nine key informants (1 team physician, 1 physiatrist, 2 physical therapy assistants, 2 administrators, 1 coach, and 2 athletes) were purposively sampled using a criterion sampling strategy and were selected for fieldnote observations as well as for interviews. **Data Collection and Analysis:** Observations were recorded and analyzed by the primary investigator, a participant observer, using quality assurance sensitizing concepts. A semi-structured interview guide was used during individual interviews. Interviews and focus groups were transcribed verbatim, translated

from Spanish to English, and checked for accuracy. Interviews were analyzed with a typological analysis, a nine-step method in which the researchers search for common trends and typologies stemming from predetermined focus points from sensitizing concepts. Peer debriefing was used as a form of trustworthiness. **Results:** Three overarching categories emerged from the data: organizational cohesion, continuity and quality of care, and standards and expectations. Organizational cohesion describes a need for a vision, defined roles, an established hierarchy and the case for shared resources. Continuity and quality of care themes included the need for increased resources, patient-focused communication amongst providers and improved provider-patient interactions. The standards and expectations category included themes on administrator and provider preparation, patient expectations and governmental support. **Conclusions:** Future research of the Salvadoran SM team should have greater focus on the effects of the organization's structure and process on patient outcomes to more clearly identify the success of the organization. In addition, El Salvador's SM services' success may be realized when participant expressed concerns regarding organizational cohesion, continuity and quality of care, and standards are addressed.

Frequent Consumption of Energy Drinks: Examining the Differences Between Collegiate Athletes and Other Students

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Context: Caffeinated Energy Drinks (ED) are dietary supplements that have the ability to reduce fatigue, increase alertness and increase motor activity. Caffeine consumption is monitored by the NCAA and increased levels can result in a positive drug test and can lead to dehydration and cardiac events. Despite the potential performance enhancement and adverse reactions of EDs, there is little research on the consumption of EDs among collegiate athletes. **Objective:** We assessed frequent ED consumption (consumed on three or more occasions in the past 30 days) and ED-related motivations in a sample of college students and examined differences between college student athletes and college student non-athletes. **Design:** We used a cross-sectional design. **Setting:** Participants completed the survey in classrooms and athletic facilities. **Patients or Other Participants:** A convenience sample of 692 (205 varsity athletes) college students between the ages of 18 and 25 (age = 20.4 ± 1.42 years, 397 females, 446 Caucasians 64.6%) completed the survey. We had an overall response rate of 98.1%. **Interventions:** We compiled 58 questions from previous surveys (Malinauskas et al, 2007; McCabe & Teter, 2007; Rabiner et al., 2009) to assess ED consumption and ED-related motivations via a paper and pencil survey. **Main Outcome Measures:** Students indicated the number of occasions they had consumed an ED in the previous thirty days. Responses ranged from none to 40 or more occasions and were recoded into a dichotomous variable. Students reporting consuming three or more EDs were coded as frequent users. ED users were asked to indicate all of the motivations for consumption during previous thirty days. To assess motivations, a list of possible motivations was provided and students selected all motivations that applied to their consumption. Chi-square and regression analyses were conducted to determine differences between student-athletes and non-athletes. **Results:** Overall 18.8% of the sample (non-athletes 21.4% v. student-athletes 12.7%) consumed EDs frequently. Our regression analysis indicated that student athletes were 42.1% less likely (OR = 0.579, CI = 0.355-0.947, p = 0.034) to be classified as a frequent ED user. Among all participants, the most commonly endorsed motivations for frequent ED consumption were to have more energy, and to study longer. Compared to student non-athletes, more student athletes were motivated to use these energy drinks to improve their athlete performance ($\chi 2 = 9.627$, p = 0.07). **Conclusions:** Although ED consumption in student-athletes in this sample was lower than non-athletes, the percentage was still higher than previous examinations of ED consumption (Malinauskas et al, 2007). Survey results also indicated that student-athletes were often motivated to consume EDs frequently to enhance their athletic performance. Based on these results, athletic trainers should determine the use of EDs at their institution and educate student-athletes on the adverse health and eligibility consequences.

Work-Related Injuries Experienced by Certified Athletic Trainers: The WRROCAT Study

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Context: Despite knowledge that health care workers have high rates of musculoskeletal injuries, it is well established that many of these injuries go unreported to workers compensation and national surveillance systems. Little is known regarding work-related injuries of certified athletic trainers (AT). **Objective:** To determine the 12-month incidence and prevalence of work-related injuries and the nature of reporting and management strategies. **Design:** Cross-sectional. **Setting:** Population-based online survey. **Patients or Other Participants:** ATs currently certified by the Board of Certification, Inc (n = 29,051) who had some patient contact and worked as an AT were eligible. Of 10,000 randomly selected ATs, 1,826 participated in the baseline survey (18.3%). **Interventions:** The online survey was pilot tested with 25 AT volunteers. Online survey links were emailed in May of 2012 and followed by three reminders. **Main Outcome Measures:** Self-reported work-related injury in the previous 12 months and management strategies including medical care, work limitations or modifications, and time off work. Descriptive statistics (frequency and percent) described injury rates per 200,000 work hours, injury prevalence, characteristics, reporting and management strategies. **Results:** 247 ATs reported 419 work-related injuries during the previous 12 months for an injury rate of 21.62 per 200,000 hours (95% CI: 19.55-23.69). The 12-month prevalence of any injury during that period was 13.5% [95% CI: 12.0%-15.1%]. Injury events occurred in outdoor (40%) or indoor (20%) event locations and in the clinic or treatment center (19%). Low back (26%), hand/fingers (9%), and knee (9%) were frequently affected body sites. Injuries were frequently caused by bodily motion/overexertion (50%), contact with objects/equipment (22%), or slips/trips (13%). Over half of the injuries (137/247) required medical care from private health providers (31%), co-workers (24%), and/or the ATs themselves (31%). A quarter of injured ATs missed work (n=53): 45% missed 1-3 days, 21% missed 4-7 days, and 34% missed 8 or more days. ATs took time off on sick leave (60%), workers' compensation (38%), and/or vacation (17%). Most injured ATs (n=191) did not file a workers' compensation claim for their injury because they were able to manage it themselves (71%), the injury didn't meet filing requirements (20%), concern about the effect filing would have on their job (13%), and for confidentiality reasons (5%). Half of injured ATs were limited at work (n = 125) and 89% modified or changed their AT work as a result of the injury. Modifications included changing work techniques (71%) or duties (28%), decreasing patient contact hours (18%), or changing the type of patient usually treated (9%). **Conclusions:** More than half of work-related injuries required medical care or limitations at work and the majority were not reported to workers' compensation. Understanding how athletic trainers care for and manage their work-related injuries is important given few take time off work.

The Effects of One- and Two-Person BVM Ventilations Compared to Resuscitation Masks in Healthcare and Pre-Hospital Care Providers: A Systematic Review

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Context: Although not called upon daily, preparation and proper execution of emergency care skills such as bag-valve-mask (BVM) ventilation by trained providers is critical to the well-being of patients in respiratory and cardiac arrest. Factors like technique, mask seal, and bag compression/recoil may disrupt air volume delivered and affect resuscitation outcomes. **Objective:** Systematically review the literature to evaluate the efficacy of one- and two-person BVM ventilation compared to resuscitation masks (RM) in healthcare and pre-hospital care providers. **Data Sources:** Relevant articles were identified from the following electronic databases: PubMed and Medline using the following terms: "bag valve mask [TI] OR resuscitation mask [TI] OR pocket mask AND ventilation", and "BVM AND ventilations" resulting in 55 studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed, randomized controlled trials or controlled trials without randomization using a BVM and/or RM in human or manikin models, (2) trained providers, (3) written in English, (4) available abstract, and (5) included study outcomes measuring adequate ventilation (ie., tidal volume [TV] and/or peak airway pressure [PAP]). **Data Extraction:** Three reviewers independently assessed and graded studies using the Physiotherapy Evidence Database (PEDro) scale. Data of interest were participants, interventions, descriptive data (ie., means, SD), inferential statistics, and effect size (calculated from data when applicable) of the main outcome measures. **Data Synthesis:** Ten manikin studies met the inclusion criteria, all full reports. PEDro scores ranged from 5 to 9

points (maximum = 10 points), average of 6.17 ± 1.04. Total participants were 518, mean age of 28.7 ± 4.1. Trained providers included: EMTs, paramedics, respiratory therapists, residents and physicians, nurses, and lifeguards. Eight studies examined TV in milliliters (mL) or liters (L), two examined TV in milliliters/kg (mL/kg). Four studies found TV was significantly higher in 2-person BVM ventilation than 1-person. Fluck and Sorbello found TV (mL) was higher in 2-person BVM (9050 ± 2350) than 1-person BVM (8550 ± 3200) and RM ventilation (5600 ± 3050). Comparatively, three studies found the BVM had lower TV than a RM or other methods (SMART-Bag, mouth-to-mouth). Three studies examined PAP (cm of water), one finding that PAP was increased with 2-person BVM (27.2 ± 11.7) compared to 1-person (21.8 ± 10.6). EMTs demonstrated greater ventilation effectiveness than anesthetists while paramedics were the only ones able to generate the recommended TV when using 1- or 2-person BVM. **Conclusions:** Results suggest that 2-person BVM ventilation is superior to 1-person BVM ventilation based upon the higher TV and PAP. However, when compared to RM, BVM (single- or two-person) ventilation does not always result in higher TV. Athletic trainers should equip their emergency kits with and practice using both a BVM (single- and two-person) and RM as the type of situation, availability of, and comfort level of the responders may determine what equipment is necessary.

Athletic Trainer's Beliefs and Implementation of Evidence-Based Practice

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Context: Limited information is known about the clinical behaviors of athletic trainers (ATs) as it pertains to evidence-based practice (EBP). Understanding the beliefs and implementation of EBP among ATs will help determine appropriate strategies to improve implementation. **Objective:** To examine the AT's beliefs and implementation of EBP. **Design:** Cross sectional. **Setting:** Online survey. **Patients or Other Participants:** The survey was sent to 4000 randomly selected ATs. A total of 466 individuals (235 males and 231 females, age 35.5 ± 9.9 years) completed the online survey (11.7%). **Interventions:** The survey consisted of three sections: (1) demographics (2) 16-item EBP Beliefs Scale (EBPBS), and (3) 18-item EBP Implementation Scale (EBPIS). The EBPBS used a 5-point Likert scale to rate participants' level of agreement with each statement. The EBPIS used a 5-point Likert scale to rate participant's EBP use within the last eight weeks. Cronbach α and Spearman-Brown r reliability coefficients for the EBPBS were .90 and 0.87 respectively and 0.96 and 0.95 respectively for the EBPIS. Content and criterion validity were established by a panel of experts. Independent variables included: educational level, years of experience, employment setting, journal access, preceptor status, and third party reimbursement documentation. **Main Outcome Measures:** Dependent variables were the EBPBS (ranging from 16 [strongly disagree] to 80 [strongly agree]) and EBPIS (ranging from 0 [0 times] to 72 [≥8 times]) composite scores. Kruskal-Wallis one-way ANOVA and Mann Whitney U tests were used to determine differences in responses between independent variables. **Results:** ATs median score (56.00 ± 7.86) on the EBPBS revealed a neutral belief in the importance of EBP. EBPBS scores were higher among ATs required to document for third party reimbursement (59.00 ± 1.85, U = 7094.50, P = 0.001), with access to current research beyond the Journal of Athletic Training (56.00 ± 0.92, U = 11377.50, P = 0.016), and with varying levels of education; with higher education level exhibiting higher EBPBS scores (H (4) = 11.231, P = 0.011). A low level of implementation (9.00 ± 11.38) was found on the EBPIS, representing implementation of EBP approximately zero times in the last eight weeks. Implementation scores were higher among ATs who had served as a preceptor within the last year (11.00 ± 2.21, U = 12014.50, P = 0.013), were required to document for third party reimbursement (15.50 ± 3.04, U = 5181.50, P < .001), with access to current research through professional journals (10.00 ± 1.43, U = 7945.00, P = 0.002), and with a doctoral degree (H (4) = 10.554, P = 0.014). **Conclusions:** Participants had a neutral belief towards EBP and they are not implementing EBP concepts into patient care. This suggests that further information is needed to specifically understand why ATs are not implementing EBP, what resources are necessary for them to begin ways to deliver the resources are needed so ATs can better implement EBP into practice.

Intra and Intertester Reliability of the Dr. Goniomter Paid Application at the Elbow Joint Using an iPad 2

Wenzlaff JD, Truxton TT, Pollard-McGrandy AM, Albrecht AJ, Berry DC, Kabay M: Saginaw Valley State University, University Center, MI

Context: Unreliable standard goniometry measurements and advancement in technology have encouraged clinicians to seek alternative methods of reliably assessing joint motion. Smartphone-based goniometry using the Dr. Goniometer (DGA) (CDM SrL, Cagliari, Italy) iPhone/iPad paid application (app) has demonstrated positive results when assessing active range of motion (AROM), specifically intratester and intertester reliability at the knee. **Objective:** Determine intra- and intertester reliability of elbow extension (EE) and elbow flexion (EF) AROM using the Dr.Goniometer iPhone/iPad paid app on an iPad 2 (Apple, Cupertino, CA) in healthy participants. **Design:** Test-retest reliability study. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Thirty-one (females = 14, males = 17) 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. **Interventions:** Participants were supine for a single session measurement of EE and EF AROM by two independent testers (not blinded) using the participants' dominant arm (throwing a ball). To control measurement error, participants were supine with a small towel under their elbow as recommended in the literature. Measurements were counterbalanced to control effect bias. When maximal joint movement was achieved, a digital image using the DGA on an iPad 2 was recorded. DGA landmarks included; lateral epicondyle (axis), long axis of the humerus (stationary arm), and long axis of the radius (moveable arm). The DGA calculated motion by manually manipulating three markers so a crosshair was placed on the reported landmarks. No visual markers were used to identify landmarks. To maintain proper positioning the DGA provided a dotted line that connected the individual reference points to ensure proper alignment. Four different testers (2-certified athletic trainers each with 20+ years of experience, 2-senior athletic training students) measured each image on three separate occasions, one week apart. **Main Outcome Measures:** EE and EF 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 EE and EF ROM scores. Alpha level was set a priori at $p < 0.05$. **Results:** ICC measurements for intratester reliability values were high, ranging between 0.836-0.925 (95% confidence interval [CI]:.727, .961) for EE and 0.807-0.982 (95% CI:.607, .991) for EF. Intertester reliability values were high, 0.959 (95% CI:.934, .978) for EE and 0.887 (95% CI:.827, .936) for EF. **Conclusions:** The Dr.Goniometer app demonstrated both high intra- and intertester reliability when measuring elbow extension and flexion AROM. These results, combined with previous studies examining intra- and intertester reliability at the knee and wrist suggests that the app is a plausible option for assessing AROM in healthy participants. Further research is required to validate the use of this application for different body joints, with other clinicians, and in unhealthy participants.

Comparison of Standard Goniometry Versus the Dr. Goniometer Paid iPad/iPhone Application to Measure Wrist Flexion and Extension Range of Motion

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Context: When conducting an injury assessment, active range of motion (AROM) is traditionally documented using standard goniometry (SG). However, SG measurements have demonstrated inconsistent and unreliable results; prompting alternative/new technological applications (ie., iPad/iPhone); many which have not been validated. **Objective:** Compare the relationship and inter-rater reliability between wrist flexion (WF) and extension (WE) AROM using SG and the paid iPad/iPhone application Dr. Goniometer (DGA) (CDM SrL, Cagliari, Italy). **Design:** Quasi-experimental. **Setting:** Clinical research room. **Patients or Other Participants:** Thirty-one (males = 17, females = 14) 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. **Interventions:** Participants were seated for a single session measurement of WF and WE AROM by two independent raters (not blinded) using the participants' dominant arm (throwing a ball). To control measurement error participants sat with their wrist overhanging the table's edge, with the elbow positioned to 90o. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was assessed using referenced landmarks: radial styloid process (axis), ulna long axis (stationary arm), and fifth metacarpal long axis (moveable arm). Participants maximally flexed and extended the wrist to collect AROM. The DGA landmarks included; radial styloid process (axis), ulna long axis (stationary arm), and fifth

metacarpal long axis (moveable arm). When maximal joint movement was obtained, a digital image was obtained using the DGA. The DGA calculated motion by manually manipulating three markers so a crosshair was placed on the reported landmarks. No visual markers were used to identify landmarks. To maintain proper positioning the app provided a dotted line that connected the individual reference points to ensure proper alignment. **Main Outcome Measures:** Dependent variables were WF and WE AROM (in degrees); independent variables were SG and DGA. Pearson Correlation Coefficients were calculated to determine the relationship between SG and DGA. An intraclass correlation (ICC2,1) measured WF and WE inter-rater reliability. Alpha level was set a priori at $p < 0.05$. **Results:** Combined SG and DGA mean (SEM) rater scores for WF were 76.2 (1.2() and 75.6° (1.2°), respectively. Combined SG and DGA mean (SEM) rater scores for WE were 65.8 (1.9() and 62.0 (1.6(), respectively. Significant relationships were found between combined rater SG and DGA for WF, $r(29) = .899$, $p < .001$ and WE, $r(29) = .505$, $p = .004$. ICC measurements for inter-rater reliability values of DGA for WF and WE were .598 (95% CI:.231, .800) and .669 (95% CI:.-065, .891), respectively. **Conclusions:** Significant relationships existed between the Dr.Goniometer app and SG while inter-rater reliability values for WF and WE were fair. The app is an innovative and simple technology allowing clinicians to collect, store, and recall joint motion when needed. However, the app should be used with caution until further intra- and inter-rater reliability studies are conducted.

Comparison of Standard Goniometry Versus an iPhone Goniometry Accelerometer Application to Measure Wrist Flexion and Extension Range of Motion

Pollard-McGrandy AM, Albrecht AJ, Berry DC: Saginaw Valley State University, University Center, MI

Context: Assessing joint motion is standard practice when conducting an injury evaluation. Joint motion is often quantified using a standard goniometer (SG); but due to technological advances, alternative methods using iPhone (Apple, Cupertino, CA) applications may offer clinicians an effective and convenient means of measuring joint motion. **Objective:** To compare the relationship and inter-rater reliability between wrist flexion (WF) and extension (WE) active ROM (AROM) using SG and the iPhone application Goniometer Accelerometer (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. **Interventions:** Participants completed a single session measurement of WF and WE AROM by two independent raters (not blinded) using the dominant limb. To control measurement error participants sat with their wrist overhanging the table's edge, with the elbow positioned to 90o. Measurements were counterbalanced to control effect bias. Standard goniometric AROM was assessed using referenced landmarks: radial styloid process (axis), ulna long axis (stationary arm), and fifth metacarpal long axis (moveable arm). The App landmarks included: posterior forearm, 1" proximal from the wrist crease (position 1) and the dorsal surface of the 3rd metacarpal, 1" distal from the wrist crease (position 2). Once maximal joint movements were obtained, the iPhone was placed horizontally along position 1. "Start" was pressed to measure position 1. This was repeated for position 2, pressing "End" to calculate the available AROM. **Main Outcome Measures:** Dependent variable were WF and WE 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 WF and WE inter-rater reliability. Alpha level was set a priori at $p < 0.05$. **Results:** Combined SG and App mean (SEM) rater scores for WF were 76.2° (1.2°) and 74.2 (1.6°), respectively. Combined WE rater mean (SEM) scores for SG and App were 65.8° (1.9°) and 71.2° (1.2°), respectively. Significant relationships were also found between combined rater SG and App for WF, $r(29) = .539$, $p = .002$ and WE, $r(29) = .619$, $p < .001$. ICC measurements for inter-rater reliability values for WF and WE were .393 (95% CI:-.096, .714) and .241 (95% CI:-.214, .698) respectively. **Conclusions:** Significant relationships (moderate) existed between the App and SG; however, inter-rater reliability values were poor for WF and WE. The Goniometry Accelerator App is an unreliable tool to measure wrist joint motion and should be avoided when measuring wrist AROM. The App measures the angle presenting on the anterior surface of the joint and is not a true joint measurement. Any significant deviation in joint structure or body mass (ie., increased adipose, muscle hypertrophy) may affect the measured AROM values.

Intra- and Intertester Reliability of the Dr. Goniometer App to Assess Wrist Flexion and Extension Joint Motion Using an iPad 2

Truxton TT, Wenzlaff JD, Albrecht AJ, Pollard-McGrandy AM, Berry DC, Kabay M: Saginaw Valley State University, University Center, MI

Context: Technological advances; particularly in smartphone technology has created opportunities for clinicians to integrate smartphone applications (ie., apps) into their clinical practice to assess active range of motion (AROM) and improve measurement reliability. Smartphone goniometer based apps such as the Dr.Goniometer app (DGA) (CDM SrL, Cagliari, Italy) have demonstrated moderate to- high intra- and intertester reliability when assessing AROM at multiple locations in healthy patients. Objective: To determine intra- and intertester reliability of wrist extension (WE) and flexion (WF) active range of motion using the iPhone/iPad paid application, Dr.Goniometer on an iPad 2 (Apple, Cupertino, CA) in healthy participants. **Design:** Test-retest reliability study. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Thirty-one (males = 17, females = 14) 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. **Interventions:** Participants were seated for a single session measurement of WE and WF AROM by two independent raters (not blinded) using the participants' dominant arm (throwing a ball). To control measurement error, participants sat with their wrist overhanging the plinth's edge, and the elbow at a 90o angle. Measurements were counterbalanced to control effect bias. When maximal joint movement was obtained, a digital image was recorded using the DGA on an iPad 2. The DGA landmarks included; radial styloid process (axis), ulna long axis (stationary arm), and fifth metacarpal long axis (moveable arm). The DGA calculated motion by manually manipulating three markers so a crosshair was placed on the reported landmarks. No visual markers were used to identify landmarks. To maintain proper positioning the app provided a dotted line that connected the individual reference points to ensure proper alignment. Four different testers (2-certified athletic trainers each with 20+ years of experience, 2-athletic training students) measured each image on three separate occasions, one week apart. **Main Outcome Measures:** WE and WF 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 WE and WF ROM scores. Alpha level was set a priori at $p < 0.05$. **Results:** ICC measurements for intratester reliability values were strong, ranging between 0.887-0.987 (95% confidence interval [CI]:.720, .994) for WE and 0.844-0.964 (95% CI:.723, .981) for WF. Intertester reliability values were high, 0.993 (95% CI:.989, .996) for WE and 0.983 (95% CI:.927, .991) for WF. **Conclusions:** The Dr.Goniometer app demonstrated high intra- and intertester reliability when measuring wrist flexion and extension AROM in healthy participants. These results, combined with previous research suggest the app is a practical option for assessing wrist AROM in healthy participants. However, future research is necessary to confirm the use of this application with other joints, clinicians, and patient populations.

Reliability of a Novel Step-Down-to-Fatigue Test

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Context: Fatigue of lower extremity musculature, in particular hip and knee musculature, may effect neuromuscular control and increase injury risk during sport. Therefore, lower extremity muscular endurance should be assessed prior to return-to-sport; however, few clinically feasible lower extremity endurance tests with established reliability exist. **Objective:** To determine between-day reliability of a novel step-down-to-fatigue test. **Design:** Descriptive, test-retest reliability. **Setting:** Research laboratory. **Patients or Other Participants:** A convenience sample of 30 healthy participants (12 female, 8 male) was tested (25 ± 6yrs, 171 ± 10cm, 72 ± 11kg). Participants had no history of lower extremity injury in the last 6 months, and no history of lower-extremity surgery in the last year. **Interventions:** Testing occurred on three occasions. On each occasion, participants were asked to perform as many single-leg step-downs on the dominant-limb as possible. Session one was a familiarization session, and sessions two and three were test sessions. Step-down box height was standardized such that the stance-limb achieved 60 degrees of knee flexion at heel touch of the down-limb. Rate of step-downs was normalized to a metronome set at 75 beats-per-minute. A complete repetition was defined as the down-limb making heel-contact with one beat and returning to the level of the box within the next beat as the stance-limb achieved full knee extension. Participants' hands were required to remain on their hips throughout the test. Fatigue was defined as the point when the participant failed to correctly perform three consecutive repetitions in time with the metronome, despite strong verbal coaching. **Main Outcome Measures:** The number of repetitions completed and time until fatigue was recorded. Intra-class correlations (ICC)(2,1) and minimal detectable change (MDC) values were utilized to evaluate reliability between sessions two and three. **Results:** Mean number of step-downs completed were the following: session two = 59 ± 17 repetitions, and session three = 64 ± 19 repetitions. Reliability was good with ICC = 0.87, (95% CI (0.70-0.95), $p < 0.001$). The standard error of measure (SEM) for repetitions was 6, with an MDC of 18 repetitions. Time-to-fatigue for session two was 104 ± 27 s and session three 113 ± 32 s. Reliability when measuring based on time was slightly, but not significantly lower with ICC = 0.83, (95% CI (0.62-0.93), $p < 0.001$). SEM for time to fatigue was 11s, and MDC was 31s. **Conclusions:** A systematic improvement was observed between each session suggesting that even with a familiarization session an effect for learning may have occurred. Although the observed ICC's are good, additional practice sessions may improve reliability, thereby lowering MDC values and improving the ability of the test to detect changes in lower extremity endurance. Additionally, both ICCs and MDC values may have been influenced by the heterogeneous sample included in this study. Overall the step-down-to-fatigue test is reliable and with appropriate practice sessions has the potential to be used clinically to assess lower extremity muscular endurance.

Sex Differences on Clinical Functional Tests of the Lower Extremity Within Recreational Runners

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Context: Over 50 million Americans run as their primary form of physical activity. Unfortunately, as many as 79% of runners will sustain a running related musculoskeletal injury (RRMI) such as medial tibial stress syndrome, Achilles tendonitis, and patellofemoral pain. Research within athletic populations has focused on identifying individuals who are at an increased risk of sustaining an injury from sport. The Star Excursion Balance Test (SEBT), Single Leg Hop for Distance Test (SLHD), Weight Bearing Lunge Test (WBLT), and Single Leg Heel Raise to Fatigue Test (SLHR) have been used to assess injury risk within football, basketball, and soccer players. However, these tests have had limited application within the running population, specifically recreational runners. While sex differences do influence injury risk in other sports, before researchers and clinicians apply these functional tests within this running population, it needs to be determined if there are performance differences between sexes in the test outcomes. **Objective:** To examine differences in SEBT anterior reach (SEBT-A), SLHD, WBLT, and SLHR scores between male and female recreational runners. **Design:** Cross-sectional study. **Setting:** Laboratory **Patients or Other Participants:** Twenty eight-male (43.71 ± 12.06 yrs, 181.33 ± 6.26 cm, 84.51 ± 13.89 kg) and fifty-five female (38.76 ± 9.41 yrs, 165.78 ± 7.6 cm, 66.9 ± 13.4 kg) recreational runners volunteered to participate. **Interventions:** Participants completed a single testing session in which they performed the SEBT-A, SLHD, WBLT, and SLHR bilaterally in a random order. **Main**

Outcome Measures: For the SEBT-A the mean of 3 trials for each limb was normalized to true leg length and expressed as a percentage. The mean of the 3 trials for each limb on the SLHD was normalized to height and expressed as a percentage. The score of the WBLT represented the distance from the foot to the wall with the knee flexed to touch the wall but no longer maintaining heel contact with the ground (cm), and the SLHR was the number of successful, consecutive single leg heel raises. Paired t-tests found no difference between limbs allowing the average of limbs. Average, normalized scores for the four dependent variables were compared between males and females using Independent T-tests. Alpha was set a-priori at $P < 0.05$. **Results:** There was a significant difference between sexes on the SLHD (M: 43.04 ± 13.86%, F: 36.93 ± 11.75%; P = 0.04). There were no differences between sexes on the SEBT-A (M: 63.74 ± 4.04%, F: 64.23 ± 5.72%; P = 0.68), WBLT (M: 9.84 ± 3.29 cm, F: 9.09 ± 2.58 cm; P = 0.25), and SLHR (M: 36.8 ± 14.54 repetitions, F: 32.02 ± 12.72 repetitions; P = 0.13). **Conclusions:** Males performed no differently than females on the SEBT-A, SLHR, and WBLT. However, males performed better on the SLHD compared to females, consistent with research using these tests in other athletic populations. Recreational runners can be collapsed by sex when examining performance on the SEBT-A, SLHR, and WBLT with confidence, but not for SLHD.

Physiological and Neuromuscular Risk Factors of Preventable Musculoskeletal Injuries in the Army 101st Airborne Division (Air Assault) Soldiers: A Prospective Study

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Context: Musculoskeletal injuries have negatively impacted tactical readiness. The identification of prospective and modifiable risk factors of preventable musculoskeletal injuries can guide specific injury prevention strategies for Soldiers and health care providers. **Objective:** To analyze physiological and neuromuscular characteristics as predictors of preventable musculoskeletal injuries. It was hypothesized that Soldiers with prospective injuries would have reduced physiological and neuromuscular characteristics as measured at baseline. **Design:** Descriptive prospective-cohort study. **Setting:** Warrior Human Performance Research Laboratory. **Patients or Other Participants:** Initially, medical charts from 491 Soldiers were reviewed by certified athletic trainers. A total of 179 Soldiers (age: 26.8 ± 5.9 yrs, height: 69.1 ± 3.0 in, weight: 174.9 ± 30.0 lbs) had no injuries (NOI) and 129 Soldiers (age: 27.1 ± 6.0 yrs, height: 68.9 ± 3.5 in, weight: 177.2 ± 30.3 lbs) had at least one preventable musculoskeletal injuries (INJ). The rest of Soldiers were excluded from this analysis due to their medical records of traumatic injuries or other medical conditions. **Interventions:** All Soldiers participated in laboratory testing to examine their physiological characteristics, strength, flexibility, balance, and landing biomechanics. Injuries were tracked for 12 months following laboratory testing utilizing medical-chart document injury data. Soldiers were then divided into two groups (NOI and INJ) for group comparisons on physiological and neuromuscular characteristics. **Main Outcome Measures:** The following variables were collected at baseline: physiological characteristics (body composition using air-displacement-plethysmography, aerobic capacity during a graded treadmill running protocol, and anaerobic peak/mean power (Watts/kg) during the Wingate test), muscular strength (isokinetic knee flexion/extension and trunk rotation strength (%BW) and ratio), flexibility (hamstring and trunk rotation active range-of-motion), balance (single-leg eyes-open/closed balance on a force plate), and landing biomechanics (hip/knee flexion angles at initial contact and maximum during a double-leg stop-jump). Independent t-tests or Mann-Whitney U-tests were used for statistical analyses ($p < 0.05$). **Results:** There were 157 preventable musculoskeletal injuries identified among the INJ group. The most commonly injured locations were ankle (17.8%), low-back (15.9%), knee (12.1%), and shoulder (10.8%). The INJ group had significantly less anaerobic peak power (INJ: 12.1Watts/kg, NOI: 13.1Watts/kg, p = 0.002), mean power (INJ: 7.2 Watts/kg, NOI: 7.6 Watts/kg, p = 0.019), knee flexion/extension strength ratio (INJ: 0.47, NOI: 050, p = 0.001), and trunk rotation strength (INJ: 138.9% BW, NOI: 147.6% BW, p = 0.040). Additionally, the INJ group had significantly poor balance (higher values) in the medial-lateral (INJ: 11.9N, NOI: 9.7 N, p = 0.046) and vertical directions (INJ: 18.0N, NOI: 12.3N, 0.004) during the eyes-closed condition. There were no significant differences in body composition, flexibility, and landing biomechanics. **Conclusions:** Soldiers who later sustained preventable musculoskeletal injuries had worse anaerobic peak/mean power, strength, and eyes-closed balance. Athletic trainers and other health care providers should be aware of those risk factors when working with Soldiers. Future analyses should be conducted to investigate the effectiveness of targeted intervention exercises (based on risk factors) on preventing new or recurrent musculoskeletal injuries.

Relationship Between Clinically Available Static and Dynamic Balance Assessments

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Context: Static balance assessments are often performed as post-concussion assessments, but a growing body of literature suggests dynamic balance and movement tasks reveal balance deficits that persist beyond the typical recovery period (7-10 days). Static and dynamic balance assessments may or may not be related based on differing task demands. More research is needed to determine whether static and dynamic balance assessments contribute different information during baseline and post-concussion assessment. **Objective:** To determine if commonly performed clinical exams of static and dynamic balance scores are correlated. **Design:** Cross-sectional. **Setting:** Sports Medicine Clinic. **Patients or Other Participants:** Sixty-one Division I collegiate athletes (38 males, 23 females, age = 19.6 ± 1.4 yr, height = 182.7 ± 3.6 cm, mass = 84.5 ± 26.3 kg) in nine sports (men's and women's basketball, swimming, diving, women's soccer, golf, volleyball, men's tennis, and football) completed a baseline concussion assessment. Participants were excluded from analysis if they reported diagnosis of vestibular disorder; lower limb injury currently prohibiting full participation; and chronic ankle instability as defined by a Cumberland Ankle Instability Tool (CAIT) score <24. **Interventions:** Participants performed a lower extremity injury questionnaire, a demographic form, the Balance Error Scoring System (BESS) recorded on video, Y Balance Test-Lower Quarter (YBT-LQ), and the CAIT. The YBT-LQ reach directions (anterior -ANT; posteromedial - PM; posterolateral - PL) were performed in a counterbalanced order. Three raters, with inter-rater reliability >0.85, graded the BESS videos. Two raters, with inter-rater reliability >0.90, administered the YBT-LQ and measured limb length of the non-dominant limb. **Main Outcome Measures:** Four Pearson correlation coefficients were calculated to determine the relationship between the total number of BESS errors and the YBT-LQ 1) ANT, 2) PM, 3) PL; and 4) composite (COMP) reach distances (normalized as percentage of limb length - %LL) (α=0.05). **Results:** No significant correlations existed between the total number of BESS errors (13.6 ± 4.6) and: ANT (67.0 ± 7.3% LL) ($r = -0.10$, $p = 0.43$), PM (106.4 ± 9.8% LL) ($r = -0.08$, $p = 0.55$), PL (102.1 ± 11.6% LL) ($r = -0.12$, $p = 0.35$), or COMP (91.8 ± 8.0% LL) ($r = -0.12$, $p = .35$) reach distances. **Conclusions:** Athletes may have differing individual abilities regarding static and dynamic balance. Static and dynamic balance measures may represent differing constructs, which may mean that both are important during concussion assessment. Clinicians should consider testing both static and dynamic balance, rather than focusing on static only, to obtain a more comprehensive view of balance ability. Further research is needed to determine if dynamic balance assessments are clinically meaningful during concussion assessment and more sensitive and specific to post-concussion balance deficits.

Adolescent Athlete's Utilization and Perceptions of Ankle Braces to Prevent Ankle Sprains

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Context: The efficacy of Ankle Braces (AB) to prevent ankle sprains is well documented. However, there is limited data regarding the perceptions that adolescent athletes have regarding AB use. **Objective:** To determine the utilization and perceptions of AB efficacy in a sample of adolescent athletes. **Design:** Cross sectional study. **Setting:** Data were collected during the summer of 2014 at a series of sport camps and club team competitions. **Patients or Other Participants:** Adolescent basketball, football, soccer and volleyball players were recruited to participate. **Interventions:** Subjects completed a paper/pencil, validated survey (reliability: $r = 0.698$) used to quantify utilization of ankle injury prevention strategies and consisted of a series of dichotomous (Yes, No) and Likert scaled questions. **Main Outcome Measures:** The dependent variables included the percentage of subjects utilizing AB. Fisher's Exact tests and Wilcoxon Rank Sum tests were used to analyze responses by sex, sport and previous ankle sprain (PAS) and no ankle sprain (NoAS). **Results:** A total of 800 out of 1,312 athletes (61%) agreed to participate. Subjects (age = 15.7 + 1.7 yrs.) included female (n = 408) and male (n = 392), basketball (n = 258), football (n = 158) Soccer (n = 232) and volleyball (n = 152) players. Two hundred seventeen (27%) reported a PAS on one or both ankles. Two hundred forty nine subjects (31%) wore an AB on one (63%) or both (37%) ankles. AB use was higher ($p < 0.001$) in subjects with PAS (56%) than NoAS (27%) and higher ($p < 0.001$) in females (39%) than males (22%). Soccer players (18%) were less likely ($p < 0.001$) to wear AB than basketball (37%), football (25%) and volleyball (49%) players. Subjects with PAS (62%) were more likely to agree ($p = 0.029$) that AB would prevent injuries than NoAS subjects (52%). There

was no difference (p = 0.407) between females (56%) and males (54%) in the belief that AB would prevent injuries. Soccer players (41%) were less likely (p < 0.001) to agree that AB would reduce injuries than basketball (56%), football (65%) and volleyball (67%) players. There was no difference (p = 0.115) in the belief that wearing an AB would decrease athletic performance between PAS subjects (19%) and NoAS (19%). Males (22%) were more likely (p = 0.004) than females (15%) to agree that wearing ankle braces would decrease athletic performance. Volleyball players (10%) were less likely (p < 0.001) to agree that wearing ankle braces would decrease athletic performance than basketball (24%) and soccer players (25%). Criteria cited by subjects to consider using an AB was comfort (37%), injury prevention efficacy, (26%) and athletic trainer recommendation (14%). **Conclusions:** The utilization and the perceptions regarding AB varies considerably by sex, sport and previous injury status. Athletic trainers need to consider these variables when recommending AB for their athletes.

Competition-Related Injury Incidence in Para-Taekwondo

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Context: Full-contact taekwondo sparring for persons with acquired/congenital physical impairments (i.e., para-taekwondo) is fairly new with five world championships to date. As athletes in this population are at an increased risk for debilitating injuries, it is important to know the extent of injury and to investigate means to which these injuries can be mitigated and prevented. The aim of this study was to present injury incidence rates for injuries at an international competition. **Design:** Prospective observational epidemiological study. **Setting:** 5th World Para-taekwondo championships. **Patients or Other Participants:** 92 males (28.8 + 5.7 years, 178.3 + 4.7 cm, 73.0 + 9.6 kg) and 21 females (28.6 + 6.6 years, 163.3 + 4.1 cm, 52.6 + 2.6 kg). **Interventions:** All athlete exposures and minute exposures were recorded by the research team during competition. An injury was defined as any complaint from an athlete for which they sought medical care by tournament medical personnel. All injuries were diagnosed by the head tournament physician and first author. Incidence rates were calculated per 1000 athlete-exposures (A-E) and per 1000 minute-exposures (M-E). An athlete exposure is defined as when an athlete participates in a competition match. Each match includes two athletes, thus there are always two athlete exposures per match. Total minutes of each match (1 minute 30 seconds) were calculated. In the event that a match ended early (e.g., due to injury or superiority point differential) the exact time the match ended was recorded. **Main Outcome Measures:** injury incidence rate with 95% confidence intervals (CI). **Results:** A total of 186 A-Es and 366 M-Es were recorded with 9 total musculoskeletal injuries. Sprains (21.5/1000 A-E, 95% CI = 0.43 to 42.6 and 10.9/1000 M-E, 95 % CI = 0.22 to 21.6) were the predominant injury type. Contusions were the next predominant injury type with 10.7/1000 A-E, 95% CI = -4.1 to 25.6 and 5.5/1000 M-E, 95% CI = -2.1 to 13.0. Concussion incidence was 5.4/1000 A-E, 95% CI = -5.2 to 15.9 and 2.7/1000 M-E 95% CI = -2.6 to 8.1). Non-contact injuries (26.9/1000 A-E, 95% CI = 3.3 to 50.4 and 13.6/1000 M-E, 95% CI = 1.7 to 25.6) were the most common injury mechanisms. Most injuries occurred during the second match (21.5/1000 A-E, 95% CI = 0.43 to 42.6 and 10.9/1000 M-E, 95% CI = 0.22 to 21.6). The turning kick was most responsible for injuries (21.5/1000 A-E, 95% CI = 0.43 to 42.6 and 10.9/1000 M-E, 95% CI = 0.22 to 21.6) **Conclusions:** Contrary to previous studies, ligament sprains were more common than contusions. Attention may be warranted to prevent non-contact injuries.

The Effects of High Intensity Interval Training (HIIT) with L-Arginine Versus HIIT on Cardiovascular Function

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Context: We conducted a study that compared vascular function using the flow mediated dilation (FMD), microvascular (deoxygenation) response, cardiovascular fitness (VO2peak) and exercise tolerance following two weeks of HIIT with placebo and in a group that was given a L-arginine supplement. L-arginine is precursor of nitric oxide (NO) and is known to play a very important role in maintaining vascular function and health. **Objective:** The primary purpose of this study was to examine the endothelial response in the brachial artery after two weeks of HIIT with and without the nutritional supplement. The secondary purpose of this proposed study was to compare the effect of two weeks of HIIT with and without L-arginine supplementation on O2 uptake, and the time to exhaustion during progressive ramp exercise. **Design:** Experimental (single-blind) controlled **Setting:** Research Laboratory **Patients or Other Participants:** 15 healthy adult men between 18-35 years of age that have no signs, symptoms, or known diagnoses of a cardiovascular or pulmonary disease or musculoskeletal injuries based upon the responses to a standardized medical history questionnaire. **Interventions:** Flow-mediation dilation (FMD) technique was used to measure brachial artery dilation. Subjects performed progressive ramp exercise on an electromagnetically braked stationary bike for the determination of VO2peak, peak work rate (W), exercise tolerance (time to exhaustion), and microvascular response. Subjects were randomized into one of two groups. Group 1 participated in high intensity interval training (HIIT) while consuming a placebo (HIIT-P), and Group 2 participated HIIT while consuming 6 g of L-arginine (HIIT + L-A). The HIIT consisted of 10 bouts of exercise on a cycle ergometer for 60 seconds at an intensity of 80% peak W. Each bout of exercise is followed by 60 seconds of recovery consisting of pedaling with 30 W. Subjects completed 6 sessions in 2 weeks (3 times a week). Then, FMD and progressive ramp exercise were repeated. **Results:** Mean ± SEM of time to exhaustion in HIIT + L-A versus HIIT-P results during progressive ramp exercise of pre-test and post-test were 930 ± 61.8 s and 972.3 ± 62.7 s versus 998 ± 25.3 s and 1033.3 ± 35.9 s ($P < 0.05$). Peak W in HIIT + L-A versus HIIT-P results during progressive ramp exercise of pre-test and post-test were 291.1 ± 20.7 W and 307.3 ± 20.4 W versus 290 ± 11.1 W and 302.1 ± 12.5 W ($P < 0.05$). However, FMD, VO2peak, and microvascular response were not statistically significant. **Conclusions:** Only two variables (peak W and time to exhaustion) in both groups were statistically significant. The use of a nutritional supplement containing L-arginine during HIT may not lead to any additional improvements in vascular function or exercise performance compared to HIT alone.

Psychosocial Influence on the Placebo Response for Treating Musculoskeletal Pain

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Context: The treatment of musculoskeletal pain and dysfunction varies among athletic trainers and may include the use of therapeutic modalities, i.e., phototherapy. Much research has been directed toward the therapeutic benefits of these pain-relieving modalities. However, limited research has assessed the value of a placebo effect as a therapeutic intervention after injury. **Objective:** To quantify the extent to which the patient-therapist interaction enhances the response to treatment and clinical outcome. **Design:** Double blind randomized trial. **Setting:** Controlled research laboratory. **Patients or Other Participants:** Forty (Ht = 1.70 m, Wt = 66.6 kg, BMI = 22.4) otherwise healthy men (n = 11) and women (n = 29) between the ages of 18 and 35 volunteered to participate. **Interventions:** Participants were required to come to the laboratory for three test sessions 48-hours apart (Day 1, 3 and 5). During the initial session (day 1), baseline measures were assessed and participants underwent a fatigue protocol for the biceps using an isokinetic dynamometer (KinCom 125 AP, Isokinetic International, Chattanooga, TN). Participants were then assigned to either an augmented interaction (AI) or limited interaction (LI) condition before receiving a sham phototherapy treatment. Participants returned on day 3 and day 5 for follow-up testing. Prior to receiving the sham treatment, the therapist provided instructions and feedback to patients allocated to the AI condition with regards to the effectiveness of the treatment and expectations in terms of pain perception and functional recovery, along with answering any questions the participant may have. Participants allocated to the LI condition were provided no feedback or expectancy from the therapist prior to the sham treatment. **Main Outcome Measures:** Maximum voluntary isometric contraction (MVIC), relaxed

elbow angle (RANG), and a visual analogue scale (VAS) for pain perception were used as outcome measures. The VAS contained a line from 0-10 with 0 representing no pain or soreness and 10 representing extreme pain or soreness. Each outcome measure was analyzed using a separate ANOVA with repeated measures on the second factor (time). Statistical significance was set a priori at $p < 0.05$. **Results:** The AI group were less symptomatic in terms of reduction in perceived pain compared to the LI group at day 3 follow-up ($F(1,38)$; $p = 0.041$, $\Sigma 2 = 0.11$). The mean VAS score at each visit for the AI group was 2.1mm (SD = 1.83 mm); 34.65 mm (SD = 23.88 mm); 7.1 mm (SD = 7.89mm) in comparison to the LI group at 2.05 mm (SD = 1.99 mm); 49.4 mm (SD = 27.93 mm); 12.8mm (SD = 12.34 mm). There were no between-group differences with respect to functional impairment. Impairment outcomes did not differ significantly between placebo conditions for MVIC ($p = 0.886$, $\Sigma 2 = 0.001$) or RANG ($p = 0.167$, $\Sigma 2 = 0.05$). **Conclusions:** Results suggest that augmented interaction with the patient before providing a modality treatment will have a more profound placebo effect on lowering pain perception than reducing functional impairment during recovery from musculoskeletal injury.

The Influence of Acute Injury and Pain on Subjective and Objective Sleep Measures in Collegiate Athletes

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Context: People who suffer from pain often sleep poorly. Sleep is needed to perform optimally during the day, which can include competing or rehabilitation for athletes. It is unclear if the pain athletes experience after suffering an injury disrupts their sleep. **Objective:** To identify self reported and objective sleep changes in athletes after an acute musculoskeletal injury. **Design:** One group, repeated measures design. **Setting:** All sleep measurements occurred at each subject's residence. **Patients or Other Participants:** Thirteen collegiate athletes who suffered an acute injury participated in the study (9 males and 5 females, height = 178.8 ± 10.3 cm, mass = 86.2 ± 27.3 kg, age = 21.1 ± 1.7 years). **Interventions:** All subjects were recruited within 24 hours after suffering an acute injury and their pain and sleep were measured for the next 6 days. All subjects completed a sleep journal indicating wake and bed times as well as day pain, night pain, alertness, fatigue, and self-reported sleep quality for the 6 days. Objective sleep efficiency (SE) was measured using an Actiwatch Score. In addition, at baseline state anxiety (STAI-S) was recorded. Separate one-way ANOVA's were used to measure the change in all self reported measures and SE. Pearson correlations were used to identify relationships between anxiety and day pain, night pain, sleep quality, alertness, fatigue, and SE ($\alpha = 0.05$). **Main Outcome Measures:** Current pain, night pain, alertness, fatigue, and self perceived sleep quality were measured each day for the 6 days using visual analogue scales. The SE was calculated from movement data recorded on the AS. **Results:** The average amount of practices/games missed was (9.6 ± 12.7). In addition, all subjects experienced a significant amount of day pain 24 hours after injury, which decreased at night but the difference was not significant for day 1 (day 1 pain = 38.5 ± 14.3, day 1 night pain = 24.6 ± 18.3: $F = 1.35$; $p = 0.260$). In addition the amount of day or night pain did not decrease significantly over the 6 days($F = 2.59$; $p = 0.139$). Alertness and perceived sleep quality improved across the 6 days with the biggest change being from day 2 to day 6 (alertness: day 2 = 44.1 ± 21.9; day 6 = 72.6 ± 20.4; $p < 0.001$. Sleep quality: day 2 = 46.3 ± 18.3; day 6 = 77.5 ± 15.3; $p < 0.001$). There was a trend toward a decrease in SE over the 6 days ($F = 2.348$; $p = 0.056$). Lastly, there was a significant correlation between anxiety and SE on the first day ($r = -0.71$, $p = 0.021$) **Conclusions:** Injured athletes reported poorer alertness and perceived sleep quality after being injured which improved 6 days after injury. The improvement in perceived sleep was not noted in the objective sleep measures. A decrease in alertness and perceived sleep quality may affect working memory and rehabilitation immediately after injury. The relationship between anxiety and SE for the first night may support addressing anxiety soon after injury to avoid poor sleep. More research is needed to support addressing sleep during the recovery of injury in athletes.

Pre-Participation Screening for Mental Health Conditions Among Collegiate Student-Athletes

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Context: Universal screening for mental health disorders as part of the pre-participation exam (PPE) in collegiate sports medicine settings is an important strategy for facilitating early detection and care provision. Limited evidence exists about the nature of mental-health related PPE screening in U.S. collegiate sport. **Objective:** To assess whether institutions screen for mental health disorders as part of the PPE, the disorders for which screening occurs, and whether there is variability in screening by institutional characteristics. **Design:** Cross-sectional survey. **Setting:** Electronically administered survey. **Patients or Other Participants:** Head athletic trainers and team physicians at all NCAA member colleges were contacted by email and invited to participate (n = 365, response rate = 30.30%). Most (85.04%) participants were head athletic trainers. **Interventions:** The online survey, which was hosted on the Qualtrics platform, assessed the independent variables of division of competition, number of sports medicine clinicians and student-athletes at the participant's institution, and whether their sports medicine department has a written plan related to student-athlete mental health. Items were developed in consultation with clinicians who work in college sports medicine settings and pilot tested in this population for comprehension. Data were collected in September 2014. **Main Outcome Measures:** Participants selected "yes" or "no" in response to prompts about whether their institution's PPE screens for each of following six issues: eating disorders, depression, anxiety, alcohol abuse, illegal drug use, and prescription drug abuse. Responses of "yes" were summed to create a screening index. Multivariable linear regression was used to determine the association between institutional characteristics and screening index score. **Results:** Fewer than half of the responding clinicians indicated that their sports medicine department administers a screening instrument for eating disorders (43.75%), depression (31.80%), anxiety (30.16%), or illegal drug use (45.72%), and just over half screen for alcohol abuse (55.92%), or prescription drug abuse (51.00%). The mean screening index score for the sample was 2.50 (SD = 2.25). Around around one-third of participants (31.51%) were at institutions that did not screen for any of the six mental health issues. Multivariable linear regression found significant differences in screening index score by the ratio of student-athletes to athletic trainers ($B = -0.004$, $SE = 0.00$, $p = 0.042$) and whether or not the sports medicine department has a written plan related to student-athlete mental health ($B = -1.32$, $SE = 0.26$, $p < 0.001$), but not by division of competition when controlling for these other independent variables. **Conclusions:** The substantial between-institution variability in PPE screening practices suggests that opportunities exist to make these screening practices more widespread. Opportunities may include requiring institutions have a written plan related to student-athlete mental health and providing guidance on evidence-based screening tools for institutions to use in the PPE. However, staffing issues may constrain screening implementation and must be addressed if more demands are to be placed on sports medicine clinicians.

Mid Back Pain in a Collegiate Varsity Rower: A Case Report

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Background: A twenty-two year old female collegiate varsity rower presented with mid-back pain with no radiculopathy. Her pain was described as stiff and achy, that can be sharp with movement. Her symptoms began approximately 3 weeks prior to report, during the mid-spring crew season. Prior to this incident, she did not have any previous history of back pain. Her symptoms included decreased thoracic mobility with rotation, side bending, trunk extension and flexion, all with pain upon active and passive end range of motion. She was tender to palpation over T6 and T7 vertebrae and the thoracic Erector Spinae muscles and also presented with poor scapular stabilization and scapulohumeral rhythm. **Differential Diagnosis:** Thoracic vertebrae hypomobility, thoracic disc pathology, thoracic scoliosis, thoracic vertebrae stress fracture, scapular hypermobility, altered scapulohumeral rhythm, Erector Spinae muscle spasm. **Treatment:** Initial interventions were directed to increase thoracic mobility and improve scapular stabilization and scapulohumeral rhythm. Strength and Conditioning exercises and rowing activity were modified to decrease symptoms through the end of the competitive season. After four weeks of rehabilitation and modified activity, scapular stabilization and scapulohumeral rhythm had improved, but with only temporary symptom relief. Radiographic evaluation revealed proper vertebral alignment, no significant thoracic disc height loss and no stress fracture. An MRI ordered by the team physician revealed a shallow, 2 mm disc protrusion at levels T4-5, T6-7 and T7-8 minimally indenting the ventral CSF space. Based upon MRI and clinical evaluation, she was allowed to complete her competitive season with continued modifications. Upon completion of the season, all rowing activity was discontinued and an extensive rehabilitation plan was developed, including manual therapy, lower extremity mobility and flexibility, and core stabilization. She currently remains symptom free and progressing back to full activity. **Uniqueness:** Intervertebral disc injuries are seen in the lumbar and cervical spine, but rarely in the thoracic spine. Intervertebral thoracic disc herniation is uncommon and accounts for 0.1-4.0% of all intervertebral disc herniation, typically occurring at the T11-12 segmental level. Based on the MRI findings, and the rarity of this condition, this athlete's biomechanics were more thoroughly assessed by the sports medicine and coaching staffs. During this evaluation, it was determined that the patient displayed a lack of ankle and hip mobility, forcing her to compensate during the "catch" phase of the rowing stroke. This compensation manifested as adding trunk flexion in the mid thoracic spine during this phase to increase the length of her stroke, and in turn causing her injury. **Conclusions:** Rowing is completed in unison, with an advantage to a rower who has a long, powerful stroke. An athlete may knowingly or unknowingly compromise the biomechanics of the stroke in order to gain a competitive edge or to merely reach the desired range of motion. Due to the specifics of the rowing stroke and its repetitive nature, it is imperative for the athletic trainer to understand the proper biomechanics. Educating both coaches and rowers on the proper mobility and strength needed to reach the desired position with the proper biomechanics would not only decrease risk of injury, but also increase horizontal power and improve performance. It is not uncommon for a collegiate rower to begin his or her career in college. Therefore, the clinician should assess an athlete's joint mobility and strength to ensure he/she has the proper biomechanics and mobility to adequately complete a full long powerful rowing stroke prior to competition.

Low Back Pain with Radiculopathy in a College Baseball Athlete

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Background: Athlete is a 20 year-old (72 inches and 186lbs) male NAIA baseball athlete. Athlete's prior medical history includes left labrum tear with shoulder stabilization surgery 18 months prior. Athlete reported to athletic trainer following competition and weight training complaining of general low back pain extending into his left buttock for approximately 2 ½ weeks duration. Athlete denied any specific mechanism. Initial evaluation revealed no obvious deformities, gross pelvic obliquity, or signs of trauma. Athlete was point tender over left SI jt., gluteus maximums, and left hamstrings. Full Active ROM and strength with hip flexion, extension, abduction, adduction, internal, and external rotation. (+) Faber's Test for Pain, (+) Slump Test, (+) SLR test (+), Ober and Thomas tests (-). **Differential Diagnosis:** SI Jt. Sprain, Gluteus Maximus strain, Sciatica, Piriformis syndrome, Lumbar Sprain, Lumbar Disc herniation with radiculopathy, Lumbar stress fracture. **Treatment:** Athlete began conservative treatment with athletic training staff with no significant relief after two weeks. Athlete was then referred to physician due to no change in signs and symptoms and the beginning of radiculopathy extending into the left buttock. Athlete underwent physician evaluation with X-ray and MRI without contrast. X-rays were normal, MRI revealed leftward eccentric at L4-5 disc protrusion which contributed to moderate leftward asymmetric recess impingement. Athlete was further treated conservatively with prescription steroids and ongoing therapeutic exercises. With minimal relief and failed conservative treatment, which included epidural steroid injections, through

consultation with the physician, it was decided that the athlete would undergo a L4-5 microdiscectomy. Following surgery, athlete underwent 4 months of intensive rehabilitation. Athlete returned fully to the spring competitive baseball season without complaints or problems. **Uniqueness:** Lumbar back pain is a common complaint found in college athletes. Evidence has indicated that incidence of low-back pain in college athletes varies and, similar to findings in the general population, most back injuries do not involve herniated intervertebral disks. In fact, one 10-year study of college athletes reported that only 7.2% of back pain complaints were related to a disk injury. Although disk herniation is not a frequent cause of sports-related back pain, its treatment is often difficult because of the controversies surrounding non-operative management versus surgery, particularly if the injury occurs during the competitive season. This specific case highlights the use of a microdiscectomy to treat the athlete following the unsuccessful use of conservative treatment. This case is unique because there is no evidence-based research on the outcomes and efficacy of electing surgical treatment versus conservative treatment in returning elite athletes back to competition. Research among the general population indicated that return to activity outcomes is similar between conservative treatment and microdiscectomy surgery for single layer lumbar herniation. Specifically, research has suggested that outcomes of conservative treatment or microdiscectomy in individuals with lumbar disc herniation seemed to be satisfactory in terms of their ability to return individuals to their original levels of activities. Further research has suggested that the 1-year outcomes were similar for patients assigned to early surgery and those assigned to conservative treatment with eventual surgery if needed. **Conclusions:** This case highlights the diagnosis and treatment of an athlete suffering from a L4-5 disc herniation with radiculopathy and his successful return to competition with microdiscectomy intervention. This case further highlights the success of a microdiscectomy in an elite athlete once conservative treatment efforts failed. This single case review refutes evidence applied to the general population suggesting that there is no statistical difference in conservative treatment measures versus microdiscectomies when treating single layer disc herniations. This case further highlights the complexities of treating athletes related to low back pain and the need for early interventions.

Idiopathic Brachial Neuritis in a Collegiate Football Player

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Background: A 22 year old offensive lineman presented with pain in his right posterior shoulder and scapula and numbness and tingling in his right arm and hand. He had a history of right anterior labrum repair two years prior and a rotator cuff strain two months prior. The pain began a few hours after waking and became progressively worse. No previous mechanism of injury was recalled. Numbness and tingling increased from the 4th and 5th digits to his entire hand. There was palpable tenderness of the rhomboid major muscle and spasm of the upper trapezius muscle. Cervical extension, right lateral flexion, and glenohumeral range of motion were decreased. Wrist and hand range of motion was also decreased due to weakness. Patient had diminished dermatomes and myotomes for C6-T1. **Differential Diagnosis:** Nerve root impingement, muscle spasm, neuritis. **Treatment:** Initial treatment included a combination of ice for pain relief and later heat was administered to decrease spasm. Ice decreased the pain while heat dramatically increased his symptoms prompting immediate referral to a physician. C-spine and shoulder x-rays were unremarkable for bony deformity. Patient was placed on oral steroids(Prednisone), pain medication(Loratab) and muscle relaxers(Flexiril). An MRI was ordered when symptoms did not improve after the initial 24 hours and was unremarkable for any type of musculoskeletal trauma. Four days post evaluation there was a decrease in pain, however there was still radicular symptoms and decreased ROM at the glenohumeral joint and wrist/hand. He was referred to a spine specialist, diagnosed with brachial neuritis and Parsonage Turner Syndrome and prescribed Neurontin for nerve-generated pain. Shoulder ROM was within-normal-limits (WNL) after 6 days of treatment and wrist ROM and grip strength were WNL after 10 days. Treatment included gentle range of motion and pain management. Following the return of normal range of motion low level shoulder exercises including internal rotation, external rotation,

scaption and flexion were implemented. Wrist ranges of motion and grip strength were stimulated with warm water submersion and continuous ultrasound on a 1mHz setting was used over the rhomboid major and upper trapezius to facilitate muscle relaxation.18 days from presentation of symptoms and upon the return of full range of motion and strength the athlete returned to participation. On day 19 he had numbness and tingling in the hand with a transient neuropraxia. It was determined that he discontinued use of the Neurontin 24 hours prior. Neurontin was readministered and within 2 days strength was WNL allowing the return to participation. At the 33 day mark the athlete had an insidious episode which resolved in 24 hours and returned to full participation for the reminder of the season. **Uniqueness:** Parsonage Turner Syndrome occurs in 1.64 out of 100,000 individuals in the United States. Most cases resolve within months however recovery can take years after initial onset, most cases are expected to make a full recovery. The cause of reported cases include, viral infection, following surgery or following trauma to the shoulder. Our physician thought this case originated from a virus, which is the most common reported cause. **Conclusions:** Rehabilitation includes pharmaceutical treatment for inflammation and therapeutic exercises to restore range of motion, strength and decrease the chance of atrophy. Symptoms resolved within 35 days and it has been reported that they often last months to year. Cessation of Neurontin treatment should be done gradually. Immediate discontinuation of treatment may result in a return of symptoms, therefore patient education is important. This condition should be considered when a patient presents with insidious onset of unilateral shoulder pain followed by neurological symptoms of the upper extremity.

Pneumomediastinum in a Division III Golfer

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Background: A 19 year old male Division III golfer experienced a sudden onset of chest pain following a fall on his right shoulder from a height of approximately one-two feet during a morning weight lifting session. Patient also stated that while weight lifting, he was holding his breath creating valsalva maneuver during some exercises. Patient was not on any medications and had no drug allergies. Patient did not have any previous pertinent medical history. After an increase in chest pain, Patient went to emergency department on his own, prior to evaluation by athletic training staff. **Differential Diagnosis:** Pneumothorax, esophageal perforation, injury to ribs, sternum, or costochondral cartilage, cardiac disease, or allergic reaction. **Treatment:** Upon exam at the emergency department, patient complained of chest pain rating 3/10. He had a brief fever with vital signs within normal limits. Patient was alert and oriented, with mild distress due to chest pain. ENT exam was unremarkable. Breath sounds were equal with symmetrical chest wall expansion. Breath sounds revealed crackles. Laboratory reports showed elevated WBC, protein total, albumin level, bilirubin total, and hemoglobin. The results also showed decreased sodium level, chloride level, and osmolality. Initial chest x-ray showed moderate pneumomediastinum and a non-contrast CT scan showed small right apical pneumothorax. A pneumomedaistinum is defined as free air in the mediastinum of the lungs. Barium Esophagram showed no evidence of extraluminal leakage. The emergency room doctors prescribed 650mg of acetaminophen every six hours for fever reducer and pain reliever. He was given 800mg of ibuprofen for pain relief every six hours. The patient spent two days in the hospital and was discharged on the third day. During his time in the hospital, he was prescribed rest and was monitored closely. He followed up with athletic trainers and team physician for further treatment. He was held from participation and was scheduled for a follow-up appointment one week later. Another chest x-ray was taken and compared to the initial chest x-ray; pneumomediastinum was no longer present. Patient reported improvements since being discharged from hospital. Patient returned to full activity, with gradual return to weight room. **Uniqueness:** Pneumomediastinum is rarely seen in athletics. Most sports related cases are seen in contact sports, high altitude, or underwater activity. More specifically, pneumomediastinum has been reported in young males participating in contact sports or during weight lifting due to Valsalva maneuver. In this particular case, the pneumomedisatinum could have been caused by the trauma from the fall or the increase in internal pressure from the valsalva maneuver while weight lifting. As an athletic trainer, it is important to be aware of this relatively rare condition and the symptoms that accompany it in order to make proper referrals for chest x-rays and other diagnostic testing. **Conclusions:** In this case, athlete was able to return to full participation a week after being released from the hospital. He was able to complete th season with no complications. Pneumomediastinum is rarely seen in athletics. The individual may have discomfort with movement and deep inspirations. Chest x-rays are needed to diagnose a pneumomediastinum and to rule out a pneumothorax. Often, pneumomediastinum are treated with NSAIDs for pain and rest, allowing it to close on its own. Patient should be monitored daily for any change in symptoms. Follow-up chest x-rays should be taken to determine if pneumomediastinum has resolved, which typically will resolve in a few days. After complete resolution of pneumomediastinum, individual can return to activity with no restrictions.

Spontaneous Pneumomediastinum in a Collegiate Sprinter

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Background: Nineteen year old female collegiate sprinter reported feeling chest pain beginning midafternoon and continued to worsen through the evening. She reported an insidious onset of symptoms, described the pain as stabbing which worsened while taking a deep breath. Pain did not radiate. She reported to the Athletic Training room and had a pulse of 92, blood pressure 115/82 mmHG, and was afebrile. She reported no other symptoms other than central chest pain. Patient participated in weight training and practice more than four hours before onset of symptoms with no issues. Patient has a history of asthma, but reported not having to use her inhaler or any complications in past year. She also recently returned from a competition nine hours drive away. **Differential Diagnosis:** Gastroesophageal Reflux Disease, Blood clot **Treatment:** Patient was transported and admitted to the emergency room. Patient was initially given an analgesic GI drink that did not lessen her symptoms. Chest X-ray and blood test was ordered to determine if a blood clot was present. X-ray showed no remarkable results, while blood tests revealed a possible blood clot. Chest CT scan was ordered and revealed a spontaneous pneumomediastinum (SPM). The patient was admitted into the hospital by the pulmonology department for observation, and was discharged within 24 hours of arriving in the emergency room. The hospital pulmonologist prescribed rest and narcotics for pain management, which the patient chose not to fill. Patient was restricted from all physical activity for two weeks, and restricted from all air travel for three months. She reported a gradual decrease in pain during the first two days after being discharged from the hospital. She complained of some associated shortness of breath. By the third day she had no chest pain or dyspnea. Because of a need to fly for the conference meet, the patient requested a second opinion and followed up with a pulmonologist 11 days after discharge. The pulmonologist allowed a full but gradual return to track activities, but limited patient to lifting anything more than 10 pounds to reduce large increases in intrathoracic pressure. The patient also underwent a spirometry test to measure lung function for a previous history of asthma that was normal. The pulmonologist however, recommended use of an albuterol inhaler during the return to activity progression. He also adjusted the restrictions on air travel, permitting the patient to fly for the conference track meet 5 weeks after symptoms resolved. **Uniqueness:** To the best of our knowledge, this is the first reported case of SPM in a collegiate sprinter. SPM has previously been reported mainly in young male athletes, and most often after trauma, and there is very little evidence of reported treatment and return to activity protocols. **Conclusions:** Patient recovered fully and returned to practice 14 days after discharge from hospital. She was limited in the weight room to body weight exercises for the duration of the season, but returned to full participation in practice. Patient completed a successful season, qualifying for the NCAA first round competition. She reported no complications or return of symptoms through the duration of the season, showing that full recovery is possible and expected following SPM. SPM is a rare condition that should be considered in a differential diagnosis of chest pain, especially following intense Valsalva maneuvers.

First Rib Fracture and Pneumothorax in College Football Player: A Case Report

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Background: A 21-year old male Division I Football wide receiver (height 187.96 cm. weight 95.25 kg) presented with pain in his chest wall after diving for a ball during a football game. The athlete was running down the sideline and stretched to catch the ball. He landed on his left shoulder and upper chest and had immediate pain in these areas. The athlete reported to the athletic trainer with difficulty with deep inspiration. His voice sounded more hoarse than normal. The athlete had no prior history of rib fractures, pneumothorax, or any respiratory condition. After a few minutes the athlete felt referred pain to his right chest wall. The athlete was then referred to the team physician for further testing. **Differential Diagnosis:** Posterior sternoclavicular displacement, glenohumeral subluxation, intercostal strain, rib fracture. **Treatment:** X-rays of the ribs taken at the time of injury were negative. He was told to rest and take Aleve as needed for pain. Over a 48-hour time span, the athlete's symptoms minimally improved, but he reported still having chest pain and orthopnea. The team physician's systemic review found no outstanding findings, with vitals being normal. A follow up CT scan of the chest done two days post-injury revealed a right-sided pneumothorax of less than 10%, inferring no evidence for need of a chest tube, pneumomediastinum extending into the soft tissues of the neck, anterior chest wall and supraclavicular regions. In addition, a nondisplaced first rib fracture, posterior subluxation of the 1st left costochondral joint, and subcutaneous emphysema was found. The athlete was informed of his injuries and told to monitor signs and symptoms for worsening respiratory status. The athlete was prescribed a bone stimulator for 4-6 weeks to help with healing the first rib fracture. One week post- injury the athlete progressively improved, as

vocal tone and deep inspiration returned to normal. Seventeen days post-injury, the pneumothorax and subcutaneous emphysema both resolved. The 1st rib fracture and costochondral subluxation were stable. The team physician cleared him to begin light cardiovascular exercises after 4 weeks from the initial injury and to participate during non-contact practice. The athlete was cleared for full participation 5 weeks post-injury. **Uniqueness:** The athlete presented with numerous life threatening injuries. The initial x-ray was negative for fractures; however, follow up imaging revealed a fracture. The athlete's initial pain on the left shoulder and chest area migrated to the right side chest and shoulder within minutes. Pneumomediastinum, defined as air in the mediastinum, is an uncommon condition that occurs in up to 10% of patients with blunt thoracic and cervical trauma. **Conclusions:** Athletic trainers should always be aware of signs and symptoms of respiratory medical emergencies. It is important to request follow up diagnostic imaging to ensure the athlete's safety and health. A request of CT imaging allows the medical staff to see conditions like pneumothorax and pneumomediastinum that normal x-rays cannot see. This benefit's the athlete and allows the sports medicine team to properly address the situation and develop a return to play protocol.

Double Nerve Transfer in a Recreational Alpine Skier: A Case Study

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Background: A 25 year old healthy male recreational alpine skier injured his shoulder during a fall. The patient stated his shoulder contacted a rock during the collision. The patient complained of immediate pain in his right shoulder and numbness on the lateral aspect of his right shoulder and upper arm. Initial examination revealed weakness resulting in an inability to abduct the right arm. Deformity of the right distal clavicle was also apparent. **Differential Diagnosis:** Fractured clavicle, fractured scapula, fractured acromion process, dislocated shoulder, brachial plexus injury, supraspinatus rupture, axillary nerve injury, suprascapular nerve injury. **Treatment:** The patient was sent to the emergency room where a CT scan confirmed the presence of a fracture along the lateral border of the right scapula and fracture of the right clavicle near the acromion process. The patient was placed in a sling for six weeks to allow for the clavicle and scapula to heal. After five months the patient was still unable to contract the deltoid or the teres minor muscles. Electromyographic testing indicated a loss innervation of the suprascapular nerve. A nerve conduction test indicated no innervation of the axillary nerve or suprascapular nerve. The decision was made for the patient to undergo double nerve transfer surgery. A double nerve transfer surgery was performed with the goal of restoring function of the axillary and suprascapular nerves. Currently the patient is 26 months post-surgery. The patient began physical therapy at nine months post-surgery when innervation initially returned to the posterior deltoid and supraspinatus muscles. Nerve transfer surgeries require extensive healing time and may not reestablish full innervation and functional abilities that were present prior to injury. Rehabilitation requires the re-innervation of the muscles before full therapy can be initiated. **Uniqueness:** Scapular fractures are rare in sports, requiring a significant traumatic force as the mechanism of injury. The patient lost innervation of both his supraspinatus and his deltoid muscle. The patient underwent a prolonged period of time with limited progress toward restoring innervation to the specific musculature and loss of innervation from the suprascapular nerve. The double nerve transfer surgery is uncommon. A confounding factor was a clavicle fracture which went unhealed and is still displaced. This case is important as it highlights the need for athletic trainers to be prepared to assist patients with long-term recovery after traumatic injury. Further, with cases like this, athletic trainers need to be ready to help patients in coping with possible terminal loss of function. **Conclusions:** The skiing injury resulted in a complete loss of muscular function. A of double nerve transfer was utilized to try to reestablish muscular innervation and function. This patient began physical therapy after signs of re-innervation to the musculature. Range of motion has returned to near pre-injury level compared bilaterally. The clavicle fracture is still displaced and surgical repair of the fracture is currently being discused.

Duplicate Hypertrophic Reversed Palmaris Brevis Muscle: A Case Report

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Background: A 16-year-old female rugby athlete complained of sudden onset of right wrist pain while flipping a large military style tire weighing approximately four hundred pounds. Upon assessment she did not report feeling or hearing a pop. There was nothing remarkable other than swelling and tenderness over the anterior aspect of the wrist and distal forearm. The patient was diagnosed with a contusion and treated symptomatically for pain and inflammation. The patient noted improvement over the next couple weeks as she rested the hand, however any time she tried to return to activity the volar aspect of her wrist swelled and became very painful. The pain prevented her from participating in rugby and other recreational activities. Because she is right hand dominant, activities of daily living also began to cause her discomfort. Upon reassessment, there were no changes regarding symptoms and no changes with regards to the appearance of the hand. Because the injury did not respond as a typical contusion would, the patient was referred to a physician for further assessment. **Differential Diagnosis:** Ganglion cyst, flexor carpi ulnaris rupture, aberrant palmaris longus, palmaris brevis sign, rheumatoid arthritis, tenosynovitis, carpal fracture and tumor. **Treatment:** Upon physician assessment, the patient had full elbow and wrist range of motion and she was able to make a composite first. She reported some diminished sensation over the ulnar digits and had a small non-pulsatile mass on the volar aspect of the wrist. The physician's initial diagnosis was a ganglion cyst or a flexor carpi ulnaris rupture. Magnetic resonance imaging (MRI) revealed an unknown mass in the wrist. Due to concern for a tumor, the patient and her family chose to have surgical exploration after consultation with the physician. During surgery, the surgeon discovered an anomalous muscle mass that was hypertrophic and extended eight centimeters proximally along the forearm. The mass was then excised. The physician determined that the excised muscle was an aberrant revered palmaris brevis muscle due to its origin along the transverse carpal ligament. **Uniqueness:** While an anomalous palmaris longus muscle is commonly described and other aberrant muscles identified, an aberrant palmaris brevis is unique. In fact, to our knowledge this is the first case of an aberrant revered palmaris brevis muscle. Even more unique is its large size and the fact that it continued proximally along the forearm instead of distally into the hand. Although an anomalous muscle is uncommonly associated with ulnar nerve compression at the wrist, it is likely that the decreased sensation reported by the patient was due to ulnar nerve compression by this muscle. **Conclusions:** It is important to understand the anatomy of the hand and the occurrence of a duplicate muscle. An unknown mass can be attributed to an anatomical abnormally rather than an acute injury or benign growth. Nerve compression by an anomalous muscle can lead to further complications. Since removal of the muscle, the patient has returned to full activity without complication.

Treatment of an Osteochondritis Dissecans of the Capitellum: Allograft Cartilage Matrix in an Adolescent Overhead Throwing Athlete

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Background: A 15 year old healthy, right hand dominant male baseball catcher and ice hockey forward, presented with right elbow pain and stiffness. Pain was described as ongoing and worsening over the past few months following baseball season. The patient described an insidious onset of injury. Physical examination revealed moderate effusion of the elbow and active range of motion(ROM) of 135 degrees of flexion and 25 degrees from full extension. At end ROM the patient described pain with extension, pronation and supination. Valgus stress test was positive, with no tenderness over the medial aspect of the elbow. All other special tests were negative. **Differential Diagnosis:** Ulna collateral ligament sprain, Panner's Disease, osteochondritis dissecans(OCD), avascular necrosis, apophysitis of the medial epicondyle, loose bodies, proximal ulna fracture, distal humerus fracture. **Treatment:** Radiographs revealed a lesion on the capitellum. Magnetic resonance imaging(MRI) revealed a 9mmx15mm lesion in the anterior-inferior aspect of the capitellum and multiple loose bodies. The patient was diagnosed with an OCD lesion of the capitellum with multiple loose bodies. The patient underwent arthroscopy, removal of loose body, extensive debridement, synovectomy, and microfracture. Following the microfracture an allograft cartilage matrix was placed in the defect and covered with a fibrin sealant. Following surgery the patient was placed in a hinged elbow brace for 6 weeks and began full active and passive ROM. At 6 weeks, the patient had no pain, effusion, or tenderness. The patient was 10 degrees from full flexion, 5 degrees from full extension,

and 20 degrees from full pronation. The patient's rehabilitation progressed to include gentle non-impact shoulder and elbow strengthening exercises. Clearance to begin weight lifting and ice hockey was given at 6 months. The patient was released to skate, practice puck/stick drills, but prohibited from contact activities. At 9 months the patient was released to activity, including baseball with no restrictions. **Uniqueness:** Elbow injuries in adolescent baseball players are common, with most injuries being "little league elbow" affecting the medial apophysitis. Less commonly seen are OCD lesions of the capitellum, only occurring in 1.3% to 1.6% of little league baseball players. This case is unique not only because of the type of injury, but also because of the surgeon's treatement of the lesion; preference to use allograft cartilage matrix as opposed to an osteochondral autograft transfer system(OATs). Due to the size and margins of the lesion the surgeon felt an allograft cartilage matrix implant would be a better choice over an OATs procedure, which is more commonly used with unstable and very large OCD lesions. The use of an allograft cartilage matrix is an advancing technology that has been used in knee and ankle OCD lesions with good preliminary results. There is little research on its use and outcomes in elbow OCD lesions and further research is needed in this advancing treatment in order to document outcomes and improve patient care. **Conclusions:** At 9 months following surgery the patient returned to full activity including baseball with full ROM and no pain. Athletic trainers may see young throwing athletes who have insidious onset of lateral elbow pain. A thorough and timely assessment should be done to rule out medial apophysitis or an OCD lesion. Early treatments of OCD lesions may prevent irreversible chondral damage and the need for surgery. If unrecognized and left untreated the OCD lesion may increase in size and loose body formation may occur leading to surgical intervention.

Wrist Pain in an Intercollegiate Football Player

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Background: A 22 year-old, male running back with no significant history presented to the AT on the sideline during a game with severe left wrist pain and paresthesia secondary to falling on outstretched hand. On-site evaluation revealed dorsal carpal deformity with diffuse swelling and tenderness, wrist flexor paralysis, and hypoesthesia over the palm, index and middle fingers. **Differential Diagnosis:** Scaphoid fracture, wrist sprain, wrist strain, TFCC tear, lunate dislocation, perilunate dislocation, median neuropathy. **Treatment:** The patient was disqualified from activity, splinted, iced, provided home care instructions, and referred to the team orthopedist. Status-post two days, radiographs identified a complete dislocation of the distal row of the carpus relative to the lunate, without fracture, with the lunate articulating with the radius. A CT scan further revealed an associated lunate volar tilt and anterior cortex impaction and distal radius impaction. The orthopedist preliminarily diagnosed the patient with a perilunate dislocation, and consulted with a hand specialist to determine appropriate care. The patient was re-splinted, instructed to continue icing, prescribed analgesics, and referred to a hand specialist. Status-post four days, the patient continued to experience pain and paresthesia. The hand specialist identified diffuse ecchymosis, swelling, deformity, tenderness, limited motion, and intact neurovascular function. The patient was definitively diagnosed with a dorsal perilunate dislocation with a median neuropathy. Two days later, he underwent a volar and dorsal open reduction K-wire fixation, median nerve decompression, and ligamentous repair. Status-post two months, the cast and K-wires were removed and the patient began rehabilitation consisting of thermotherapy, manual therapy, and aggressive wrist ROM and grip strengthening exercises. Status-post three months, radiographs revealed a volar compartment deformity to the lunate with associated degenerative changes. The patient continued rehabilitation focusing on wrist mobility, while restraining from strengthening exercises. Status-post four months, demonstrating improved motion, but still suffering from pain, the patient was cleared to begin non-weight bearing strengthening exercises. Status-post five months, examination identified continued pain, CKC activity difficulty, and dorsal wrist swelling. Radiographs revealed a scaphoid avascular necrosis. The patient was prescribed a transdermal NSAID, continued rehabilitation, and was cleared to progressively return to athletic activity. Status-post seven months, the patient reported continued pain, especially with CKC activities. Radiographs revealed cystic changes about the scaphoid and lunate. The patient was instructed to continue rehabilitation, focusing on strengthening, and was discharged from the hand surgeon's care. Status-post eight months, goniometric measurements identified 20° wrist extension deficiency. The patient reported full UE function, but experienced pain with some activities. The patient was never able to return to intercollegiate football; however, he graduated and passed the police academy physical fitness test. **Uniqueness:** Wrist sprains are a common UE injury; however, perilunate dislocations are uncommon, and even rarer in athletics because they characteristically result from a fall from a height or motor vehicle accident. Volar perilunate dislocations are seen more often than dorsal, with an estimated 3% incident rate of all wrist injuries; however, the incidence rate of dorsal dislocations remains unknown given their rarity. **Conclusions:** The wrist is an intricate structure providing an infinite number of carpal positions and motions. Perilunate dislocations result from a forceful axial load, combined with wrist hyperextension and ulnar deviation, causing carpal rotation. It is characterized by a lunate still within the fossa with respect to the distal radius, while all other carpal bones are dislocated. The effect of this injury can be subtle and complex. Significant

wrist injuries such as a perilunate dislocation are associated with a high prevalence of long-term pain and dysfunction. Despite optimal management, the prognosis is relatively poor given the high incident of post-traumatic arthritis causing losses in motion and strength.

Shoulder Pain in an Intercollegiate Basketball Player

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Background: A 21 year-old male basketball player sustained a left shoulder injury secondary to swatting a basketball while reaching for a rebound. He reported immediate severe left shoulder pain and paresthesia. On-site examination revealed a glenohumeral sulcus and an unwillingness to move. The shoulder spontaneously reduced with motion during examination. The patient then demonstrated normal distal pulses and motor and sensory function. The patient's previous medical history was significant for an anterior shoulder dislocation on the contralateral extremity. **Differential Diagnosis:** anterior glenohumeral dislocation, long head biceps tendon (LHBT) strain, SLAP lesion, Bankart lesion, Hill-Sachs lesion. **Treatment:** Status-post 20 minutes after icing, the tingling resolved and the patient was placed in a sling and referred to the team orthopedist. Status-post one day, the orthopedist ordered radiographs which identified a radiographically normal shoulder. The patient was diagnosed with a traumatic left shoulder dislocation, disqualified from basketball for three weeks, immobilized with a sling, and prescribed rehabilitation. Initial rehabilitation consisted of physical agents, ROM exercises, and isometrics. He was permitted to progress as tolerated to include rotator cuff strengthening and stabilization exercises. Status-post three weeks, the patient was cleared for participation with limited repetitions after demonstrating pain-free function in overhead provocative positions with a glenohumeral orthosis. Status-post two months, the patient's shoulder dislocated again during practice secondary to blocking a shot. He was immobilized with a sling and referred back to the team orthopedist. A second set of radiographs was ordered which also identified a radiographically normal shoulder. An MRI was ordered and revealed a torn and inferomedially displaced labrum and a Hill-Sachs lesion. Also, the LHBT was not visualized at either its attachment to the superior labrum or within the bicipital groove. Follow-up physical examination attempted to determine whether the lack of a LHBT was an anatomic variation or a proximal biceps rupture without distal migration. Visual inspection did not reveal a "popeye" deformity, and selective tissue tests resulted in negative Yergason's and speeds test. The patient demonstrated anterior instability with glenohumeral testing and was definitively diagnosed with an anterior glenohumeral instability and underwent a capsular reconstruction status-post three months. During the procedure, the LHBT was not visualized and it was concluded that its absence was an anatomic variation. Status-post five months, the patient demonstrated appropriate healing and was permitted to begin rehabilitation focusing on anterior glenohumaral dynamic stability. Status-post eight months, the patient demonstrated a full recovery; however, he was unable to return to intercollegiate basketball due to a lack of remaining eligibility. He graduated and is not expected to have further complications. **Uniqueness:** Congenital absence of the LHBT is extremely rare. Although the exact prevalence of this anomaly is unknown, only a handful of cases are reported in the literature. This congenital absence has been associated with other congenital anomalies; however, this patient was otherwise healthy. **Conclusions:** Congenital absence of the LHBT occurs as the result of an insult to the fetus at six to seven weeks of pregnancy, at which time the tendon is forming. The anomaly contributed to the shoulder instability. Data from electomyographic, cadaveric, and clinical studies suggest that the LHBT contributes to anterior stability of the glenohumeral joint in overhead positions through a proprioceptive function, and by increasing the shoulder's resistance to torsional forces in the abducted and externally rotated position. The LHBT also helps to diminish the stress placed on the inferior glenohumeral ligament. Given the lack of the LHBT, the rehabilitation program specifically focused

on improving dynamic anterior instability to compensate for the absent LHBT. Lastly, bilateral diagnostic imaging should be considered for this patient given this congenital anomaly usually occurs bilaterally.

Wrist Pain in an Intercollegiate Baseball Player

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Background: A 21-year-old, male intercollegiate outfielder presented to the AT with sharp left radiovolar pain secondary to hitting that had been present for three weeks. The patient reported hearing a pop, followed by severe pain without paresthesia or crepitus. During those three weeks, the patient continued to play, with pain ceasing at rest and increasing with swinging. The pain and disability increased; and the patient could no longer swing despite self-taping his wrist. Initial evaluation revealed tenderness over the scaphoid tubercle and anatomical snuffbox. Watson's test was negative. Functional testing identified uneasiness with handshaking and gripping objects. **Differential diagnosis:** Flexor carpi radialis strain, scaphoid impaction syndrome, scaphoid fracture, Preiser's disease, scapholunate dissociation. **Treatment:** Status-post three days, the patient was seen by the team orthopedist who confirmed the AT's findings and ordered radiographs, which were unremarkable. The orthopedist preliminarily diagnosed the patient with flexor carpi radialis tendinopathy, prescribed NSAIDs, disqualified the patient from batting, and ordered an MRI. The MRI revealed a scapholunate ligament (SLL) tear through the membranous portion. The patient was placed in a short-arm splint and referred to a hand specialist. Status-post one week, the hand specialist conservatively treated the patient by casting him. Status-post five weeks, the cast was removed and the patient was prescribed rehabilitation. He was cleared for light activity and began a modified hitting program with a wrist orthosis. Status-post two months, the patient reported dorsal wrist pain and was referred back to the hand specialist who recommended decreasing rehabilitation intensity and disqualified the patient from hitting. Status-post 10 weeks, unhappy with the progress, the opinion of a second hand specialist was obtained. Evaluation elicited positive SLL tenderness and a positive Watson's test. Radiographs revealed a scapholunate gap and the patient was definitively diagnosed with a scapholunate dissociation secondary to an SLL tear. The patient underwent arthroscopic SLL debridement and reduction with internal fixation consisting of two K-wires, and casted. Status-post four months, follow-up radiographs identified restored scapholunate alignment and the two K-wires were removed. The patient was prescribed a wrist orthosis and rehabilitation. Status-post five months, the patient was asymptomatic. Repeated radiographs revealed maintained scapholunate alignment. The patient was instructed to wear the orthosis at night and was cleared for throwing, swinging off the tee, and allowed to progress while focusing on restoring muscular strength during rehabilitation. Status-post eight months, the patient did not report discomfort with activity, but demonstrated 15° extension and a 25° flexion deficit. He was cleared for full activity with supportive wrist taping. His return to baseball did not elicit any complications. **Uniqueness:** Scapholunate disassociations characteristically occur as a result of falling on an outstretched hand, with the forearm in pronation and the wrist hyperextended, and present with crepitus and a positive Watson's test. However, this injury resulted from a non-weight-bearing activity causing forced wrist extension and rotation, and the patient initially presented without crepitus and a positive Watson's test. A majority of scapholunate disassociations also involve a fracture; however, this patient suffered an isolated SLL tear. **Conclusions:** The scapholunate articulation creates a stable column for wrist function, and the SLL plays a key role in maintaining carpal stability. The smallest disruption of this ligament leads to instability, dysfunction, and degeneration. SLL tears and subsequent disassociations can occur as a result of OKC or CKC MOIs causing forced wrist extension and rotation. Also, clinicians employing the Watson's test, should be aware of its low sensitivity when used acutely. Finally, SLL tears

create an anatomical gap which may not be present on static radiographs, requiring additional images in ulnar and radial deviation and clenched views to identify the scapholunate disassociation.

Hand Pain in an Interscholastic Football Player

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Background: A seventeen-year-old male quarterback with no significant medical history presented to the AT post-game with constant pain secondary to repetitive direct trauma to his right dominate hand during the second game of the season. Initial evaluation identified palmar swelling without ecchymosis, numbness, tingling, and loss of coordination and dexterity. The patient was treated with ice and instructed to follow-up with the AT after the weekend. Status-post two days, the patient reported to the AT continued pain and a new cold sensation in the 4th and 5th digits. Follow-up examination identified lingering palmar swelling, 4/5 finger strength, and normal neurovascular function. He was instructed to continue to ice and was referred to an orthopedist. **Differential Diagnosis:** Contusion, fracture, scleroderma, Buerger's disease, vasculitis, aneurysm, thrombosis. **Treatment:** The orthopedist ordered radiographs, which were unremarkable and no specific treatment was rendered. The patient followed up with the AT and was referred to a hand specialist. Status-post three days, the patient reported to the hand specialist continued constant pain and coldness without tingling, as well as 4th and 5th digit numbness. Physician examination identified ecchymosis, persistent swelling over the palm, tenderness in Guyon's canal, full active motion and intrinsic hand strength, and full neurovascular function. Allen testing revealed absent ulnar artery flow, without bruit or thrill but complete arch filling through the radial artery. The hand specialist definitively diagnosed the patient with Hypothenar Hammer Syndrome (HHS) and prescribed anticoagulants and calcium-channel blockers to enhance recanalization of the ulnar artery, thermotherapy and massage to encourage lysis of the thrombosis, and cleared the patient for athletic activity with the use of protective padding. The patient began treatment with the AT; however, massage was prematurely discontinued due to significant patient discomfort. Status post one-week, the patient was referred to a vascular surgeon who confirmed the diagnosis, but recommended eliminating the anticolgulants. Status-post two weeks, the patient did not report any pain, coldness, or numbness, and was instructed to follow up with the hand specialist. Physician evaluation identified normal capillary refill and neurovascular function; however, Allen testing still demonstrated absent filling through the ulnar artery with complete radial artery filling. The patient was directed to continue using the padding for activity, calcium-channel blockers, and thermotherapy for an additional six weeks. Status-post 10 weeks, the patient was able to successfully complete the season without incident and was generally asymptomatic, except for occasional paresthesia in the 4th phalange triggered by cold. Physician evaluation identified a normal extremity; however, Allen testing still demonstrated absent filling through the right ulnar artery. Status-post nine months, the patient was asymptomatic with a normal examination. The hand specialist discharged the patient. His continued athletic participation has not triggered any symptoms or complications. **Uniqueness:** HHS is considered a universally uncommon condition and is even rarer in athletics. HHS is primarily associated as an occupational injury caused by repetitive microtrauma to the hypothenar eminence in occupations such as mechanics, machinists, and carpenters, rather than acute sport-related trauma. **Conclusions:** Athletes can experience hand pain caused by vascular insufficiency. Ischemia in the hand can have a number of causes. One unusual cause is HHS, which is described as a vascular overuse syndrome creating an ulnar artery occlusion; however, an ulnar artery thrombosis can also be caused by acute trauma to the palm. Patients can present with hand pain, swelling, coldness, numbness, and a positive Allen test indicating distal ulnar artery compromise. With a slow insidious progression, HHS

can seem trivial and may consequently be ignored, increasing the risk for embolization. Early referral to the hand specialist who was familiar with HHS, and appropriate treatment avoided permanent disability.

Isolated Subscapularis Rupture in a Collegiate Baseball Player

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Background: A 19 year-old male baseball player complained of right shoulder pain after relief pitching in both games of a doubleheader. He denied any history of trauma. He was evaluated and found to have pain and point tenderness over the middle trapezius and rhomboid muscles. No pain or weakness was noted with manual muscle testing of the deltoid and rotator cuff muscles. Special tests for both joint laxity and labrum pathology were negative. Interestingly, he also played third base in the game and did not have pain with throws to first. Initially, he discontinued throwing for two weeks and began a rotator cuff and scapular muscle strengthening regimen. Treatment also included relieving trigger points with electrical stimulation, ultrasound and massage in the scapular region and exercises for shoulder flexibility and range of motion. After two weeks, a throwing program was initiated but the athlete again reported pain to the posterior shoulder. He was referred for orthopedic evaluation and noted to have positive apprehension and rhomboid-levator spasm. He was prescribed an oral prednisone taper and continued therapy for an additional two weeks. The conservative measures failed to return him to pitching off the mound thus he was referred to a different orthopedist for a second opinion. The second physician noted special tests for shoulder joint laxity and labrum pathology to be negative and manual muscle testing within normal limits. **Differential Diagnosis:** Rotator cuff tendonitis, SLAP lesion, glenohumeral subluxation or humeral stress fracture. **Treatment:** An MR-arthrogram was ordered and showed a high grade injury and 1/3 tearing of the inferior subscapularis muscle-tendon unit. The long head of the biceps had no changes and the labrum was intact. No evidence of rotator cuff impingement and no arthritic changes to the rotator cuff itself were noted. Because the athlete showed no subscapularis dysfunction and no shoulder instability he was permitted to keep playing third base but refrained from pitching for the rest of the season. The athlete continued his shoulder rehabilitation program and finished the regular season with no further incident. He maintained his rehabilitation program during the off-season and threw only a long-toss program. The athlete returned to school for the Fall season and returned to pitching off the mound without discomfort. **Uniqueness:** According to the literature, isolated subscapularis tears occur in about 10% of patients with rotator cuff tears and are frequently associated with pathology of the tendon of the long head of the biceps. Some authors claim that during surgical repair of the rotator cuff that subscapularis tendon tears can be found as high as 30%. Subscapularis tears are generally non-traumatic and associated with intrinsic degeneration, subcoracoid impingement and/or antero-superior impingement. Subscapularis lesions are less common than tears of the supraspinatus and the infraspinatus tendons. Most authors agree that in the older population partial thickness tears can be treated conservatively but in younger patients either open or arthroscopic repair is beneficial for full or partial thickness tears. **Conclusions:** This case demonstrates the necessity of prompt recognition and treatment of an unusual rotator cuff muscle injury. Subscapularis rupture should be in the differential diagnosis of athletes who present with insidious shoulder pain especially with pitching. This case supports the non-operative management and care of an isolated partial tear of the subscapularis muscle even though the supporting literature advocates surgical intervention. Rest and activity modification along with a progressive return to play is recommended for non-surgical cases. The athlete at this time is asymptomatic and has returned to all athletic and daily living activities.

Nonunion of a Distal Lunate Fracture in a Judo Military Cadet

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Background: An 18-year-old African American female judo Cadet presented to the athletic training room with severe left wrist pain. She was injured by hyperextending her wrist while blocking a teammate. Upon initial palpation, the Cadet's pain was diffuse throughout the wrist and hand. Palpation of the distal ulna elicited excessive rotation in and out of the ulnar-carpal junction compared bilaterally. Strength tests were equal, but ROM was limited due to pain. There were no signs of fractures at the initial evaluation. During a follow up evaluation, the Cadet was markedly weaker, especially in her finger extensors and exhibited a greater deficit in ROM. The Cadet has no prior history of upper extremity injury. **Differential Diagnosis:** Scaphoid fracture, extensor strain, perilunate, lunate, or mid-carpal dislocation, scapho-lunate ligament collapse, traumatic neuropathy, acute carpal tunnel syndrome. **Treatment:** The athletic trainer treated the Cadet over the course of eight months. Initially, the Cadet was given a cock-up wrist brace and treated with ice and compression. She reported for rehab daily and was evaluated by an orthopedic surgeon 5 days post-injury. The physician prescribed naproxen sodium twice a day for 10 days and recommended x-rays due to her generalized pain. The x-rays demonstrated a displaced fracture of the distal portion of the lunate. She was casted for 4 weeks and a follow-up set of x-rays were taken prior to cast removal. The x-rays revealed the fracture did not heal, but the Cadet conveyed being pain free. She reported for rehab daily for one month before leaving for summer training. The Cadet was restricted militarily from physical fitness tests and upper body activities that would aggravate the wrist joint during summer training. Upon returning from summer training two months later, the Cadet had 75% ROM and no specific weakness complaints. However, she often experienced moderate to severe pain (7/10) and soreness in the ulnar-carpal junction the day after loading activities such as push-ups and pain in ADL such as turning a doorknob. After a follow-up with the physician, an arthrogram was ordered to evaluate soft tissue integrity along with a third set of x-rays. The MRI confirmed a perforation of the TFCC, a scapholunate ligament tear, and the previously identified distal lunate fracture. The x-rays did not display evidence of lunate fracture displacement, impingement on the fragment, or osteonecrosis (Kienboeck disease). The physician recommended the conservative treatment to include returning to a wrist splint and performing rehab twice a week. On alternate days, paraffin treatments and mobilizations were utilized to assist in deficiencies in ROM. The Cadet decided to take a year off of judo training to allow the injury to heal. At the time of this study, she had achieved full ROM with no pain and was continuing to be monitored for osteonecrosis. She had returned to all activities without limitations. **Uniqueness:** Distal lunate fractures, specifically coronal fractures of the dorsal pole such as this one, are fairly rare, especially in the Cadet population. While nonunion of this type of fracture is fairly typical, lack of osteonecrosis is rare; typically, conservative treatments fail and surgical methods are recommended to prevent further complications of osteonecrosis. **Conclusions:** As seen with this Cadet, distal lunate fractures can be treated conservatively, even when other soft tissue injuries are also present. However, the fracture must be closely monitored to ensure that osteonecrosis does not occur. Rehabilitation and use of modalities can assist in the healing process and allow a high level athlete to return to all activities without pain.

The Type of Biofeedback has No Influence on Transverse Abdominis Activation

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Context: Transverse abdominis (TrA) dysfunction has been linked to low back pain (LBP). Biofeedback, such as diagnostic ultrasound (US) and pressure biofeedback (PBU) are becoming popular interventions to educate patients on proper activation of the TrA. However, there has been no research comparing the two biofeedback tools. **Objective:** To compare US and PBU on TrA activation during a single intervention session in healthy volunteers. **Design:** Controlled laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Fifty asymptomatic individuals: 27 females and 23 males (age: 22.2 ± 3.4 yrs, height: 172 ± 7.7 cm, mass: 73.1 ± 11.7 Kg) volunteered. **Intervention(s):** The participant was placed in the hook-lying position with the right TrA prepped for imaging with ultrasound gel. Three baseline images were taken of the TrA during rest and an ADIM contraction via ultrasound imaging without the participant looking at the monitor. Then, each participant was randomly assigned to one of four biofeedback groups: US, PBU, US+PBU and control. The participant used the assigned biofeedback and performed ten ADIMs with verbal instruction from the examiner: "inhale, exhale, and draw your belly button to the spine". The contraction phase was held for 5 secondsfollowed by 15 seconds rest. The US group was shown which muscle was the TrA and to try and make that muscle appear larger during the verbal cue. The PBU group had a pressure unit placed under the small of the back that was inflated to 40 mmHg. The participant held a pressure gauge and was instructed to keep the needle near the inflated value without deviating more than 2mmHg during the verbal cue. The US+PBU group was able to use both methods of biofeedback at the same time. The control group only received the verbal cue. After the 10 ADIMs were complete, the biofeedback was removed and 3 images were taken of the TrA during rest and an ADIM contraction. **Main Outcome Measures:** TrA activation ratio was calculated (contracted state/rested state) before and after the 10 ADIMs. The average of the 3 trials was used for data analysis. A 4x2 repeated measures ANOVA was used to compare TrA activation across groups. **Results:** There were no significant interactions for any of the post-intervention activation measurements among groups ($p = .501$). The US, PBU, US+PBU, and the control group were all able to activate the TrA similarly. There was also no main effect for TrA activation across time, indicating the TrA did not change thickness following the 10 ADIMs ($p = .207$). **Conclusions:** In a healthy population, it appears the use of biofeedback tools does not change TrA activation ratio. This may be due to a ceiling effect, where there is minimal room for improvement. It is unknown how these biofeedback tools would work in a population with LBP.

Core Musculature Clinical Test Measurements in Runners Enrolled in a Marathon Training Program

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Context: Over the past decade, participation in running has increased by >140% in the U.S. Unfortunately, up to 80% of runners may sustain a running-related musculoskeletal injury (RRMI). During running, the core musculature is responsible for maintaining a stable pelvis and an erect posture. Core musculature weaknesses, specifically the hip external rotators (HER), hip abductors (HABD), and lateral trunk flexors (LTFX), have been associated with RRMIs, but baseline deficiencies in core musculature in runners who sustain an RRMI has yet to be investigated prospectively. **Objective:** Examine baseline differences in HABD and HER strength, and anterior (ANT), posterior (POST), and lateral trunk flexion (LTFX) endurance between female runners who did or did not sustain an RRMI during a marathon training program. **Design:** Prospective cohort. **Setting:** Laboratory. **Patients or Other Participants:** Fifty-six female recreational runners volunteered for the study (39.07 ± 9.6 yrs, 165.78 ± 7.6 cm, 66.76 ± 13.32 kg). **Interventions:** All female runners completed a single, baseline testing session in which they performed HABD and HER strength testing, and ANT, POST, and LTFX endurance tests, bilaterally when applicable. Participants reported RRMIs (lower extremity musculoskeletal injury, related to running that caused ≥1day of interrupted running) during the training, forming the RRMI (n = 16) and Injury-free groups (n = 40) for comparison. **Main Outcome Measures:** Strength tests were performed prior to the endurance tests, with test and limb randomization. Using a hand-held dynamometer, HABD and HER strength

were tested in the supine and prone positions, respectfully. The mean of three trials of HABD and HER strength for each limb was multiplied by the moment arm (Nm) and divided by mass (Nm/kg). ANT endurance was measured as the number of successful curl-up repetitions to a bar set at a normalized height. POST and LTFX endurance was measured as the time (seconds) the participant was able to hold an extended testing position off of a platform. Values of the injured limb (RRMI group) and average of both limbs (injury-free group) were used for comparison. As group data was not normally distributed, Mann-Whitney U Tests with a Bonferroni Correction were performed with significance set at $P \leq 0.01$. **Results:** There were no differences between female runners who sustained an injury during the marathon training program and those that remained injury free for HER (Injured 0.47 ± 0.07 Nm/kg, Injury-free 0.48 ± 0.09 Nm/kg; P = 0.69) and HABD (Injured 1.12 ± 0.32 Nm/kg, Injury-free 1.15 ± 0.27 Nm/kg; P = 0.68) strength, and ANT (Injured 34.06 ± 16.7, Injury-free 25.74 ± 12.94; P = 0.06), POST (Injured 186.35 ± 58.04s, Injury-free 155.22 ± 61.78 s; P = 0.08), and LTFX (Injured 67.98 ± 26.11 s, Injury-free 61.45 ± 25.21 s; P = 0.39) endurance. **Conclusions:** Female runners that sustained an RRMI during marathon training did not present with reduced core strength and endurance at baseline compared to runners who remained injury-free. Strength and endurance of the core musculature might not contribute to the injury, but rather might be the result of the RRMI.

Effects of Testing Position on Resting Transversus Abdominis and Lumbar Multifidus Muscle Thickness

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Context: Ultrasound imaging is a non-invasive way to assess muscle function of the transversus abdominis (TrA) and lumbar multifidus (LM) by measuring the muscle thickness at rest, during movement or through volitional contraction. Dysfunction of the TrA and LM has previously been reported among individuals with a history of low back pain and may increase the risk for future episodes of pain. Previous literature has traditionally measured muscle thickness in unloaded positions, but recent studies have focused on functional positions. However, these multiple testing positions may influence muscle thickness making direct comparisons between previous findings challenging. Understanding the influence of testing position on muscle thickness could provide clinicians with additional information about muscle function of the TrA and LM muscles. **Objective:** To observe the effects of four different testing positions on muscle thickness. **Design:** Cross-sectional study. **Setting:** Clinical laboratory **Patients or Other Participants:** A total of 32 subjects (23 female/9 male, 16 with a history of low back pain and 16 without a history of low back pain, age: 23 ± 7 years, height: 169.51 ± 9.14 cm, mass: 67.26 ± 11.22 kg participated in this study. **Interventions:** Ultrasound imaging of the TrA and LM muscles during tabletop, seated, standing and walking positions. **Main Outcome Measures:** Muscle thickness was recorded at the end of normal exhalation of the TrA and LM muscles in each position using ultrasound imaging and measured for muscle thickness in millimeters. Separate one-way analyses of variance were conducted to determine the effect of position on muscle thickness across the four positions. Post hoc tests along with Cohen's d effect sizes and 95% confidence intervals were conducted for significant differences across positions. **Results:** Muscle thickness differed between positions for both the TrA ($F(3,124) = 4.310$, $p < 0.01$; tabletop: 4.2 ± 1.2 mm, seated: 5.1 ± 0.9 mm, standing: 4.7 ± 1.1 mm, walking: 4.9 ± 0.8) and LM muscles ($F(3,124) = 3.325$, $p = 0.02$; tabletop 28.4 ± 3.5 mm, seated: 28.2 ± 3.5 mm, stand: 30.7 ± 4.2, walking: 30.4 ± 5.0 mm). Muscle thickness of the TrA was lower in the tabletop position to both seated ($p < 0.01$, $d = 0.81$, (0.30,1.32) and walking ($p = 0.02$, $d = 0.61$, (0.11,1.11). Lower LM tabletop muscle thickness was observed compared to both the standing position ($p = 0.02$, $d = 0.59$ (0.09,1.10) and walking ($p = 0.05$, $d = 0.46$, (-0.03,0.96). Additionally, seated LM muscle thickness was lower than both the standing ($p = 0.02$, $d = 0.72$, (0.22,1.23) and walking positions ($p = 0.03$, $d = 0.51$, (0.01,1.01). **Conclusions:** Our results suggest testing position may influence muscle thickness of both the TrA and LM muscles. Although differences in muscle thickness between measures were small, they had moderate to large effect sizes. The clinical importance of these differences should be considered when assessing muscle thickness of the TrA and LM through normalization techniques.

Reliability of Ultrasound Imaging of Transverse Abdominis and Lumbar Multifidus in Various Positions

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Context: Activation of local core stabilizing musculature is often the goal of rehabilitation for low back pain (LBP) and accurate assessment of these muscles can guide treatment. Transverse abdominis (TrA) muscle thickness measures obtained by ultrasound imaging are reliable in resting and standing, but measures in more functional positions have not been established. Reliability of lumbar multifidus (LM) thickness measures in various functional positions is also not known. Activation ratio (AR) of TrA and LM and the preferential activation ratio (PAR), comparing thickness of the TrA to the thickness of the lateral abdominal wall, have been used to further describe the functional performance of these spinal stabilizers using muscle thickness measures obtained via ultrasound imaging. **Objective:** To determine reliability of muscle activation via ultrasound imaging measures of TrA and LM in tabletop, seated, standing and walking positions. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** There were 32 total participants in the study with 16 in the healthy group (age = 20.4 ± 1.8 yrs, height = 167.7 ± 9.0 cm, mass = 65.1 ± 10.8 kg) and 16 with a history of recurrent LBP (age = 24.8 ± 8.9, height = 171.3 ± 9.1 cm, mass = 69.4 ± 11.6 kg). **Interventions:** None. **Main Outcome Measures:** AR of the TrA and LM and PAR of the TrA in tabletop, seated, standing and walking positions were assessed by the same examiner during 2 sessions 24-72 hours apart. Statistical analysis included the determination of intraclass correlation coefficients (ICC) using analysis of variance for each muscle, position and group between sessions. **Results:** Excellent reliability was found in TrA AR between sessions for the healthy participants in tabletop (ICC3, k = 0.903). TrA AR in healthy participants also showed acceptable to excellent reliability in seated (ICC3, k = 0.613), standing (ICC3, k = 0.553), and walking (ICC3, k = 0.737). For the LBP group, TrA AR was excellent in tabletop (ICC3, k = 0.711), acceptable to excellent in seated (ICC3, k = 0.769), standing (ICC3, k = 0.821) and walking (ICC3, k = 0.797). LM AR was moderately reliable in tabletop (ICC3, k = 0.537) for LBP and fair for healthy (ICC3, k = 0.264). The PAR for healthy participants was substantially reliable in tabletop (ICC3, k = 0.668) and seated (ICC3, k = 0.684) and showed fair reliability for walking (ICC3, k = 0.455). The LBP group also had substantial reliability for PAR in the seated (ICC3, k = 0.406) and standing (ICC3, k = 0.512) positions. **Conclusions:** TrA activation ratio is a reliable method of measuring muscle thickness across multiple positions between individuals with and without a history of LBP using ultrasound imaging. This measure may be used to compare thickness of TrA across these populations or following interventions. LM activation ratio was only found to be reliable in the tabletop position.

Effects of Subconcussive Head Impacts on Concussion-Related Symptoms, Clinical Reaction Time, and Oculomotor Function in Men's Lacrosse Players

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Context: To clinicians, researchers, and athletes alike, the recent evidence suggesting the detrimental effects of subconcussive head impacts (SCHI) in collision-sport athletes is alarming. The sport of lacrosse like football, ice hockey, and soccer, has a high-risk for sport-related concussions (SRC). However, there is paucity in research examining male lacrosse players despite the high risk for SRC and the opportunity for repeated SCHI to the helmet during competition. **Objective:** To examine if SCHI had an effect on concussion-related symptoms, clinical reaction time, and oculomotor function in men's lacrosse players (MLAX) in a shortened time frame between two regularly scheduled games (Wednesday and Saturday). **Design:** Two-group pretest-posttest cohort study. **Setting:** Quiet, climate-controlled research laboratory. **Patients or Other Participants:** Subjects consisted of 18 men (height = 181.3 ± 6.6 cm, mass = 86.3 ± 6.4 kg, age = 20.6 ± 1.3 yrs) and 13 women (height = 168.6 ± 6.0 cm, mass = 61.3 ± 4.6 kg, age = 19.7 ± 1.1 yrs) collegiate lacrosse players. The non-helmeted female lacrosse players (WLAX) were chosen to serve as controls. **Interventions:** Each subject was tested on 3 separate occasions (baseline [BASE], post-game 1 [POST], and prior to game 2 [PRIOR]). Games 1 and 2 were separated by 2 days. Testing included a concussion symptom checklist (SXC), clinical reaction time (CRTA), and the King-Devick™ test (KD) of oculomotor function. **Main Outcome Measures:** SCHI were counted using videotape replays of all lacrosse games. The total number of symptoms was determined at each test session. The 3 CRT trials (time in msec.) were averaged. The KD yielded both a total time (sec.) to completion score and total number of errors committed. ANCOVA was used to determine if differences existed between BASE and POST, as well as BASE and PRIOR across all dependent measures between groups (MLAX vs. WLAX). **Results:** The SCHI ranged from 0-4 for MLAX and 0-3 for WLAX. In both groups from BASE to POST and BASE to PRIOR comparisons for all dependent variables (SXC [2.4 ± 5.0 vs. 3.7 ± 6.0] and [1.5 ± 3.1 vs. 2.2 ± 4.5], CRTA [147.2 ± 18.0 msec. vs. 153.0 ± 17.9 msec.], KD time [36.8 ± 5.2 sec vs. 37.9 ± 8.0 sec] and [35.3 ± 5.3 sec vs. 37.2 ± 8.1 sec}, and KD error [0 ± 0 vs. 0.2 ± 0.4] and [0.1 ± 0.28 vs. 0.22 ± 0.55]) there were no significant differences. CRTA BASE to PRIOR was trending towards significance (F = 3.81, p = 0.061) whereas the MLAX scores were worse (155.5 ± 27.4 msec.) than the WLAX controls (142.4 ± 17.7 msec.). **Conclusions:** Interestingly the number of SCHI in the MLAX group was well below what we had anticipated, and quite different from their helmeted counterparts in ice hockey and football. It was somewhat alarming to learn that 7 of the 13 WLAX experienced SCHI to their un-helmeted head during competition. Despite the aggressive and full-collision nature of the MLAX game, our study suggests that there are no detrimental effects on several measures of concussion following the small number of SCHI during competitive games.

A Comparison of Head Impacts in National Collegiate Athletic Association Division 1 and Division 3 Men's Lacrosse Athletes

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Context: Impact frequency and magnitude are important factors in understanding head impact biomechanics and the potential for long term effects on brain function. The frequency and magnitude of impacts have been studied in football and ice hockey but not men's lacrosse. **Objective:** To compare the frequencies and linear and angular head impact velocities in National Collegiate Athletic Association Division I (D1) and Division III (D3) men's lacrosse athletes. **Design:** Descriptive epidemiology study. **Setting:** Collegiate lacrosse fields. **Patients or Other Participants:** We recruited 17 male D1 Lacrosse athletes (height = 173.89 ± 2.45 cm; mass = 72.65 ± 3.32 kg; age = 20.44 ± .237 years) and 11 male D3 lacrosse athletes (age = 20.90 ± 1.14 years, height = 180.11 ± 5.95 cm, mass = 83.91 ± 9.04 kg). **Intervention(s):** The D1 participants wore helmets instrumented with the GForce Tracker (Gforcetracker Inc., Markham, Ontario, Canada) while the D3 participants wore xPatch sensors (X2 Biosystems, Seattle, WA) adhered to the skin during practices and games of the 2014 spring lacrosse season. We analyzed video footage of practices and games to verify impact mechanisms for all participants. **Main Outcome Measure(s):** The xPatch and GForce tracker sensors recorded frequency and linear accelerations (g) of head impacts over 15 g. We calculated incident rates per 1000 exposures and incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CIs) for games and practices and used an ANOVA to compare the linear accelerations between the two levels. **Results:** We recorded 5999 impacts throughout 1093 exposures in

the D1 participants (IR = 5488.56, 95% CI = 5349.67-5627.45) while a total of 167 head impacts were successfully verified in our D3 participants during 542 total exposures (IR = 308.12, 95% CI = 261.39-354.85; IRR = 17.81, 95% CI = 15.27-20.77). We identified 2766 impacts during 226 D1 competitions (IR = 12238.94, 95% CI = 11782.82-12695.05) and 112 impacts during 172 D3 game exposures (IR: 651.16, 95% CI = 530.57-771.76; IRR = 18.80, 95% CI = 15.56-22.70). During practices, we recorded 3233 head impacts in 867 exposures (IR = 3728.95, 95% CI = 3600.41-3857.49) for our D1 players and 55 impacts during 370 practice exposures for the D3 athletes (IR: 148.65, 95% CI = 109.36-187.93; IRR = 25.09, 95% CI = 19.22-32.75). The ANOVA showed the level of play significantly altered the linear accelerations overall ($F_{1,6164} = 4.11$, $P = .04$, $\omega^2 < .01$, $1-\beta = .53$) with D3 athletes registering higher linear accelerations (32.92 ± 19.41) than D1 (29.46 ± 21.81). In addition, we found statistically higher linear accelerations in D3 (33.81 ± 20.98) athletes compared to D1 (27.53 ± 18.90) during practices ($F_{1,3286} = 5.94$, $P = .02$, $\omega^2 < .01$, $1-\beta = .68$), but not during games ($F_{1,2876} = .11$, $P = .75$, $\omega^2 < .01$, $1-\beta = .06$). **Conclusions:** We speculate the substantially higher IRs for the D1 athletes may be due to higher intensity of practice and games. The higher linear accelerations in D3 athletes may due to height and mass differences as unlike other sports, the D3 lacrosse athletes were larger than D1. Further research is needed on placement and use of sensors to measure head impact biomechanics in sport, allowing comparisons between teams and levels of competition.

Real-Time Head Impact Measurements in Intercollegiate Men's Lacrosse Players

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Context: Epidemiologic data describing head impact incidence is limited for men's lacrosse and Division III athletics. Increasing the understanding of head impact biomechanics concerning player position and athletic event may aid in improving prevention or reduction of the incidence and severity of head injuries. **Objective:** To compare head impacts of Division III intercollegiate men's lacrosse players across positions during practices and games. **Design:** Descriptive epidemiology study. **Setting:** Collegiate lacrosse field. **Patients or Other Participants:** 11 NCAA Division III men's lacrosse players (age = 20.90 ± 1.13 years, height = 179.88 ± 5.99 cm, mass = 83.91 ± 9.04 kg). Player positions included: 2 attacks, 2 midfielders, 1 face off specialist (FOS), 2 long-stick midfielders (LSM), 3 defenders, and 1 goalie. **Interventions:** Participants wore xPatch sensors (X2 Biosystems, Seattle, WA) adhered behind their right ear for athletic events during the spring 2014 lacrosse season. Player position and athletic event served as the independent variables. **Main Outcome Measures:** The xPatch collected location, linear accelerations, and angular accelerations of head impacts. We filmed all events allowing verification of recorded impacts. We calculated incident rates (IR) per 100 exposures and incidence rate ratios (IRR) with corresponding 95% confidence intervals (CI) across player position. We used a MANOVA to compare the linear and angular accelerations between the player positions. **Results:** We verified a total of 167 impacts during the study period. During games, FOS experienced the greatest incidence of head impact (IR = 29.16, 95% CI = 19.50-38.82) while LSM experience the lowest incidence of head impact (IR = 2.94, 95% CI = 1.12-4.76; IRR = 9.92, 95% CI = 4.91-20.03). The MANOVA revealed player position significantly altered the combined dependent variables during games (multivariate $F_{8,212} = 2.368$, $P = 0.018$, $\eta^2 = 0.082$). ANOVAs revealed a main effect for rotational acceleration ($F_{4,107} = 2.82$, $P = 0.029$, $\omega^2 = 0.09$), however not for linear acceleration ($F_{4,107} = 2.23$, $P = 0.071$, $\omega^2 = 0.04$) in games. During practices, FOS experienced the highest incidence of head impact (IR = 7.50, 95% CI = 4.29-10.71) and LSM experience the lowest incidence of head impact (IR = 1.23, 95% CI = 0.38-2.08; IRR = 6.10, 95% CI = 2.67-13.75). MANOVA showed player position altered the combined dependent variables during practices (multivariate $F_{10,96} = 1.943$, $P = 0.048$, $\eta^2 = 0.168$). ANOVAs revealed main effects for rotational ($F_{5,49} = 3.06$, $P = 0.018$, $\omega^2 = 0.16$) and linear accelerations in practices ($F_{5,49} = 3.55$, $P = 0.008$, $\omega^2 = 0.19$). Tukey's post hoc tests revealed significantly higher linear accelerations in attack compared to FOS ($P = .012$), FOS compared to midfield ($P = .012$), and rotational velocity in FOS compared to midfield ($P = .008$) during practices. **Conclusions:** FOSs had the highest incidence rate of head impacts in both games and practices as the position incorporates head and shoulder contact throughout a face-off. Attacks and FOS sustained high magnitude hits most likely due to the propensity of contact with opponents occurring while running at higher speeds. This data can be utilized clinically to help modify player behavior with proactive and strategic rule changes to reduce head impact incidence rates.

Effect of Impact Mechanism on Head Accelerations in Intercollegiate Men's Lacrosse

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Context: Exposure to head impacts is a leading cause of concussive brain injuries. Rule enforcement is a modifiable factor in sport to prevent potential injury-causing head impacts. Describing head impacts is a vital component to understanding and preventing head trauma in sport. **Objective:** To determine the frequency and differences in linear and angular head impact velocities according to impact mechanism in NCAA Division III men's lacrosse athletes. **Design:** Descriptive epidemiology study. **Setting:** Collegiate lacrosse field. **Patients or Other Participants:** 11 male NCAA Division III lacrosse athletes (age = 20.90 ± 1.14 years, height = 180.11 ± 5.95 cm, mass = 83.91 ± 9.04 kg). **Intervention(s):** Participants wore xPatch sensors (X2 Biosystems, Seattle, WA) adhered to the skin on the right mastoid process during practices and games of the 2014 spring lacrosse season. We analyzed video footage of practices and games to verify impact mechanisms. **Main Outcome Measure(s):** The xPatch sensors recorded frequency, linear accelerations (g), and rotational accelerations (rad/s2) of head impacts. Mechanisms observed were head to head (HtH), head to body (HtB), head to ground (HtG), stick to head (StH), ball to head (BtH), and a combination of two or more mechanisms. We calculated incident rates per 1000 exposures with corresponding 95% confidence intervals (CIs) for each impact mechanism and used MANOVAs to compare the linear and angular accelerations between mechanisms. We set the alpha value to .05 a priori. **Results:** A total of 167 head impacts were successfully verified and coded with a mechanism using video footage during 542 total exposures. We identified112 impacts during 172 game exposures (IR = 651.16 95% CI = 530.57-771.76) and 55 impacts were identified during 370 practice exposures (IR = 148.65, 95% CI = 109.36-187.93), translating to an incident rate ratio of 4.381 (95% CI = 3.172-6.049). The highest incident rate was StH (IR = 105.17) and the lowest was BtH (IR = 3.69, IRR = 28.5, 95% CI = 6.96-116.74). Two of the 108 potential penalty-evoking, game head impacts (HtH, HtB, or StH) were called penalties (IR = 18.52, 95% CI = 0.0-44.18) during the 172 game exposures (IR = 11.63, 95% CI = 0.00-27.74). MANOVA showed the impact mechanism significantly altered the combined dependent variables (multivariate $F_{10,330} = 2.064$, $P = .027$, $\eta 2 = .118$, $1\text{-}\beta = .892$). We also found main effects for both linear acceleration ($F_{5,161} = 2.445$, $P = .036$, $\omega^2 = .041$, $1\text{-}\beta = .761$) and rotational acceleration ($F_{5,161} = 3.151$, $P = .010$, $\omega^2 = .060$, $1\text{-}\beta = .872$). Tukey post hoc tests revealed significant differences between HtH and HtB in both linear ($P = .027$) and rotational ($P = .004$) accelerations, with higher accelerations for HtH. **Conclusions:** While HtH, HtB, and StH mechanisms are penalty-inducing offences in men's lacrosse, HtG, BtH, and combination impacts had similar head accelerations, both linearly and angularly. Additionally, the frequency of penalty-evoking impacts during games was vastly greater than the rate at which they were deemed penalties. If penalties and rules are created to protect players from traumatic head injury, the current rules should be more heavily enforced and possibly modified.

Comparison of Head Impact Location During Games and Practices in Division III Men's Lacrosse Players

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Context: Head impacts have been studied extensively in football, but little research has examined men's lacrosse. In football athletes, previous research has shown that impacts to the top and front of the helmet are associated with neuropsychological changes while side impacts have been found to be more likely to cause concussive injuries. With the associations seen in football, it is important to understand the location and velocity of head impacts sustained during men's lacrosse to reduce the risk of head injury. **Objective:** Examine head impact locations during men's lacrosse games and practices. **Design:** Descriptive epidemiology study. Setting: Collegiate lacrosse field. **Patients or Other Participants:** 11 Division III men's lacrosse players (age = 20.9 ± 1.13 years, mass = 83.91 ± 9.04 kg, height = 179.88 ± 5.99 cm) with no currently diagnosed concussion. **Interventions:** We applied xPatch sensors (X2 Biosystems, Seattle, WA) to participants behind the right ear prior to games and practices. Sensors recorded data on linear and angular velocity as well as the location of head impacts. The location of the head impacts and the type of event (game or practice) served as the independent variables. We filmed all events and verified recorded impacts. **Main Outcome Measures:** Linear and angular velocity served as the dependent variables. We calculated incidence rates (IRs) with 95% confidence intervals (CIs) for the different impact locations and compared the effect of impact location on the dependent variables using a MANOVA. We set the alpha value to .05 a priori. **Results:** We collected 167 head impacts, with 112 head impacts occurring during games and 55 occurring during practices. For games, the IR was 651.16 impacts per 1000 exposures (95% CI = 530.57-771.76).

The IRs for the different head impact locations during games were: back 169.64 (95% CI = 93.36-245.92), front 392.86 (95% CI = 276.78-508.94), side 410.71 (95% CI = 292.02-529.41), and top 26.79 (95% CI = 3.53-57.10). The impact location did not significantly affect the combined dependent variables in games (multivariate $F_{6,214} = .401$, $P = .878$, $\eta^2 = .022$, $1-\beta = .166$). For practices, the IR was 148.65 per 1000 exposures (95% CI = 109.36-187.93). The IRs for the different head impact locations during practices were: back 272.73 (95% CI = 134.71-410.75), front 309.09 (95% CI = 162.16-456.02), side 400.00 (95% CI = 232.85-567.15), and top 18.18 (95% CI = 17.45-53.82). The impact location had no significant effect on the combined dependent variables during practices (multivariate $F_{6,100} = 1.36$, $P = .238$, $\eta^2 = .145$, $1-\beta = .510$). **Conclusions:** The finding that the side of the helmet had the highest IR for head impacts in both games and practices is concerning because such impacts have been shown to be more likely to result in concussive injury. Based on our results, we suggest behavior modification in men's lacrosse athletes to reduce the incidence of impact to the side of the head and improved helmet designs to help decrease the force from side head impacts in an effort to reduce potential injury.

The Availability of Athletic Trainers to Assess Sport Related Concussions in Various Football Settings

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Context: In most but not all football settings, the Athletic Trainer (AT) is the primary medical provider available to assess Sport Related Concussion (SRC) injuries. Due to the high number of SRC injuries take place in football, it is crucial to document the extent that ATs are available in various football settings. **Objective:** To determine the availability of ATs in youth, middle, and high school football settings in the state of Wisconsin. **Design:** Cross-sectional study. **Patients or Other Participants:** Members of the Wisconsin Football Coaches Association (WFCA) participated in person (paper/pencil) at their annual meeting or online through e-mail solicitation. A convenience sample of 701 of 1411 coaches (49.68%) who were WFCA members completed the assessment. **Interventions:** Subjects reported their coaching level and high school enrollment (if applicable) and asked a series of questions regarding the services provided by an AT and the availability of an AT at practices and competitions. **Main Outcome Measures:** The main outcome measure was the availability of an AT based on the level of play and school enrollment size. Fisher's Exact tests ($p < 0.001$) were used to analyze the responses. **Results:** Subjects included n = 104 (16%) youth/middle school (YMC) coaches, n = 292 (42%) Sub-Varsity [high school assistant, junior varsity head and freshmen head coaches] coaches (SVC) and n = 305 (44%) head varsity coaches (HC). Two hundred thirty six (40%) coached at high schools with an enrollment of <400 students, n = 172 (29%) 400-800 students, and n = 184 (31%) >800 students. The availability of an AT for YMC practices (7%) was lower ($p < 0.001$) than SVC (51%) and HC (53%). The availability of an AT for YMC home games was lower (YMC = 47%, SVC = 92%, HC = 94%; $p < 0.001$) and for away games (YMC = 30%, SVC = 80%, HC = 85%; $p < 0.001$). For high school settings, The AT availability at each practice was significantly higher ($P < 0.001$) for enrollments >800 (83%), than 400-800 (55%) and <400 (17%), and significantly higher ($p < 0.001$) at away games for enrollments >800 (90%), than enrollment of 400-800 (72%) and <400 (72%). Fewer ($p < 0.001$) YMC coaches (5%) utilized ATs to fit players' football helmets than SVC (21%) and HVC (24%). Fewer ($p < 0.001$) YMC coaches (38%) had an AT to perform baseline concussion assessments than HC (91%) and SVC (87%). There was no difference ($p = 0.272$) in the utilization of ATs to provide baseline computer assessments by school enrollment (<400 = 83%, 400-800 = 86%, >800 = 89%. **Conclusions:** The availability of an AT for football teams to assess and manage SRC injuries varies considerably based on the level of play and high school enrollment size. ATs need to work with sport governing bodies to advocate for greater AT access to football players in all settings.

Athletic Trainers' Perceived Challenges Toward Concussion Management in the Secondary School Setting

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Context: The continued focus on sport-related concussion in both the popular press and medical literature requires all individuals involved with secondary school sports to continually review and revise concussion management plans. However, while the intent is to have all schools follow state laws, district policies, and best practices, individual school demographics, including the number of athletic trainers (AT) on staff, the number of athletes, and the facility size may limit aspects of the concussion management plan. While recent surveys have identified what ATs use for concussion management, limited information is available to understand ATs' perceived challenges regarding the implementation of these plans. **Objective:** To explore ATs' perceived challenges toward concussion management at the secondary school level. **Design:** Consensual qualitative research was used as the method to understand the challenges ATs encounter when managing concussions. **Setting:** Individual phone interviews were conducted for all participants. **Patients or Other Participants:** 14 ATs (6 females, 8 males; age = 40.8 ± 12.5 years; athletic training experience = 16.1 ± 11.1 years), representing 13 states, were interviewed. **Data Collection and Analysis:** One individual phone interview was conducted with each participant. Once the interviews were transcribed, a four-person research team coded the data into themes and categories. Each researcher independently coded the data, and then the team met to reach a final consensus to ensure accuracy and representativeness of the data. Triangulation of the data was ensured by the use of multiple researchers, participant member-checking, and the

use of internal and external auditors. **Results:** Participants reported several challenges toward concussion management in the secondary school setting. One of the main challenges identified was an inconsistency of concussion education levels and management practices among other healthcare providers included as part of the concussion management team. Inconsistencies with education levels among parents and coaches were also noted. Additionally, ATs discussed communication difficulties with other healthcare providers as well as parents and coaches. A lack of facility and/or personnel resources also created challenges for ATs; baseline testing was often reported unavailable due to the lack of trained personnel to assist with test administration. **Conclusions:** There are numerous challenges ATs encounter regarding concussion management in the secondary school setting, primarily with education levels and communication among those involved in the concussion management process, as well as the lack of available facility and personnel resources. These perceived challenges may make it difficult to ensure effective management and care for student-athletes following a concussion. To minimize the potential challenges ATs may encounter in the secondary school setting, it is essential to continue to promote concussion education to healthcare professionals, school personnel, coaches, and family members who may be involved in the recovery process for a student-athlete following a concussion to ensure a common understanding of the management plan.

Athletic Trainers' Self-Perceived Satisfaction of Current Concussion Management Practices in the Secondary School Setting

Cohen GW, Welch CE, Kay MC, Tierney DK, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Athletic trainers (AT) play a significant role in developing and implementing concussion management policies and procedures in the secondary school setting. These policies and procedures typically require that the AT communicate with other personnel in order to address multiple facets of the concussion management plan. While the financial and personnel resources available at secondary schools often dictate the specifics of the policies and procedures, little is known about ATs' self-perceived satisfaction regarding the current concussion management policies and procedures at their respective secondary school. **Objective:** To explore ATs' self-perceived satisfaction with the concussion management policies and procedures in the secondary school setting. **Design:** Consensual qualitative research was used as the research tradition to explore ATs' perceptions and experiences with their concussion management policies and procedures. **Setting:** Individual phone interviews. **Patients or Other Participants:** 14 ATs (6 females, 8 males; age = 40.8 ± 12.5 years; athletic training experience = 16.1 ± 11.1 years), representing 13 states, were interviewed. **Data Collection and Analysis:** Each participant was interviewed once via telephone. Once the interviews were transcribed, the data were coded for themes and categories. Final themes and categories were determined via consensus of a four-person research team. Each research team member independently coded a portion of the data and created a preliminary codebook. The research team then met as a group to discuss and finalize a consensus codebook that richly captured the data. To decrease researcher bias, triangulation occurred through participant member checking, the inclusion of multiple researchers, as well as the inclusion of internal and external auditors. **Results:** ATs' perceived their current concussion management policies and procedures to be adequate and reported high levels of satisfaction with their concussion management practices. Participants identified the level of care they provided with baseline testing, education, on-field assessment, access to other healthcare specialists, and return-to-play progressions as the reasons for their high levels of satisfaction. However, ATs had lower perceived levels of satisfaction with the knowledge level of other members of the management team regarding concussion, as well as their access to resources to aid in the management of concussions, such as additional personnel and the availability of concussion assessment tools. ATs identified areas for improvement, including access to additional clinical tools, personnel resources, clinician education, parent education, and governing bodies' recommendations. **Conclusions:** Overall, ATs identified a high level of self-perceived satisfaction with their own current concussion management policies and procedures; however participants were concerned about the perceived lack of knowledge in other concussion team members such as school nurses, school administrators and community physicians. While ATs were generally satisfied with how concussions are managed at their school, they did acknowledge that improvements could be made if additional resources were allocated for these efforts.

Athletic Trainers' Perceptions of the Academic Accommodations Procedures for Student-Athletes Following A Sport-Related Concussion in the Secondary School Setting

Erickson CD, Valovich McLeod TC, Kay MC, Sleight AJ, Welch CE: A.T. Still University, Mesa, AZ

Context: Academic accommodations (AA) are often an essential component of recovery for student-athletes following a sport-related concussion. There are numerous aspects to consider when implementing AA, including an established academic management team and the implementation of a return-to-learn progression, yet little is known regarding athletic trainers' (AT) perceptions of the current AA procedures in the secondary school setting. **Objective:** To gain insight on ATs' perceptions of current AA procedures for student-athletes following a sport-related concussion in the secondary school setting. **Design:** This qualitative investigation was modeled after the consensual qualitative research approach. **Setting:** Individual phone interviews were conducted for all participants. **Patients or Other Participants:** 16 ATs employed in the secondary school setting (8 females, 8 males; age = 39.6 ± 7.9 years; athletic training experience = 15.1 ± 5.6 years), representing 12 states, were interviewed. A criterion sampling method was utilized to solicit participants. **Data Collection and Analysis:** A semi-structured interview protocol was used to allow for flexibility in accordance with the emergent qualitative design. Following transcription, themes were established based on a consensus process by a 4-person research team. Each researcher independently coded the data and created a comprehensive codebook. The research team then met as a group to formulate a consensus codebook that appropriately represented the data. To increase the reliability of the data, triangulation occurred through the use of multiple researchers, internal and external auditors, and participant member-checking. **Results:** ATs identified several components of AA procedures that are essential to include as part of the concussion management process. Particularly, participants discussed the importance of a formal AA policy as well as the various types of informal and temporary AA that should be considered for a student-athlete following a concussion. ATs also reported the need for a return-to-learn progression as well as an identified AA management point person to facilitate AA as part of the concussion management plan. Furthermore, participants discussed their perceptions of which healthcare providers and school personnel should be included in an established AA management team. **Conclusions:** Until recently, most attention has been given to managing the physical aspects of a student-athletes' recovery following a sport-related concussion. However, it is vital for ATs to focus on ensuring student-athletes are allowed sufficient cognitive rest via the incorporation of AA during the recovery process. The findings from this study demonstrate ATs' perceptions regarding the need for a formal AA policy and a structured return-to-learn progression. To ensure successful implementation of AA during the concussion recovery process in both the school and home environment, it is necessary to ensure an established AA management team is developed. Additionally, it is important to identify which team members will facilitate the return-to-learn progression and promote communication between all members of the AA management team.

Athletic Trainers' Perceived Challenges Toward the Implementation of Academic Accommodations for Student-Athletes Following a Sport-Related Concussion in the Secondary School Setting

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Context: The importance of implementing cognitive rest and academic accommodations as part of the concussion management process for student-athletes following a sport-related concussion in the secondary school setting has gained significant attention. While athletic trainers (AT) may be involved in the implementation of academic accommodations, little is known regarding the challenges they may encounter within the secondary school setting. **Objective:** To qualitatively explore ATs' perceived challenges regarding the implementation of academic accommodations following a sport-related concussion in the secondary school setting. **Design:** A consensual qualitative research tradition was used as the primary approach for this study. **Setting:** An individual phone interview was conducted with each participant. **Patients or Other Participants:** 16 ATs employed in the secondary school setting (8 females, 8 males; age = 39.6 ± 7.9 years; athletic training experience = 15.1 ± 5.6 years), representing 12 states, were interviewed. **Data Collection and Analysis:** A semi-structured interview protocol was used to allow for data to emerge throughout the interviews. Once all interviews were transcribed, the research team collectively coded transcripts. Themes and categories were created based on the consensus process by a four-person research team. All research team members analyzed and coded the transcripts independently to create a comprehensive codebook that captured the main themes and categories. The research team then met to discuss and establish a consensus codebook that represented the data appropriately. To reduce research bias, triangulation of the data occurred via the use of multiple researchers, internal and external auditors and participant member checking

to accurately analyze the data. **Results:** ATs identified several potential challenges prohibiting the implementation of academic accommodations in the secondary school setting. Primarily, participants perceived school personnel, parents, and the patients themselves as major barriers preventing successful implementation. ATs' reported these individuals often had difficulties with compliance of the academic accommodations plan that was developed for concussed student-athletes or they often did not effectively communicate with the AT or other school personnel. The lack of a formal academic accommodations school policy also presented challenges for ATs. Additionally, participants discussed inconsistency between return-to-play and return-to-learn protocols, as well as a lack of concussion education and awareness among community members (ie, other healthcare providers, school personnel and administrators, parents, coaches) as a challenge toward the implementation of academic accommodations in the secondary school setting. **Conclusions:** The perceived challenges ATs' experience toward the implementation of academic accommodations in the secondary school setting may prohibit whole-person management for student-athletes who need sufficient cognitive rest following a concussion. Education on the importance and proper implementation of academic accommodations could facilitate both patient and community member compliance. Additionally, academic accommodations best practices should be identified to assist healthcare professionals and school personnel in the development of formal academic accommodations policies in the secondary school setting.

Influence of Arterial Stiffness on Neurocognitive Performance in High School and Collegiate Athletes

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Context: The Brain Acoustic Monitor (BAM) is a novel tool that acoustically measures cerebral blood flow and factors that affect perfusion such as arterial stiffness. Increased arterial stiffness is associated with reduced neurocognitive function in an elderly population. It is unknown whether there are similar relationships in a young, healthy population. **Objective:** To determine whether arterial stiffness is associated with neurocognitive performance in adolescent and collegiate athletes. **Design:** Descriptive laboratory study. **Setting:** Clinic. **Patients or Other Participants:** 178 collegiate and high-school athletes volunteered (110 males, 67 females; age = 18.91 ± 2.35 yrs; height = 175.84 ± 10.79 cm; mass = 76.44 ± 17.63 kg). **Interventions:** All participants underwent baseline BAM testing. Two small sensors were applied to the forehead and one at a digital artery to produce composite arterial pressure waves from each location. Three 10-second readings were recorded for processing. Each subject also completed the Sideline Concussion Assessment Tool 3 (SCAT3) and either the Concussion Resolution Index (CRI) or the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). Test type varied based on institutional policy and was completed prior to the start of the competitive season. **Main Outcome Measures:** Average arterial pressure waves were generated and right and left systolic interval (sec), peak interval (sec), and augmentation index (percent) were calculated. SCAT3 scores were broken down into the Standardized Assessment of Concussions (SAC) and Balance Error Scoring System (BESS) total scores. CRI outcomes included simple and complex reaction time (RT) and processing speed while ImPACT outcomes included visual and verbal memory, processing speed, and RT. Tertiles were formed based on each neurocognitive outcome to indicate high, middle, or low performance. BAM variables were compared between tertiary groups using one-way ANOVA. Step-wise linear regression models were also used to determine if BAM measures were able to predict neurocognitive performance. Participants were grouped and analyzed according to which computerized neurocognitive testing they received. **Results:** Right augmentation index was a significant predictor for CRI complex ($R^2 = 0.093$, $p = 0.023$, $b = -0.020$) and simple RT ($R^2 = 0.159$, $p = 0.002$, $b = -0.013$), while left systolic interval was a significant predictor of ImPACT visual-motor processing speed ($R^2 = 0.063$, $p = 0.039$, $b = -164.270$). Group comparisons revealed that low CRI complex RT performers had significantly lower right augmentation index (%) than high performers (low: 17.49 ± 14.0, middle: 21.4 ± 17.3, high: 29.37 ± 17.6; $p = 0.012$). High BESS performers had lower left augmentation index than middle performers (low: 17.15 ± 12.9, middle: 22.69 ± 17.3, high: 16.21 ± 12.9; $p = 0.025$). **Conclusions:** Reduced augmentation index appears to be most consistently associated with poorer neurocognitive performance in healthy collegiate and high school athletes. While differences in performance were found, the magnitude was not clinically relevant compared to differences found following concussion. As such, it is likely that cerebral arterial stiffness measures obtained here are one of many factors that influence neurocognitive performance in this population.

Baseline Assessment of Cerebral Arterial Stiffness in High School and Collegiate Athletes

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Context: Current concussion assessment tools do not allow for direct measurement of the pathophysiological processes that follow sport concussion. The Brain Acoustic Monitor (BAM) may offer a solution via acoustic measurement of cerebral blood flow and factors that affect perfusion such as arterial stiffness. However, it is important to know what factors influence this measure before the tool is used on an injured population. **Objective:** To determine whether differences in arterial stiffness exist based on sex, age group, concussion history, and sport type. **Design:** Descriptive laboratory. **Setting:** Laboratory. **Patients or Other Participants:** 57 high school and 121 collegiate athletes participated (110 males, 68 females, age = 19 ± 1.85 years, height = 175.49 ± 12.27 cm; mass = 76.45 ± 17.55 kg). **Intervention(s):** The BAM was used to measure cerebral blood flow acoustically. Assessment involved application of two sensors to the forehead and one at a digital artery for recording of composite arterial pressure waves at each location. Three 10-second readings were recorded for processing. **Main Outcome Measures:** The slope and shapes of the arterial pressure waves were analyzed using a custom transformation algorithm in Matlab®. Dependent variables from the curve analysis included left and right systolic interval (SI), peak interval (PI), and augmentation index (AIx). Kruskal-Wallis and Mann-Whitney U tests of independent means were used to compare groups based on age (≤18 years, ≥19 years), gender, sport type(collision, contact, noncontact), and concussion history. Medians and interquartile ranges are presented. **Results:** No significant differences in cerebral arterial stiffness were seen between groups based on age, sex,

or concussion history. Multiple differences were seen between sport categories. Left SI and PI were lower for individuals who participated in collision (SI: $p = 0.001$; PI: $p = 0.006$) and contact sports (SI: $p \leq 0.001$, PI: $p = 0.009$) compared to those in noncontact sports (SIcollision = 0.067 (0.06, 0.07), SIcontact = 0.066 (0.006, 0.07), SInoncontact = 0.08 (0.07, 0.11); PIcollision = 0.076 (0.064, 0.117), PIcontact = 0.075 (0.065, 0.113), PInoncontact = 0.118 (0.075, 0.145)). This was identified on the right side for PI only (PIcollision = 0.094 (0.067, 0.0134), PIcontact = 0.092 (0.062, 0.137), PInoncontact = 0.133 (0.106, 0.147); $p = 0.001$ and $p = 0.003$ for noncontact vs. collision, contact respectively]). The contact athletes showed significantly lower left AIx compared to collision athletes ($p = 0.049$) and noncontact athletes ($p = 0.005$) as well as lower right AIx compared to noncontact athletes ($p = 0.019$) [Left: AIxcollision = 20.2 (6.2,31.1), AIxcontact = 13.1 (3.1,25.3); AIxnoncontact = 25.6 (10.1, 40.1); Right: AIxcollision = 20.1 (9.2,32.6), AIxcontact = 16.8 (6.7,28.6), AIxnoncontact = 25.2 (18.1,35.1)]. Bilateral PI, bilateral SI, and right AIx were not different between collision and contact athletes. **Conclusions:** There were no differences in baseline BAM measures associated with age, sex or concussion history. However, student-athletes participating in collision and contact sports had increased measures of arterial stiffness in our sample. Measurement of cerebral arterial stiffness with the BAM is relatively new and this limits the clinical meaningfulness of these results. However, because of the association of baseline stiffness in individuals who are at risk for cumulative forces to the head, these measures should continue to be studied.

The Acute Effect of Caffeine Ingestion on ImPACT™ Test Performance

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Context: The management of mild traumatic brain injury has become an area of great concern and controversy in the athletic setting. Numerous states have adopted legislation mandating evaluation and return to play criteria for interscholastic athletics, while other sport governing bodies have adopted similar policies. Many of these recommend neurocognitive tests like Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT™) as a management tool that is administered prior to and then serially after suffering a concussion. However, comparing post-injury testing to baseline testing only accurately identifies cognitive changes if both the baseline and post-injury tests are valid. Because of this, it is important for the clinician to identify any potential threats to this validity. Caffeine has been shown to improve reaction time (RT), visual information processing and working memory, which are similar to the tasks used during ImPACT™. Thus, it is possible that caffeine ingestion could improve performance during neurocognitive testing and therefore threaten ImPACT™ validity. **Objective:** To examine the effects of acute caffeine ingestion on ImPACT™ performance. **Design:** A randomized and counterbalanced double blind cross-over design. **Setting:** ImPACT™ was performed on a desktop computer in a quiet, fully enclosed and illuminated room. **Patients or Other Participants:** Fifteen healthy males and females (age = 19.5 ± 1.2 years, height = 169.5 ± 7.4 cm, mass = 71.2 ± 15.3 kg) with no history of physician diagnosed head injury, learning disability or any form of attention deficit or cardiovascular disorder volunteered. Potential subjects were excluded if they were prescribed any type of stimulant, anti-depressant or antianxiety medication for regular use. **Interventions:** Subjects were assessed at the same time of day under three randomly ordered conditions, treatment (T), placebo (P) and control (C) with each separated by a period of one week. During the T condition, subjects ingested 6.0 mg*kg-1 body mass of anhydrous caffeine in capsule form with 592-ml of water. The P condition consisted of 6.0 mg*kg-1 body mass of dextrose in identical capsule form with water. The C condition consisted of water ingestion only. **Main Outcome Measures:** ImPACT™ composite scores for verbal (Mverb) and visual memory (Mvis), visual motor speed (PS), RT, impulse control (IC) and a cognitive efficiency index (CEI) were compared under each of the three conditions and were assessed 60-min after ingestion. **Results:** No significant differences in Mverb ($F_{2,28} = 3.09$, $p = .061$, C = 91.13 ± 7.60, P = 90.20 ± 10.46, T = 95.07 ± 4.70), Mvis ($F_{2,28} = .022$, $p = .978$, C = 76.93 ± 12.60, P = 77.53 ± 12.79, T = 77.20 ± 11.98), PS ($F_{2,28} = .245$, $p = .784$, C = 43.45 ± 5.51, P = 44.30 ± 6.51, T = 43.71 ± 4.87), RT ($F_{2,28} = 1.65$, $p = .209$, C = .59 ± .09, P = .59 ± .08, T = .57 ± .07), IC ($F_{2,28} = 2.15$, $p = .135$, C = 5.20 ± 4.77, P = 6.27 ± 4.20, T = 5.20 ± 2.98) and the CEI ($F_{2,28} = 2.26$, $p = .123$, C = .37 ± .17, P = .38 ± .16, T = .45 ± .12) were observed when comparing the C, P and T conditions. **Conclusions:** The results suggest that caffeine ingestion 60-min prior to test administration failed to improved neurocognitive performance. Thus, it is not necessary for clinicians to standardize caffeine intake prior to baseline and serial ImPACT™ testing.

Effect of Target Type on Ocular Near Point of Convergence in a Healthy, Active Collegiate Population

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Context: Measuring ocular Near Point of Convergence (NPC) has recently emerged as a concussion assessment tool in young athletes. A cut point of >5cm has been recommended as indicating ocular-motor dysfunction. There has been little investigation examining if clinically accessible target types (e.g., pen) affects NPC and no examination of NPC in a healthy, active collegiate population. **Objective:** Since NPC utilizes multiple brain pathways it could prove useful in the diagnosis of sport concussion. The purpose of this study was to determine if target type effects NPC in a physically active college population. **Design:** A cross-sectional repeated measures design. **Setting:** Laboratory setting. **Patients or Other Participants:** Thirty-nine subjects signed IRB-approved consent forms and participated in this study (males = 13; females = 26). All participants were between 18 and 30 years of age (23.6 + 3.1 yrs). Exclusionary criteria included not using corrective eyewear (e.g. contact lenses, glasses, etc.); any disease, disability, or other issue that affects the ocular system; recent (within 6 months), unresolved, or chronic brain injury. **Interventions:** The independent variable was target type (three different sized font letters [1.0M, 1.25M, 1.6M] in a reduces Snellen chart format, a drawn black line, and pen tip). Using a near point ruler (Burnell Vision Training Products, Mishawaka, IN), the NPC was measured for all subjects with the different targets. For each trial the target was moved toward the participant's face at eye level at a slow pace of about 1-2 cm/s. Each target was tested twice and all trials were randomized. NPC distance was determined one of two ways: either the participant stated when diplopia occurred, or the tester noted abnormal eye tracking. Data analysis included a repeated measures ANOVA and followed-up paired samples t-tests using IBM SPSS Statistics Version 21 ($p < .05$). **Main Outcome Measures:** NPC (cm) is the closest point in space where a person can see one target with binocular vision. **Results:** NPC ranged from 1.5 to 10cm in this population. The ANOVA identified statistically significant differences ($F(4,152) = 2.568$, $p = .040$) between target types. The middle sized font (6.0 + 1.63 cm) was significantly receded versus the line (5.6 + 1.59 cm; $t(2.344)$, $p = .024$) and pen (5.7 + 1.54 cm; $t(2.052)$, $p = .047$). There was also a difference between the largest sized font (6.0 + 1.66 cm) and the line ($t(2.317)$, $p = .026$). NPC for the three different font sizes were all approximately 6.0 + 1.41 to 1.66 cm. **Conclusions:** Statistically significant differences in NPC existed between target types, however clinical significance of the difference (<.5cm) may be lacking. For the college aged physically active population, the measurement of NPC is not affected by target type. A cut point of 5cm indicating dysfunction may not be appropriate in this population as measurements ranged up to 10cm.

The Effect of Caffeine on ImPACT Performance

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Context: The ImPACT is a commonly used neurocognitive measure used to assess sport concussion (SC) for athletes at all levels of sport. Athletes are commonly administered the ImPACT prior to injury (baseline) in order to compare post-injury test results. Caffeine is a potential extraneous source of error which may influence cognitive performance and is commonly used by young athletes to increase energy levels. **Objective:** To examine the effect of caffeine on ImPACT performance in healthy college students. **Setting:** Research Laboratory. **Design:** Crossover trial **Patients or Other Participants:** Participants consisted of 26 healthy college students (male = 5, female = 21) who were 18.5 + .76 years of age. Subjects were randomly assigned into two counterbalanced groups in order to minimize potential order effects associated with the administration of 100 mg of caffeine or placebo capsules. **Interventions:** All subjects completed 3 time points (Days 1, 7 and 14) at which Green's Word Memory Test (WMT) was completed as an external measure of effort prior to and following the completion of ImPACT. Participants were excluded if they scored below 85% on any WMT composite score, deemed as invalid based on ImPACT's validity criteria, or did not complete all three time points. At Day 1, the WMT and ImPACT form 1 were administered to familiarize subjects with each test and to minimize practice effects between Days 7 and 14. At Day 7, participants were administered either a caffeine citrate or placebo capsule one hour prior to completing the WMT and ImPACT form 2. At Day 14, the remaining capsule was administered one hour prior to completing the WMT and ImPACT

form 3. **Main Outcome Measures:** Paired t-tests compared performance between Days 7 and 14 on ImPACT (Verbal and Visual Memory, Visual Motor Speed, Reaction Time, Impulse Control, and Total Symptom score) and WMT (Immediate and Delayed Recall, Consistency, Multiple Choice, and Paired Recall) composite scores. Analyses were performed with $\alpha = .05$. **Results:** All participants provided a valid effort as defined by the WMT and ImPACT. There was no significant difference between caffeine and placebo ingestion for any ImPACT or WMT ($p > .05$) composite score. **Conclusions:** Overall, 100 mg of caffeine, which is similar to an 8 ounces of commonly used energy drinks (e.g. Redbull, Rockstar, Monster, Full Throttle) did not influence ImPACT performance. Future research is needed with a larger sample size and administration of varying amounts of caffeine to determine its potential influence on performance on ImPACT and other computerized neurocognitive measures commonly used to assess SC.

Clinical Reaction Time is Not Significantly Affected by Moderate-Intensity Aerobic Exercise

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Context: Diminished reaction time has been used as diagnostic criteria to determine the occurrence, and recovery from, concussion. The clinical reaction time (RTclin) test uses a manual visual-motor activity to measure reaction time. The RTclin test has been recommended for clinical use in determining if a concussion has been sustained (i.e., immediate evaluation) and monitoring recovery from concussion. As athletic trainers work with patients who often suffer concussions during athletic participation, it is important to determine how exercise affects the RTclin test. **Objective:** To determine the effect of exercise on RTclin. **Design:** A pretest-posttest design. **Setting:** An exercise physiology laboratory. **Patients or Other Participants:** A sex-balanced convenience sample of 40 physically active college students were randomly assigned to a control (n = 20, mean age = 20.8 ± 1.67 y, age range = 19 to 24) or experimental (n = 20, mean age = 21.45 ± 1.70 y, age range = 19 to 25) group. All participants had to be free of vestibular disorders and head injury for the previous 3 months. Participants also abstained from exercise prior to study participation on the day of testing. **Interventions:** Participants completed baseline RTclin testing. The exercise group completed a 30-minute treadmill running protocol (5 minute self-paced warm-up; 5 minute run at ≤ 65% of heart rate reserve [HRR]; 15 minute period at 65-75% HRR; 5 minute self-paced cool down). The RTclin was re-administered within 5 minutes of exercise completion. The control group rested for 30 minutes following baseline testing, and the RTclin test was re-administered. **Main Outcome Measures:** Dependent and independent t-tests were used to determine group differences as appropriate. Alpha level was set at $p \leq 0.05$. **Results:** The exercise protocol was effective at increasing participants' heart rate ($p < 0.001$) with a mean increase of 27.3 ± 7.09 BPM at post-test measurement and rate of perceived exertion ($P < 0.001$) with a mean increase of 6.72 ± 1.32. A significant difference in the mean score change of RTclin was not found ($t(38) = -0.512$, mean difference = -2.49, $p = 0.61$, 95% CI: -12.36, 7.37) between groups. Of the participants, 15 in each group produced faster reaction times and 5 in each group produced slower reaction times at post-testing. **Conclusions:** Exercise did not appear to affect RTclin performance and exercise alone seems unlikely to produce a false-positive. Repeat testing, however, appears to have the potential to produce a false positive (25% of participants) or improved performance (75% of participants). The improved performance may be indicative of a practice or learning effect which warrants additional research. The false positive rate provides support for the use of a battery of tests when determining the onset and resolution of concussion.

Rasch Partial-Credit Model Calibration of the Clinical Presentation of Concussion Symptoms

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Context: Symptom assessment is widely recognized as a critical component of concussion protocols. Research has identified the 22 most common concussion-related symptoms, which are usually measured by their severity. Symptom duration and frequency are associated with concussion recovery. Understanding the clinical presentation of concussion-related symptom severity, frequency and distress may be key to determining their effects on recovery and improving concussion management strategies. **Objective:** To evaluate item difficulties and patterns in the clinical presentation of 22 common concussion symptoms among concussed athletes. **Design:** Observational design. **Setting:** Clinical Athletic Training Room. **Patients or Participants:** Fifty symptomatic concussion days were observed across thirteen patients who volunteered for this study (4 females) with a mean age of 19.7 ± 0.9 yrs. All participants were active members of a sports team and had been diagnosed with a concussion within 24 hours. **Interventions:** A self-report symptom questionnaire was used to assess 22 common concussion-related symptoms (22 symptoms x 3 aspects = 66 items) and has been used previously to evaluate symptoms in concussed athletes. Participants were asked to complete the symptom questionnaire daily until all symptoms had resolved. **Main Outcome Measures:** Despite the small sample size, Rasch partial-credit model was used to examine the clinical presentation of 22 concussion-related symptoms. This model has been successfully used in athletic training. Dependent variables included mean item difficulty logits, standard deviations and mean square residuals (MNSQ). Item difficulty logits are related to the probability of experiencing a symptom where lower values indicate higher likelihood of experiencing the symptom. Symptoms with MNSQ <0.5 or >1.5 indicate poor fit. **Results:** Data were person-mean centered (0 ± 1.69 logits) to allow comparisons of items across ability measures. Item difficulty ranged from 0.21 to 4.51 logits. Headache (frequency = 0.21 logits, severity = 0.63 logits) was reported as the most likely symptom followed by fatigue (frequency = 0.85 logits), pressure in the head (frequency = 0.86 logits) and confusion (severity = 0.96 logits). Feeling nervous (distress = 2.98 logits) emotional (severity = 3.27 logits) and sadness (frequency, severity, and distress = 4.51 logits) were reported as the least likely symptoms. Neck pain, balance problems, drowsiness, and trouble falling asleep indicated poor fit. These symptoms are also associated with many other conditions or may represent different dimension, which may explain their poor fit. **Conclusions:** For example, an athlete with a symptom score of 0.96 logits would be more likely to experience headache, fatigue, pressure in the head and confusion (items have logits lower than person score of 0.96), but less likely to experience symptoms such as difficulty concentrating and blurred vision which have higher logit scores. The clinical presentation of symptoms may be clinically useful in determining recovery and educating patients following concussion.

Is Body Mass Index Percentile a Covariate to Functional Performance Tests in Adolescents With and Without Chronic Ankle Instability?

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Context: Body mass index may be a confounding factor in chronic ankle instability (CAI) in adults. However, it is unclear whether body mass index percentile (BMI%) influences functional performance test (FPT) scores in an adolescent population with and without CAI. **Objective:** To determine if BMI% is a contributing covariate to functional performance test scores in adolescents with and without CAI. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Forty-two participants were categorized into two groups. The CAI group (9 male, 7 female; age = 15.7 ± 1.2 yrs; height = 16.8 ± 7.6 cm; mass = 62.5 ± 7.7 kg; BMI% = 72.9 ± 24.2%) had at least 1 moderate-severe ankle sprain, 2 episodes of giving way at the ankle, a Cumberland Ankle Instability Tool (CAIT) score ≤24 and an Identification of Functional Ankle Instability (IdFAI) score ≥11 indicating poor function. The control group (16 Male, 10 female; age = 15.8 ± 1.5 yrs; height = 163.7 ± 7.0 cm; mass = 56.3 ± 7.0 kg; BMI% = 54.9 ± 19.7%) had no history of ankle injury, CAIT scores ≥29, and IdFAI scores ≤10 indicating good function. **Interventions:** Participants completed the CAIT and IdFAI questionnaires. A single rater (reliability >0.89) measured performance on the Star Excursion Balance Test (SEBT) in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions, and the Single Leg Hop Test (SLHT). **Main Outcome Measures:** SEBT reach distance was normalized to % leg length and 3 trials were averaged. The average of 2 SLHT trials was calculated in seconds. A one-way Analysis of Covariance (ANCOVA) was conducted ($\alpha<0.05$) after a preliminary check of the homogeneity-of-slopes assumption. **Results:** The homogeneity-of-slopes assumption was supported ($p > .05$). For SLHT, the CAI group (adjusted mean 18.0sec 95% CI 16.6,19.3sec) was significantly slower than the control group (11.2sec 95% CI 10.1, 12.2sec) ($F(1,39) = 58.4$, MSE = 6.7, $p < .001$, $\eta2 = 0.60$). BMI% was a significant covariate ($F(1,39) = 4.5$, $p = .04$, $\eta2 = 0.10$). For SEBT, the CAI group (adjusted means ANT 53.4% [95% CI 47.7, 59.1], PM 68.5% [61.6, 75.3], PL 63.2% [58.2, 68.2]) performed significantly worse than the control group in all directions (ANT 73.7% [69.3, 78.1], PM 87.7% [82.4, 93.0], PL 74.8% [71.0, 78.7]) ($F(1,39) = 13.0$ to 30.4, $p = .001$) but BMI% was not a significant covariate ($F(1,39) = 0.01$ to 0.84, $p > .05$, $\eta2 \leq 0.02$). **Conclusions:** The CAI group performed significantly worse than the controls in each direction of the SEBT and in the SLHT. BMI% was only a significant covariate in the SLHT, accounting for 10% of the variance, but did not appear to vary with SEBT reach distance. BMI% may be a factor that influences performance on jumping or agility tests, but not necessarily semi-dynamic balance tests. BMI% may need to be considered when testing an adolescent population with CAI.

Kinetic Clustering of Patients With Self-Reported Ankle Instability During a Jump Task

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Context: Self-report survey instruments have traditionally defined ankle instability (AI). While self-report instruments classify ankle instability by self-perceived symptoms and movement deficits, movement neuromechanics in this patient population are quite variable. For this reason it is difficult for clinicians and researchers to identify specific neuromechanical alterations that might lead to poor movement strategies and perpetuate AI. **Objective:** To identify multiple clusters of joint kinetic (i.e., net joint torques) characteristics in a large sample of patients with self-reported AI. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** 80 subjects (23 ± 2 yrs) with a history of ankle sprains (4.4 ± 3.2), scored below 90% (83 ± 9) on the Foot and Ankle Ability Measure (FAAM) ADL, below 75% (62 ± 13) on the FAAM Sport, reported at least 2 "yes" responses (4 ± 1) on the MAII, and had no sprain in the previous 3 months. **Interventions:** High-speed video (250 Hz) and force plate (2500 Hz) data were used to estimate internal net sagittal and frontal plane ankle, knee, and hip joint torques during 5 trials of a max vertical jump, onto a force plate, that was immediately followed by a lateral jump. **Main Outcome Measures:** A curve or "function" was generated for each trial from the data collected during the stance phase of the jump task. Bayesian statistical modeling was used to create clusters from the functions generated from the joint torque curves. Functions were clustered using the following landmarks: initial joint torque at ground contact, minimum and maximum joint torque over the function, percent of function complete when minimum and maximum

joint torque occurred, number of times the derivative of the curve crossed zero, and the joint torque at take-off. Cross-classification matrices were used to measure cluster dependences across the kinetic variables. **Results:** 5-7 distinct clusters were identified among the various variables (joints and planes). Each cluster was considered significantly different from the other within each variable. Summary functions/curves will represent each distinct cluster. The maximum proportion of subjects sharing similar clusters from at least two different kinetic characteristics (joint and plane) ranged from 0.10 to 0.58. **Conclusions:** Multiple distinct joint torque functions were identified in a "homogenous" group of patients with self-reported AI, suggesting that multiple distinct neuromechanical alterations exist in an AI patient population. Further, patients shared similar clusters between variables, suggesting distinct overall movement strategies, involving multiple joints and planes. These data should be considered when using self-report instruments to identify AI, as these instruments may not be sensitive enough to provide evidence of a single movement strategy that places AI patients at risk. More data are needed to provide clinical identification techniques for each of the data clusters.

Altered Vertical Ground Reaction Forces in Participants With Chronic Ankle Instability While Running

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Context: Altered gait kinematics and kinetics are associated with subjects with chronic ankle instability (CAI). However, limited research has examined if vertical ground reaction forces are altered during running in subjects with CAI. **Objective:** To compare the components of vertical ground reaction forces in subjects with and without CAI during running. **Design:** Cohort Study. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Eleven subjects with CAI (5 men, 6 women; age = 21.2 + 1.3 years, height = 1.73 + 0.09 m, mass = 68.07 + 11.16 kg) and thirteen control subjects (7 men, 6 women; age = 20.4 + 3.6 years, height = 1.75 + 0.08 m, mass = 66.49 + 10.38 kg) volunteered for the study. All subjects were experienced runners who were consistently running at least 20 miles per week for the past year. The control subjects had no history of fractures, lower extremity surgeries, and injuries within the past three months. The CAI subjects had a minimum of one significant ankle sprain, were currently experiencing feelings of instability, and a score of 11 or higher on the Identification of Functional Ankle Instability questionnaire. **Interventions:** After a warm-up period, subjects ran on a Bertec instrumented treadmill (Columbus, OH) for five minutes at 3.3 m(s-1. Data were collected during the last thirty seconds of the trial at 1200 Hz with Vicon Nexus software (v1.7, Centennial, CO). A fourth order Butterworth filter at 45 Hz was applied to the data for processing. Using a custom built program in R (R Foundation for Statistical Computing, Vienna, Austria), five continuous trials of heel to toe running were identified per subject and averaged together for statistical analysis. A multivariate ANOVA was used calculated to determine differences between the groups. Follow-up univariate ANOVAs were performed on any significant findings. **Main Outcome Measures:** The dependent variables were impact peak force(N/BW), active peak force(N/BW), time to impact peak force(ms), time to active peak force(ms) and average loading rate((N/BW)/s). **Results:** Results of the multivariate ANOVA showed a significant difference between groups (P = 0.002). Follow-up test revealed that the CAI group had significantly higher impact peak forces (CAI = 2.05 + 0.24 N/BW, Control = 1.69 + 0.20 N/BW, P = 0.001) and active peak forces (CAI = 2.71 + 0.18 N/BW, Control = 2.52 + 0.08 N/BW P = 0.002) compared to the control group. The CAI group also had significantly increased loading rate (CAI = 93.84 + 10.89 (N/BW)/s, Control = 77.77 + 10.04 (N/BW)/s, P = 0.001) and a shorter time to reach the active peak force (CAI = 117.27 + 5.96 ms, Control = 131.46 + 6.09ms, P = 0.001) compared to the control group. No significant difference was found in the time to reach the impact peak force (P = 0.96) between groups. **Conclusions:** The increase in impact and active peak forces could potentially be a result of the altered kinematics of foot positioning in individuals with CAI. Further, weakness of the musculature of the lower leg during the loading phase of running gait could increase the forces upon impact. The presence of altered loading rates could predispose individuals with CAI to stress fractures.

Lower Extremity Biomechanics in Patients With Chronic Ankle Instability: A Statistical Parametric Mapping Analysis

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Context: The condition of chronic ankle instability (CAI) has been previously associated with changes in kinematics and kinetics during gait. These assessments were often limited to single plane assessments at discrete time points. The complex coordination of the entire lower extremity may be related to continued instability seen in CAI patients thus necessitating more complex and innovative analysis strategies. **Objective:** To compare hip, knee and ankle kinematics, kinetics and ground reaction forces (GRF) during walking and jogging gait between CAI patients and healthy controls. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Forty-one young adults (CAI, n = 21, # previous ankle sprains = 4.9 ± 3.2, height = 1.7 ± 0.8 m, mass = 71 kg; Control, n = 20, # previous ankle sprains =0 ± 0, height = 1.7 m ± 0.2, mass = 65.8 kg ± 13.7) participated. **Interventions:** None. **Main Outcome Measures:** Subjects walked (4.83 km/hr) and jogged (9.66 km/hr) on an instrumented treadmill interfaced with a 12 camera motion analysis system. 3-D kinematics and kinetics of the ankle, knee, and hip were assessed across the entire gait cycles, and 3-D GRF were assessed across the stance phase. A statistical parametric mapping (SPM) technique, based on Pataky's previously validated methods, was used as an exploratory assessment of group differences across all dependent variables. SPM is a statistical technique that allows for assessment of multidimensional datasets, such as seen in gait biomechanics, while minimizing statistical bias. It uses an adjusted t-statistic based on the number of comparisons and smoothness of the waveforms which changes the a priori p-value for significance within each comparison. **Results:** The exploratory SPM analysis identified single vector differences in GRF, subtalar joint frontal plane motion, and ankle joint moments during walking and jogging gait. During walking, the CAI group had significantly greater anterior GRF from 22-46% (mean difference = 83.3 ± 5.1 N/kg) and 53-91% (mean difference = 58.0 ± 0.72 N/kg) of stance phase and significantly more subtalar inversion from 58-100% (mean difference: 4.6° ± 0.9°) of the entire gait cycle. During jogging, the CAI group had significantly greater subtalar inversion from 20-92% (mean difference=3.9° ± 0.5°), greater plantar flexion moments from 6-10% (mean difference = 237.3 ± 17.29 Nmm/kg) and 50-83% (mean difference = 294.2 ± 44.8 Nmm/kg), and greater eversion moments from 7-72% (mean difference = 266.7 ± 6.84 Nmm/kg) of the gait cycle. No significant differences were identified at the knee or hip. **Conclusions:** The altered ankle kinematics and kinetics exhibited by the CAI group indicate a potential change in neuromuscular control. Aberrant ankle position and force production throughout the gait cycle may put CAI patients at risk for recurrent inversion mechanisms and giving way episodes. The SPM analysis identified similar findings to previous results using single measure statistical comparisons, but the group differences identified with SPM were across larger intervals of the gait cycle. The SPM analysis technique may represent a more robust statistical technique to identify differences in complex data sets common to gait analysis.

Differences in Foot Type in Those With Chronic Ankle Instability, Copers, and No History of Lateral Ankle Sprain

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Context: Following a lateral ankle sprain, it is not clearly understood why some patients experience residual symptoms while others go on to function without any impairments. Differences in foot type might be one potential explanation for these differences. **Objective:** To investigate differences in arch index in those with CAI, copers, and controls participants. **Design:** A cohort study. **Setting:** University Athletic Training research laboratory. **Patients or Other Participants:** Fifty-seven participants volunteered for this study: 20 CAI participants (age, 20 ± 3 years; height, 173.61 ± 7.84 cm; mass, 73.91 ± 17.58 kg), 17 coper participants (age, 20 ± 2 years; height, 171.34 ± 7.75 cm; mass, 71.18 ± 13.00 kg), and 20 control participants (age, 20 ± 1 years; height, 169.90 ± 9.50 cm; mass, 64.53 ± 14.01 kg). The Identification of Functional Ankle Instability (IdFAI) questionnaire was used to determine the presence of CAI. The subjects in the CAI group reported a history of lateral ankle sprains, frequent "giving way", and a score of 11 or higher on the IdFAI. Subjects in the copers group had a history of one lateral ankle sprain occurring greater than 12 months prior to the study, but never experienced any episodes of their ankle "giving way" or other residual symptoms. The subjects in the control group had no history of ankle sprains. **Interventions:** All participants completed a single test session. Each participant walked barefoot across Tekscan pressure mats (HR Mat Research, Tekscan, Inc., South Boston, MA) at a self-selected walking speed. An acceptable trial included one in which total foot contact was recorded on both pressure mats with no observable alteration of gait (i.e "stutter stepping" or lengthening/shortening their step length in order to land on the pressure mats). Three trials were completed. Arch index is calculated as [Midfoot/

(Hindfoot+Midfoot+Forefoot)]. Each composite footprint was divided into Hindfoot, Midfoot, and Forefoot boxes and the total contact area from each of the boxes was calculated. Arch index values of ≤0.21 indicate pes cavus, 0.22-0.25 indicate pes rectus (normal), and ≥0.26 indicate pes planus. **Main Outcome Measures:** The dependent variable was arch index. A one-way ANOVA was used to identify differences between the groups. **Results:** The results of the statistical analysis revealed no significant differences in arch index between the three groups ($F_{2,54} = 0.26$, $p = 0.77$). The mean arch index was 0.19 (SD = 0.08; 95% CI = .15 to .22) for the CAI group, 0.18 (SD = 0.09; 95% CI = .13 to .23) for the Coper group, and 0.17 (SD = 0.08; 95% CI = .13 to .21) for the control group. **Conclusions:** It appears that foot type, classified in this study as arch index, does not differ between people with CAI, copers, and no history of ankle injuries. Within each group there was a wide range of foot types, but in general, the majority of participants had either a normal or pes cavus foot type.

Lower Extremity Joint Coupling Variability Before and After Prolonged Exercise With Chronic Ankle Instability

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Context: Chronic ankle instability (CAI) results in recurrent sprains and feelings of "giving way" in the ankle. CAI has been associated with changes in ankle kinematics. Recently, multi-segmental assessment of shank-rearfoot joint coupling has identified alterations in the coordination of the rearfoot and shank segments indicating that CAI may present a constraint on sensorimotor coordination. Proximal alterations at the knee and hip kinematics have been identified during jumping tasks in patients with CAI and injury risk has been shown to increase following prolonged exercise. Changes in the lower extremity coordination may be related to increased episodes of instability in CAI patients and may be altered by prolonged exercise. **Objective:** To evaluate joint coupling vector coding variability (VCV) between subjects with CAI and healthy controls during walking and jogging gait before and after prolonged exercise. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Ten subjects with self-reported CAI (age: 21.8 ± 2 yrs, height: 1.7 ± 0.08 m, mass: 64.6 ± 12 kg) and 13 healthy subjects (23.8 ± 5 yrs, height: 1.74 ± 0.11 m, mass: 74.9 ± 0.11) with no history of lower extremity injury participated. **Intervention(s):** Walking (4.83 km/hr) and jogging (9.66 km/hr) gait were performed on a treadmill before and after a 36-minute exercise protocol consisting of progressive uphill walking and plyometric exercises. **Main Outcome Measures:** Pre-to-post exercise VCV mean difference between CAI and control groups were calculated throughout the gait cycle for 4 joint couples: ankle frontal-knee sagittal, ankle sagittal-knee sagittal, ankle frontal-hip frontal, and ankle sagittal-hip frontal. Negative mean differences in VCV indicate decreased VCV from pre-exercise to post-exercise. For each speed, the means and 90% confidence intervals (CI) were calculated across the entire gait cycle and increments in which the CI bands for the groups did not cross each other for at least 3 consecutive percentage points of the gait cycle were identified. **Results:** In walking, the CAI group had lower VCV mean differences from 77-80% of the gait cycle in the ankle frontal-knee sagittal couple indicating less stride-to-stride variability after exercise (CAI: -0.11 ± 0.04, Healthy: 0.05 ± <0.01). During jogging, the CAI group had lower VCV mean differences in the ankle frontal-hip frontal couple from 53-55% (CAI: -0.12 ± 0.01, Healthy: 0.25 ± 0.01) and 90-94% (CAI: -0.05 ± <0.00, Healthy: 0.25 ± 0.01). The CAI group had lower VCV mean differences in the ankle sagittal-hip frontal couple from 7-10% (-0.12 ± 0.02, Healthy: 0.12 ± 0.03). **Conclusions:** Decreased joint coupling variability mean differences indicate that the CAI group had decreased VCV from pre-exercise to post-exercise. The Healthy group had increased VCV following exercise. Prolonged exercise may further constrain patients with CAI leading to a less adaptable coordination pattern. The combination of CAI and fatigue following prolonged exercise may place these individuals at risk for further lateral ankle sprains. Proximal alterations indicate a central role in lower extremity coordination and may indicate complex adaptation in patients with CAI following prolonged exercise.

Eversion Strength and Surface Electromyography Measures of the Peroneal Muscles in Two Testing Positions

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Context: Individuals with chronic ankle instability (CAI) have strength deficits compared to healthy controls, however, the influence of foot position on force and surface electromyography (sEMG) measures of the peroneus longus (PL) and peroneus brevis (PB) have not been previously investigated. A study investigating the influence of foot position on these measures could provide insight on whether these muscles can be isolated during assessment. **Objective:** To compare eversion force and sEMG amplitudes of the PL and PB in two testing positions (neutral, plantar flexion (PF)) in two groups (control, CAI). **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-eight young adults with CAI (height = 169 ± 8.8 cm, mass = 71 ± 14 kg, age = 21 ± 3 years, sex = F: 19 M: 9) and 28 healthy controls (height = 169 ± 8.2 cm, mass = 71.5 ± 16 kg, age = 22 ± 4 years, sex = F: 19 M: 9) participated. **Intervention(s):** None. **Main Outcome Measures:** Hand-held dynamometer force measures were recorded during maximum isometric eversion contractions in two testing positions (neutral, PF) while sEMG amplitudes of the PL and the PB were simultaneously recorded. Force measures were normalized to body mass (Nm/kg) and sEMG amplitude during contraction were normalized to amplitude during a quiet baseline of the corresponding muscle (unitless measure). Force measures were analyzed with a 2x2 group by position ANOVA, while sEMG amplitude measures were analyzed with a 2x2x2 (group by position by muscle) ANOVA. Post-hoc comparisons were made by comparing 95% confidence intervals (CI) of relevant conditions. **Results:** A significant group by condition interaction was identified for the force measures (P = 0.03).The CAI group produced less eversion force than the control group in both the neutral (CAI (mean [95% CI] = 1.64 [1.46–1.81] Nm/kg; Control = 2.10 [1.93–2.28] Nm/kg) and PF (CAI = 1.40 [CI: 1.27–1.54] Nm/kg; Control = 1.73 [1.60–1.87] Nm/kg) positions. For sEMG amplitudes, there were significant group by position (P = 0.02) and muscle by position (P = 0.04) interactions. The group by position interaction was explained by the smaller mean difference (2.8 [-0.5-6.2]) in pooled PL and PB sEMG amplitude between the neutral and PF positions in the CAI group, and the larger mean difference (9.2 [4.8-13.5]) between positions in the control group. The position by muscle interaction was explained by the larger mean difference in pooled CAI and control groups' sEMG amplitude between positions for the PL (7.8 [4.6–11.0]), compared to a smaller mean difference for the PB (4.2 [0.8-7.6]). For both muscles, higher sEMG amplitudes were recorded in the PF position than the neutral position. **Conclusions:** The CAI group had decreased eversion strength in both neutral and PF positions relative to the control group. Additionally, the CAI group did not have as large of an increase in PL and PB sEMG amplitude when testing in the PF position compared to the neutral position as did the control group. It appears clinicians cannot conclusively isolate the PL and PB muscles from each other during isometric eversion strength assessment.

Rehabilitation for Chronic Ankle Instability With and Without Destabilization Devices: A Randomized Controlled Trial

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Context: Chronic ankle instability (CAI) patients have deficits in self-reported function, range of motion (ROM), strength, balance and functional movements. Ankle destabilization devices can increase lower extremity muscle activity during functional tasks and may be a useful rehabilitation tool to improve deficits associated with CAI. **Objective:** To determine whether a 4-week impairment-based progressive rehabilitation program that includes ankle destabilization devices (Device) has greater beneficial effects on self-reported function, ROM, strength and balance compared to traditional rehabilitation (No Device) in CAI patients. **Design:** Single-blinded randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-six patients with CAI (No Device: N = 13, height = 169 ± 11 cm, mass = 75 ± 14 kg, age = 21 ± 3 years, sex = M7,F19; Device: N = 13 height = 169 ± 7 cm, mass = 66 ± 13 kg, age = 21 ± 3 years, sex = M:7,F:19) participated. **Intervention(s):** Following baseline measures, participants were randomized into No Device and Device groups. Both groups completed 4-weeks of supervised impairment-based progressive rehabilitation and then repeated all measures. The Device groups had Myolux destabilization devices incorporated into their rehabilitation programs while the No Device group did not. **Main Outcome Measures:** Self-reported function was assessed using the Foot and Ankle Ability Measure (FAAM) activities of daily living (ADL) and sport subscales. Ankle dorsiflexion ROM was measured in standing straight-knee (SSK) and bent-knee (SBK) positions. Eversion strength was assessed using a hand-held dynamometer during maximum isometric contractions. A composite score of three reach directions for the Star Excursion Balance Test (SEBT) was used to measure

dynamic balance. A force plate was used to measure static balance and calculate center of pressure (COP) velocity during single-limb eyes-closed balance. Each dependent variable was compared using a 2x2 (group by time) ANOVA and post-hoc tests as appropriate. **Results:** There were no significant group by time interactions for any dependent variables ($P > 0.05$). Furthermore, there were no significant group main effects for any measures ($P > 0.05$) except ROM where the Device group had significantly more SSK ($P = 0.003$) and SBK ($P = 0.026$) dorsiflexion than the Device group at baseline, but did not have greater pre-to-post change scores than the No Device group. There were significant time main effects for all measures when groups were combined indicating that both groups improved with rehabilitation. With both groups combined, self-reported function (FAAM-ADL% Pre (Mean ± SD) = 86.7 ± 7.5, Post = 95.8 ± 4.6, $P < 0.001$; FAAM-Sport% Pre = 66.5 ± 13.4, Post = 86.3 ± 9.8, $P < 0.001$), dorsiflexion ROM (SSK Pre- = 38.1 ± 9.6°, Post = 42.8 ± 8.7°, $P = 0.02$; SBK Pre = 42.2 ± 10.1°, Post = 47.3 ± 9.8°, $P = 0.001$), eversion strength (Pre = 1.64 ± 0.39 N/kg, Post = 2.08 ± 0.49 N/kg, $P < 0.001$), dynamic balance (SEBT Pre = 75.1 ± 7.8, Post = 79.1 ± 6.7, $P = 0.003$), and static balance (COP velocity Pre = 9.8 ± 2.8 cm/s, Post = 9.0 ± 2.3 cm/s, $P = 0.03$) all improved following rehabilitation. **Conclusions:** Rehabilitation that included destabilization devices was not more effective at improving self-reported function, ROM, strength and balance when compared to no devices as both groups had similar improvements. Impairment-based progressive rehabilitation, with or without the use of destabilization devices, was effective at improving clinical outcomes associated with CAI and should be used when treating CAI.

Accuracy of Ligamentous Laxity Measures in Stable and Unstable Ankles

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Context: Chronic ankle instability (CAI) often develops following lateral ankle sprain, but the role of mechanical laxity in classifying ankle stability status is unclear and could help determine clinical outcomes. **Objective:** To determine the accuracy of an arthrometer talar tilt test for mechanical laxity in identifying CAI and to establish cutoff scores for the test. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Eighty-seven volunteer recreational athletes (42 males, 45 females, age 20.7 ± 2.0 yrs, height 169.9 ± 9.5 cm, mass 70.2 ± 13.1 kg) who participated in ≥90 minutes of physical activity/week. Control participants (n = 32) reported no history of ankle sprains or giving way at the ankle and scored ≥29 on the Cumberland Ankle Instability Tool (CAIT), indicating good ankle function. CAI (n = 39) and coper (n = 16) groups reported a history of moderate-severe ankle sprain ≥1 year ago. The CAI group reported ≥2 episodes of ankle instability in the last year while copers had none. The CAI group scored ≤26 on the CAIT indicating poor ankle function, while copers scored ≥29. **Interventions:** Participants completed the CAIT and an ankle injury history form, then underwent lateral ankle ligament instrumented arthrometry testing for inversion talar tilt. The ankle was positioned in neutral and the knee flexed to 20º while 150N were applied to the ankle by a single rater (reliability >0.80). **Main Outcome Measures:** Maximum linear displacement (mm) and maximum angular rotation (º) were extracted and averaged over the last 2 trials. Sensitivity (Sn) and 1-specificity (1-Sp) values were calculated for each measure. Area under the curve (AUC) for receiver operating characteristic (ROC) curves was used to estimate the accuracy of each measure (α=0.05). Cutoff scores were calculated using Youden's Index (J), along with positive and negative likelihood ratios (LR+, LR-) and odds ratios (OR) to determine if the cutoff score could identify those with CAI. **Results:** Groups were not different in age or mass ($p > 0.05$) but copers were taller than controls ($p = 0.03$). The CAI group had significantly lower CAIT scores (19.9 ± 5.1, $p < 0.001$) than the coper and control groups (29.0 ± 1.2, 29.8 ± 0.4) who were not different ($p > 0.05$). Significant AUC values and cutoff scores were found for maximum linear displacement (AUC = 0.69; 95% CI 0.58, 0.80; $p = 0.002$; Sn = 0.56; 1-Sp = 0.27; cutoff = 38.7 mm; J = 0.29; LR += 2.08; LR- = 0.60; OR = 3.48) and maximum angular rotation (AUC = 0.70; 95% CI 0.59, 0.81; $p = 0.001$; Sn = 0.67; 1-Sp = 0.33; cutoff = 15.4º; J = 0.33; LR += 2.00; LR- = 0.50; OR = 4.00). **Conclusions:** Mechanical laxity testing has some limited utility in identifying those with CAI compared to control and coper groups. Clinicians may use instrumented arthrometry with cutoff scores as part of their identification process for those with CAI. Identifying a CAI sub-group with mechanical laxity may help determine appropriate treatment paths for better clinical outcomes.

Plantar Cutaneous Mechanoreceptor Thresholds Differ Among Uninjured Controls, Copers, and Those With Chronic Ankle Instability

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Context: Cutaneous mechanoreceptors are known to provide crucial input in the task of maintaining postural stability. Those with chronic ankle instability (CAI) have known postural control deficits relative to uninjured controls and those that have sprained their ankle but not developed CAI (i.e. copers). Those with CAI have also been reported to have higher thresholds of plantar cutaneous sensation but this phenomenon has yet to be explored in copers. **Objective:** To determine if cutaneous sensation thresholds around the foot/ankle complex differ among uninjured controls, copers, and those with CAI. **Design:** Cross Sectional. **Setting:** Research Laboratory. **Patients or Other Participants:** 45 participants (age: 20.2 ± 2.8 yrs; height: 167.6 ± 9.9 cm; mass: 6.3 ± 14.7 kg) in three equal groups: Control (CON), Coper (COP), and CAI completed the investigation. Group assignment was determined using the Foot and Ankle Ability Measure (FAAM), FAAM-Sport and the Ankle Instability Instrument. **Interventions:** Foot/ankle complex cutaneous sensation thresholds were evaluated using a set of 20 Semmes-Weinstein monofilaments, which test light touch threshold. The monofilaments differed in thickness and index value (1.65-6.65), with a smaller index requiring a lower threshold for activation than a larger index. Cutaneous thresholds were tested at 4 sites: head of the 1st metatarsal (1MT), base of the 5th metatarsal (5MT), calcaneus (CL), and the sinus tarsi (ST). **Main Outcome Measures:** Foot/ankle complex cutaneous testing was carried out using a 4-2-1 stepping algorithm. Cutaneous thresholds were determined as the last monofilament detected after 3 consecutive attempts to detect a smaller monofilament. The thresholds were analyzed using a Kruskal-Wallis test to determine group differences and Mann-Whitney U tests to determine locations of differences due to the ordinal nature of the data. **Results:** Significant group differences were detected at the 1MT ($X2 = 6.39$, $p = 0.041$), 5MT ($X2 = 7.97$, $p = 0.019$), CL ($X2 = 6.75$, $p = 0.034$), ST ($X2 = 12.7$, $p = 0.002$). 1MT median threshold scores (Control: 3.22, Coper: 3.61, CAI: 3.61) were significantly higher in those with CAI relative to controls ($U = 56.6$, $p = 0.019$). 5MT median threshold scores (Control: 3.22, Coper: 3.22, CAI: 3.61) were significantly higher in those with CAI relative to controls ($U = 58.0$, $p = 0.023$) and copers ($U = 55.0$, $p = 0.016$). CL median threshold scores (Control: 3.61, Coper: 3.61, CAI: 4.17) were significantly higher in the CAI group relative to copers ($U = 54.5$, $p = 0.015$). ST median threshold scores (Control: 3.22, Coper: 3.84, ST: 4.08) were significantly higher in the CAI ($U = 35.0$, $p = 0.001$) and coper groups ($U = 59.5$, $p = 0.026$) relative to controls. **Conclusions:** The results are consistent with previous cutaneous threshold findings between controls and those with CAI. Higher ST thresholds in CAI and copers relative to controls may be due to the initial ankle injury and represent an acute sprain sequela that copers successfully compensate for to avoid recurrent injury. However, higher 5MT thresholds in CAI relative to copers and controls may represent an adaptation that leads to CAI development.

Effect of Neuromuscular Fatigue on Lower Extremity Energetic Patterns in Subjects With Ankle Instability

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Context: Skeletal muscles absorb the kinetic energy of the body during the landing phase of jumping. Fatigue and ankle instability (AI) impair neuromuscular control and dynamic stability of the lower extremity. Little is known, however, regarding exercise-induced fatigue alterations of joint energetics in subjects with AI. **Objective:** To investigate the effect of fatigue and AI on lower-extremity energetic patterns during a forward-side jump. **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** 25 CAI (23.3 ± 1.9 yrs, 176.5 ± 10.5 cm, 70.9 ± 11.4 kg), and 25 matched healthy control subjects (23.7 ± 2.5 yrs, 175.0 ± 10.8 cm, 70.3 ± 12.8 kg) were categorized according to the FAAM (ADL: 84.3 ± 7.6 %, Sport: 63.6 ± 8.6 %) and MAII (3.7 ± 1.2). **Interventions:** Fifty-nine reflective markers were place over anatomical landmarks to calculate joint powers. Subjects performed five forward-side jumps on a force plate before and after fatiguing exercises. To induce fatigue, subjects began 5-min incremental running on a treadmill between 5-6 mph. Next, subjects performed 20-second lateral counter movement jumps (CMJ), and 20 vertical CMJs. After each fatigue cycle, subjects performed one max vertical jump. Subjects repeated three exercises until RPE reached 17 and the vertical jump height fell below 80% of max jump height. Functional linear models ($p < 0.05$) were used to evaluate differences between two conditions (pre- vs post-fatigue) in each group (CAI and control) for lower-extremity joint powers. This analysis compared variables as polynomial functions rather than discrete values. Functions (curves) were compared between groups across conditions. Pairwise comparison functions as well as 95% confidence interval (CI)

bands were plotted to determine specific differences. If 95% CI bands did not cross the zero line, we considered the difference significant. **Main Outcome Measures:** Joint power (W/kg) was measured during the landing phase of a forward-side jump which was from initial foot contact (0%) to peak knee flexion (100%). **Results:** Significant group by fatigue interactions were found during 25-35% and 65-100% of landing in knee joint power and during 25-35% and 60-65% of landing in hip joint power. In the control group, increased knee joint power and decreased hip joint power were found during 20-40% of landing while decreased knee joint power and increased hip joint power during 50-80% of landing following fatigue. In the AI group, fatigue increased knee joint power and decreased hip joint power at initial foot contact while knee joint power between 50-70% of landing was decreased, while hip joint power was not affected. No group by fatigue interaction was found in ankle joint power. **Conclusions:** After fatigue, AI subjects demonstrated altered energetic patterns, redistributing joint powers to compensate for muscle fatigue in an attempt to control landing motion. This altered energetic pattern potentially imposes the kinetic energy on connective tissues such as ligaments and bones, which could increase injury risk during functional activities.

The Influence of Foot Posture on Static and Dynamic Postural Control in Those With Chronic Ankle Instability

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Context: Patients with chronic ankle instability (CAI) commonly exhibit static and dynamic postural control deficits. It is unclear if additional factors such as foot posture influence postural control insufficiencies in these individuals. **Objective:** Investigate the influence of foot posture on static and dynamic postural control in individuals with CAI. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Twenty physically active adults with self-reported CAI participated. Participants reported at ≥1 ankle sprain, ≥2 episodes of giving way in the past three months, answered "yes" to ≥4 items on the Ankle Instability Instrument, and ≤24 on the Cumberland Ankle Instability Tool. The Foot Posture Index (FPI) categorized subjects into neutral (FPI = 0 to +5) and pronated (FPI = +6 to +12) groups. Thirteen subjects had a neutral foot posture (male = 3; age = 24.85 ± 2.07 years; height = 168.13 ± 13.17 cm; weight = 73.69 ± 14.27 kg; FPI = 3.08 ± 1.93) and seven had a pronated foot posture (male = 2; age = 22.43 ± 2.07 years; height = 168.73 ± 13.17 cm; weight = 73.22 ± 14.27 kg; FPI = 7.43 ± 0.98). There were no significant differences between groups in age, height, or weight ($p \geq 0.22$). **Interventions:** All subjects reported for one session. Dynamic postural control was assessed using the anterior direction of the Star Excursion Balance Test (SEBT-AR). Subjects performed four practice trials and three collection trials that were normalized to leg length. Static postural control was assessed through three, 10s trials of barefoot single-limb stance on a forceplate with eyes open and closed. The investigators measuring postural control were blinded to group. **Main Outcome Measures:** The independent variable was group (neutral, pronated). Dependent variables were SEBT-AR (%) and time-to-boundary (TTB) (s). TTB variables included 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 for both eyes open and closed. Independent t-tests examined differences between groups for all measures. Alpha was set at a-priori $p \leq 0.05$ for all analyses. Cohen's d effect sizes (ES) were calculated for each comparison. **Results:** No significant between group differences were identified in SEBT-AR (neutral = 74.45 ± 4.05 %; pronated = 70.53 ± 4.64 %; p = 0.07; ES = 0.92), eyes closed TTB-SD AP (neutral = 1.21 ± 0.30 s; pronated = 1.47 ± 0.38 s; p = 0.12; ES = -0.78) or eyes open TTB-mean AP (neutral = 4.73 ± 1.25 s; pronated = 5.82 ± 1.41 s; p = 0.09; ES = -0.84), TTB-mean ML (neutral = 1.61 ± 0.50 s; pronated = 2.09 ± 0.65 s; p = 0.08; ES = -0.86), TTB-SD AP (neutral = 2.98 ± 0.99 s; pronated = 3.68 ± 1.36 s; p = 0.20; ES = -0.63) and TTB-SD ML (neutral = 1.36 ± 0.72 s; pronated = 1.66 ± 0.61 s; p = 0.36; ES = -0.44). Significantly greater TTB values were identified for pronators in eyes closed TTB-mean AP (neutral = 1.87 ± 0.34 s; pronated = 2.33 ± 0.52 s; p = 0.03; ES = -1.14), TTB-mean ML (neutral = 0.63 ± 0.16 s; pronated = 0.83 ± 0.23 s; p = 0.03; ES = -1.11), and TTB-SD ML (neutral = 0.49 ± 0.21 s; pronated = 0.77 ± 0.30 s; p = 0.03; ES = -1.14). **Conclusions:** The pronator group demonstrated greater eyes closed static postural control. However, the large effect size indicates those with neutral foot postures demonstrated greater dynamic postural control despite the lack of statistical significance. These findings indicate pronated foot postures may create somatosensory and mechanical alterations that create task-specific deviations in postural control. Therefore, foot posture should be considered when examining postural control in those with CAI.

The Immediate Effects of Sensory-Targeted Ankle Rehabilitation Strategies on Time-to-Boundary in Those With Chronic Ankle Instability

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Context: Deficient sensory input from damaged ankle ligament receptors is thought to contribute to functional impairments associated with chronic ankle instability (CAI). By targeting other available sensory receptors, may enhance rehabilitation outcomes for those with CAI. **Objective:** To evaluate the immediate effects of sensory-targeted rehabilitation strategies (STARS) on eyes closed single limb stance time-to–boundary (TTB) scores in those with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** 80 patients with self-reported CAI (33 males, 47 females; age: 22.7 ± 4.4 yrs; height: 171 ± 9.4 cm; mass: 74.3 ± 16.0 kg) participated. CAI was defined as at least two episodes of "giving way" within the past 3 months (mean: 6.21 ± 8.98); scoring <90% on the Foot and Ankle Ability Measure (FAAM) (mean: 78.89 ± 11.25%, and scoring <80% on the FAAM-Sport (mean: 62.63 ± 13.09%). **Interventions:** Patients performed 3, 10-second trials of eyes closed single limb stance on a force plate. After baseline testing, patients were randomly allocated to 4 STARS groups: joint mobilization (JM), plantar massage (PM), triceps surae stretching (TS), or control (CON). Each patient received 5 minutes of their respective STARS and was immediately reassessed on eyes closed single limb balance. **Main Outcome Measures:** For each trial, the TTB minima mean was calculated in the mediolateral (TTBML) and anteroposterior (TTBAP) directions. TTB minima means estimate the amount of time a person has to make a postural correction to prevent balance loss. The 3 trial mean for each variable was used for further analysis. Change scores (Δ) from post- to pre-STARS were generated. 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:** PM (Δ: 0.10 ± 0.19 s; ES: 0.89 (0.24 to 1.54)) resulted in improved TTBML minima mean scores ($p < 0.01$) with a large ES and a CI that did not cross zero compared to the CON (Δ: -0.16 ± 0.32 s). JM (Δ: -0.02 ± 0.38 s; ES: 0.36 (-0.27 to 0.98)) and TS (Δ: -0.05 ± 0.48 s; ES: 0.24 (-0.38 to 0.87)) failed to improved TTBML minima mean scores ($p = 0.21$ and $p = 0.40$ respectively) with small ES compared to the CON and CIs that encompassed zero. PM (Δ: 0.27 ± 0.67 s; ES: 0.2 (-0.37 to 0.88)), JM (Δ: 0.17 ± 1.01s; ES: 0.16 (-0.46 to 0.78), and TS (Δ: -0.02 ± 1.37 s; ES: 0.02 (-0.60 to 0.64) failed to improve TTBAP minima mean scores ($p = 0.37$, $p = 0.58$, and $p = 0.95$ respectively) compared to CON (-0.05 ± 1.45 s) with small ES and CIs that encompassed zero. **Conclusions:** PM was the only STARS intervention that had an immediate effect on TTBML minima means during eyes closed single limb stance. Our findings suggest that targeting the sensory information from the plantar surface of the foot via PM appears to immediately enhance ML postural control for those with CAI.

The Effect of Talocrural Joint Traction on Dorsiflexion Range of Motion and Postural Control in Individuals With Chronic Ankle Instability

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Context: Talocrural joint mobilizations that focus on posterior talar glide are commonly used to address dorsiflexion and postural control deficits in patients with chronic ankle instability (CAI). Talocrural joint traction is a manual therapy technique that could provide an effective and simpler alternative; however, the effects of this treatment have not been examined in those with CAI. **Objective:** Examine the effects of talocrural joint traction on dorsiflexion range of motion and postural control in individuals with CAI. **Design:** Double-blind, crossover. **Setting:** Laboratory. **Patients or Other Participants:** Twenty adults (14 females; age = 23.80 ± 4.02 years; height = 169.55 ± 12.38 cm; weight = 78.34 ± 16.32 kg) with self-reported CAI participated. Inclusion criteria consisted of a history of ≥1 ankle sprain, ≥2 episodes of giving way in the previous three months, answering "yes" to ≥4 questions on the Ankle Instability Instrument, and ≤24 on the Cumberland Ankle Instability Tool. **Interventions:** Subjects participated in three sessions in which they received a single treatment session of sustained traction (ST), oscillatory traction (OT) or a sham condition in a randomized order. All treatments consisted of four, 30-second sets of application with one minute of rest between sets. During ST and OT, the talus was distracted distally from the ankle mortise to the end-range of accessory motion. ST consisted of continuous distraction and OT involved 1-second oscillations between the mid and end-range of accessory motion. The sham condition consisted of physical contact without force application. Dorsiflexion was measured using the Weight-Bearing Lunge test (WBLT). Postural control was assessed dynamically using the anterior direction of the Start Excursion

Balance Test (SEBT-AR) and statically through 10-second trials of barefoot single-limb stance on a forceplate with eyes open. For each measure, three trials were completed pre and post-treatment. **Main Outcome Measures:** The independent variable was treatment (ST, OT, sham). The dependent variables included pre-to-post-treatment change scores for the WBLT (cm), normalized SEBT-AR (%) and time-to-boundary (TTB) (s). TTB variables included 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. For each dependent variable, a one-way ANOVA examined differences between treatments. Post hoc comparisons were performed when indicated using Fisher's LSD. Alpha was set a-priori at $p < 0.05$. **Results:** No significant treatment effects were identified for the WBLT (Sham = 0.12 ± 0.47 cm, ST = -0.01 ± 0.40 cm, OT = 0.51 ± 1.13 cm, p = 0.08), SEBT-AR (Sham = 0.13 ± 2.02%, ST = -0.24 ± 2.27%, OT = -0.18 ± 1.95%, p = 0.84), TTB-Mean ML (Sham = 0.27 ± 0.25 s, ST = 0.22 ± 0.32 s, OT = 0.21 ± 0.26 s, p = 0.79), TTB-Mean AP (Sham = 0.54 ± 0.87 s, ST = 0.45 ± 1.19 s, OT = 0.68 ± 0.90 s, p = 0.77), TTB-SD ML (Sham = 0.24 ± 0.82 s, ST = 0.21 ± 0.48 s, OT = 0.13 ± 0.26 s, p = 0.85), or TTB-SD AP (Sham = 0.19 ± 0.84 s, ST = 0.05 ± 1.35 s, OT = 0.54 ± 0.88 s, p = 0.30). **Conclusions:** A single treatment of ST or OT did not produce immediate changes in dorsiflexion range of motion or postural control in individuals with CAI. Future research should investigate the effects of repeated talocrural traction treatments and the effects of this technique when combined with other manual therapies.

Utilizing a Contemporary Paradigm to Classify Collegiate Athletes With Chronic Ankle Instability

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Context: Ankle sprains are a leading cause of time-loss in athletics. Chronic ankle instability (CAI) affects many following an ankle sprain. Traditional paradigms for classifying CAI have involved the assignment to one of two sub-categories; functional vs. mechanical instability. Recently, a more contemporary paradigm for classification of CAI has been suggested and involves the addition of a third sub-category titled recurrent sprains and the renaming of functional instability to perceived instability. **Objective:** To compare two different classification schemes for subjects with CAI. **Design:** Cross-sectional. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Two-hundred thirty four (138 males and 96 females) intercollegiate-student athletes from 9 high-risk sports volunteered for this study (age = 18.5 ± .8 yrs; mass = 79.6 ± 18.4 kg; height = 178.8 ± 10.9 cm). **Interventions:** Functional (perceived) instability was determined utilizing the Cumberland Ankle Instability Tool (CAIT). In addition, all subjects completed the Ankle Study Inclusion Questionnaire which focused on ankle sprain history. For this study, 3 or more sprains on the same side classified the ankle as having "recurrent sprains". Meanwhile, "mechanical instability" was assessed using an instrumented ankle arthrometer with laxity values of ≥ 12mm classified as mechanical instability. **Main Outcome Measures:** CAIT scores provided a measure of perceived instability. Recurrent sprain data was derived from the Ankle Study Inclusion Questionnaire. Anterior displacement (mm) was derived from the ankle arthrometer measurements. These variables derived from each ankle were then allocated accordingly to their appropriate groupings using both the traditional and contemporary CAI classification paradigms. **Results:** Data from 445 ankles (23 ankles excluded for missing data) were categorized. From this cohort, 183 were classified as healthy and were not used for further comparison. The remaining 262 ankles were then classified using both the traditional (2 sub-categories) and contemporary (3 sub-categories) CAI paradigms. Interestingly, 33% of the qualified ankles did not fit the traditional CAI classification model; whereas 100% of the subjects fit the more contemporary CAI classification model. **Conclusions:** Because of our 100% fit using the contemporary CAI classification model, our results offer strong support for the 3 sub-category model as proposed by Hiller et al. (2011). Perhaps utilizing this 3 sub-category model would enhance research in CAI and closely follow the recent guidelines for CAI subject classification as proposed by the International Ankle Consortium. In addition, the 3 sub-category model will provide athletic trainers a more sensitive tool for classifying subjects with CAI. Interestingly, we noted a higher percentage of subjects classified as having mechanical instabilities when compared to those classified in the contemporary model proposed by Hiller et al. (2011). The discrepancy most likely is related to the fact that they used a subjective anterior drawer test to assess mechanical instability versus the precise ankle arthrometer used in this study.

Interrater and Intrarater Reliability of the Semmes-Weinstein Monofilament 4-2-1 Stepping Algorithm in Physically Active Adults

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Context: Semmes-Weinstein Mono filaments (SWM) are used to examine light touch sensation of the skin on the extremities. SWM may be a useful tool for evaluating patients who experience decreased sensation on the plantar aspect of the foot following orthopaedic injury. The SWM 4-2-1 stepping algorithm approach for determining light touch detection thresholds may present a systematic technique to identify subtle sensation changes following injury in otherwise young, healthy, physically active adults; however, the reliability of this technique has not been examined. **Objective:** To determine the interrater and intrarater reliability of the SWM 4-2-1 stepping algorithm on the plantar surface of the foot. **Design:** Reliability. **Setting:** Laboratory. **Patients or Other Participants:** Fourteen physically active adults (4 males, 10 females, age: 23.79 ± 3.07 years, height: 170.18 ± 9.66 cm, mass: 81.20 ± 15.16 kg) volunteered. Participants were included if they had no lower extremity injury within the last six months or surgery within the past year. Two Athletic Trainers with no SWM experience served as novice raters (N1, N2) following a training session. Two Athletic Trainers experienced in SWM assessment served as expert raters (E1, E2). **Interventions:** Participants completed two sessions separated by one week. Participants were positioned prone with the head of the first metatarsophalangeal joint marked for SWM application. A 20-piece SWM kit was used to determine light touch detection thresholds. SWM were applied perpendicular to the skin, pressed into a 'C' shape, and held for 1-2s. Based on the participant's perceptual response, a heavier or lighter weighted SWM was presented for the subsequent stimulus. An adapted stepping algorithm was used to determine the lightest SWM weight that could be identified, which represented the detection threshold. SWM detection thresholds were recorded as an index value ranging from 1.65-6.65. During the initial session, all raters performed the 4-2-1 stepping algorithm on each participant to determine interrater reliability. One week later, participants were reassessed by two raters (E1, N1) to determine intrarater reliability. The order of raters was counterbalanced in both sessions. **Main Outcome Measures:** Independent variables were session and rater. The dependent variable was detection threshold. Higher detection thresholds represented decreased sensitivity. Intraclass correlation coefficients (ICC2,1) and standard error of measurement (SEM) were calculated to determine interrater and intrarater reliability. **Results:** SWM values (mean ± standard deviation) for the individual raters ranged from 3.72 ± 0.51 to 3.94 ± 0.49. Interrater reliability across all raters was ICC2,1 = 0.75 (SEM = 0.26). Intrarater reliability for N1 was ICC2,1 = 0.61 (SEM = 0.35). Intrarater reliability for E1 was ICC2,1 = 0.85 (SEM = 0.18). **Conclusions:** The 4-2-1 stepping algorithm demonstrated good interrater and moderate-to-good intrarater reliability when measured in healthy, physically active adults. Intrarater reliability was stronger in the experienced examiner suggesting novice examiners may experience more variability when evaluating detection thresholds. Overall, the 4-2-1 stepping algorithm demonstrated acceptable reliability for examining light touch detection thresholds within and between clinicians for use in clinical practice.

Return-to-Play Timelines Following Ankle Sprain in Women's Soccer Athletes

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Context: Lateral ankle sprains (LAS) are the most common injuries in soccer; medial (MAS) and syndesmotic ankle sprains (SAS) are less so. Probability of return-to-play (RTP) timelines have been determined for LAS in other sports, but have not been compared to timelines for MAS or SAS. RTP timelines for ankle injuries specific to women's soccer athletes will assist clinicians in making prognoses of return to participation for injured athletes. **Objective:** To determine incidence rates (IR) and compare the probability of RTP at specified time points following LAS, MAS, and SAS in collegiate women's soccer players. **Design:** Epidemiological. **Setting:** Secondary data analysis. **Patients or Other Participants:** NCAA women's soccer players who sustained an ankle sprain during school-sanctioned athletic participation. **Intervention(s):** First-time ankle sprains that occurred during a school-sponsored practice or competition and subsequently recorded in the NCAA Injury Surveillance System from 2005-09 were analyzed. Ankle sprains were stratified by specific location of injury (LAS, MAS, SAS). **Main Outcome Measure(s):** The dependent variable was days lost from participation after ankle sprain injury. Kaplan-Meier estimators were used to determine probabilities of RTP at specified time points. A Mantel-Cox log-rank test was used to contrast RTP probabilities by specific injury location (LAS, MAS, SAS). Alpha levels were set a priori at $p < .05$. **Results:** In total, 570 ankle sprains were analyzed (LAS: n = 437; MAS: n = 56; SAS: n = 77). The median (IQR) days to RTP for LAS = 6(3,12); MAS = 5 (3,11); SAS = 11 (5,17). Contrasts indicated that SAS had a significantly lower RTP probability at earlier time frames compared to LAS ($p = .01$) and MAS ($p = .01$).There was no significant difference between

RTP probabilities for LAS vs MAS (p = .44). Selected results are presented as RTP probability [exact 95% CIs]. Probability of a 3-day return for LAS = 25.2% [20.8,29.7]; MAS = 30.4% [18.6,45.2]; SAS = 16.9% [9.3,27.1]. Probability of a 7-day return for LAS = 59.3% [52.7,65.8]; MAS = 64.3% [42.7,80.3]; SAS = 40.3% [28.5,52.1]. Probability of a 15 to 21-day return for LAS = 89.5% [81.5,94.8]; MAS = 89.3% [58.7,97.7]; SAS = 79.2% [61.4,90.1]. **Conclusions:** As expected, the probability of RTP for SAS was lower at earlier time frames compared with LAS and MAS. This may be due, in part, to weight-bearing forces on the syndesmosis that are not as stressful to the lateral and medial ligamentous structures. Interestingly, RTP probabilities of LAS and MAS were similar across all time points; clinicians should not assume that greater frequency of an injury is associated with a faster RTP timeline. Time-to-event analysis offers a unique method of providing objective, evidence-based information on RTP decisions that are typically based largely on subjective information. Clinicians may use RTP probabilities in conjunction with traditional methods of clinical decision-making to determine more accurate RTP prognoses.

Characterization of Clinical Measures in Patients With Posterior Tibial Tendon Dysfunction

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Context: Posterior tibial tendon dysfunction (PTTD) is a progressive, debilitating condition resulting in muscle weakness and decreased functional ability, which may pose a threat to long-term physical health. The clinical and neuromuscular profiles of patients with PTTD are not well understood with respect to healthy individuals. **Objective:** To characterize self-perceived function, anatomical alignment, balance, and strength in patients with PTTD relative to healthy counterparts. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Six participants diagnosed with early stage PTTD (1M/5F, age = 53.9 ± 4.9 years, height = 169.3 ± 8.3 cm, mass = 97.1 ± 17.1 kg), and six healthy individuals (1M/5F, age = 44.0 ± 7.4 years, height = 167.6 ± 9.4 cm, mass = 75.2 ± 24.3 kg) without history of lower extremity injury participated. **Interventions:** None. **Main Outcome Measures:** All measures were completed in a single testing session. Self-perceived function was assessed by the activities of daily living subscale of the Foot and Ankle Ability Measure (FAAM-ADL). Navicular drop was assessed using a height gauge to estimate foot pronation. Time (sec) that an eyes-open single limb stance could be maintained was used to assess balance. Inversion and plantar flexion torque were measured at 60°/second with an isokinetic dynamometer and normalized to body mass (Nm/kg). All measures were recorded from the index limb of PTTD patients and compared to the side-matched limbs of controls. Independent t-tests were used to detect group differences, and Cohen's d effect sizes with 90% confidence intervals were calculated to estimate the magnitude of difference between groups. **Results:** Patients in the PTTD group had lower self-reported function than healthy individuals [PTTD = 52.2 ± 22.8%, Healthy = 99.8 ± 0.4%; p = .004, d = 2.95 (1.58, 4.32)]. Compared to the healthy group, the PTTD group demonstrated greater navicular drop [PTTD = 13.2 ± 7.1 mm, Healthy = 5.2 ± 4.5 mm; p = .04, d = 1.78 (0.66, 2.90)], impaired balance [PTTD = 5.3 ± 5.3 sec, Healthy = 56.7 ± 3.7 sec; p < .0001, d = 13.79 (9.07, 18.52)], reduced inversion torque [PTTD = 0.08 ± 0.07 Nm/kg, Healthy = 0.16 ± 0.06 Nm/kg; p = .06, d = 1.33 (0.28, 2.38)] and reduced plantar flexor torque [PTTD = 0.30 ± 0.13 Nm/kg, Healthy = 0.56 ± 0.23; p = .039, d = 1.13 (0.11, 2.15)]. **Conclusions:** Patients with early stage PTTD demonstrated diminished self-perceived function, increased foot pronation, impaired balance, and decreased strength compared to healthy individuals. Large magnitude effect sizes with confidence intervals did not cross zero were detected for each outcome measure. These results provide evidence of the magnitude of dysfunction seen in early stage PTTD patients.

The Relationship Among Trunk Strength, Trunk Power, and Knee Kinematics During a Stop Jump-Cut Maneuver

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Context: Core strength and stability have been advocated by healthcare professionals and strength and conditioning specialists to optimize performance and reduce the risk of injury/reinjury, including non-contact anterior cruciate ligament (ACL) injury. However, little research exists examining how components of core stability are related to lower extremity kinematics, particularly those that have been identified as related to ACL injury risk. Understanding these relationships may provide insight into which components of core stability should be included when designing training and intervention programs. **Objective:** To determine the relationship among trunk strength, trunk power, and knee kinematics during a stop jump-cut maneuver (SJCM). **Design:** Cross-sectional study. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** A total of 53 healthy, physically active college-aged males and females (age: 22.0 ± 2.1 years; height: 172.5 ± 8.4 cm; mass: 71.6 ± 10.4 kg) participated. **Interventions:** Isokinetic trunk flexion/extension (TFlex/TExt) and right/left rotation strength (RTR/LTR) were assessed using an isokinetic dynamometer (60°/s, 5 repetitions each). Trunk power was assessed using the front abdominal power throw (FAPT) and the side abdominal power throw (SAPT) (2kg medicine ball, 3 repetitions each). Knee kinematics were assessed during a SJCM (3 trials) using a 3D motion analysis system (200Hz) and force plate (1200Hz). For the SJCM, the subject jumped off of two feet from a distance of 40% his/her height, landed on the dominant leg on the force plate, and immediately performed a 45° cut and 2.5m run away from the stance leg. **Main Outcome Measures:** Average peak torque was calculated for TFlex, TExt, RTR, and LTR. For FAPT and SAPT, the average distance of three trials was calculated. Knee kinematics included knee valgus angle at initial contact (KVIC), total knee valgus excursion (TKVE), and knee flexion angle at initial contact (KFlexIC) during the SJCM. All data were assessed for normality using Shapiro-Wilk tests. Pearson and Spearman rho correlation coefficients were calculated for normally and non-normally distributed variables, respectively. Statistical significance was set at $p < 0.05$ a priori. **Results:** All strength measures were significantly correlated with TKVE (r: -0.358 to -0.470, $p < 0.009$), KFlexIC (r: 0.366 to 0.428, $p < 0.007$), and FAPT (r: 0.580 to 0.627, $p < 0.001$). Additionally, TFlex was significantly correlated with LSAPT ($r = 0.727$, $p = 0.049$) and RTR was significantly correlated with RSAPT ($r = 0.296$, $p = 0.032$). The FABT was significantly correlated with TKVE ($r = -0.30$, $p = 0.029$). No significant correlation was found between KVIC and any variable. **Conclusions:** Trunk strength is important in reducing total knee valgus motion and increasing knee flexion at initial contact during a SJCM. Trunk power was related to trunk strength, but not knee kinematics, potentially limiting the use of such field tests as proxy measures of strength. These findings substantiate the relationship between trunk strength and knee kinematics, supporting the importance of inclusion of core strengthening in injury prevention/rehabilitation programs.

The Effects of Trunk and Lower Extremity Strength on Optimal Landing Mechanics During a One-Legged Drop Landing Task in Air Force Special Tactics Operators

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Context: Air Force Special Tactics Operators perform missions that require operational tasks such as maneuvering over obstacles, traversing uneven terrain, and dismounting vehicles. Operators often land from such tasks with one leg instead of two and with a tactical load, potentially compounding injury risk. Suboptimal trunk and lower extremity strength measures may lead to improper landing mechanics, particularly with single leg strategies. **Objective:** To determine the relationship between lower-extremity and trunk isokinetic strength and landing mechanics in healthy male Operators. **Design:** Descriptive correlational study. **Setting:** University-operated, Special Operations Forces human performance research laboratory **Patients or Other Participants:** A total of 128 male Air Force Special Tactics Operators (Age = 27.7 ± 5.2 years, Height = 177.6 ± 5.9 cm, Mass = 83.8 ± 8.3 kg) participated. All Operators were free of self-reported injury in the previous 3 months and were cleared for full active duty. **Interventions:** Isokinetic strength was measured using an isokinetic dynamometer. A biomechanical analysis of a single leg landing from a 46 cm height was captured using a 3D motion capture system. Analyses were conducted on the

right leg only. Correlations between the dependent and independent variables were examined using Spearman's rho with significance set at $p<0.05$ a priori. **Main Outcome Measures:** The dependent variables were average peak torque (normalized to body mass) and time to peak torque (TTPT) for knee flexion, knee extension, trunk flexion, and trunk extension. Biomechanical variables were collected at initial contact (IC) and included hip abduction, hip flexion, knee flexion, knee valgus/varus, peak vertical ground reaction force, and time to peak vertical ground reaction force. **Results:** Pairwise comparisons revealed significant correlations between the following variables: hip abduction at IC and trunk flexion average peak torque ($r = 0.206$, $p = 0.023$), hip abduction at IC and knee extension average peak torque ($r = 0.225$, $p = 0.013$), hip flexion at IC and knee extension TTPT ($r = 0.209$, $p = 0.020$), and hip flexion at IC and trunk flexion TTPT ($r = 0.258$, $p = 0.004$). **Conclusions:** The current study revealed few correlations between lower extremity strength and drop landing tasks. Trunk strength was shown to be most related to landing mechanics, yet still a weak relationship between the two. Lower extremity strength did not appear to be related to landing mechanics. These results indicate that landing mechanics are likely influenced by factors other than strength such as flexibility, neuromuscular control, and proprioception. More research is warranted to determine if modifiable musculoskeletal factors that influence movement patterns can be changed to encourage optimal landing biomechanics. Supported by AFMC/AFRL FA86501226271.

Relationship Between Hip Strength and Dynamic Balance Performance

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Context: Research suggests that poor dynamic balance is related to injury risk, and that lower extremity strength affects dynamic balance. The Y-Balance Test (YBT) is a common field measure of dynamic balance. Previous studies have demonstrated moderate relationships between dynamic balance and hip strength in the frontal and sagittal planes. Only one study has evaluated hip internal and external rotation strength and found moderate correlations, however, the sample was small and only one sport was included. **Objective:** To determine the relationship between isometric hip strength and performance on the YBT. **Design:** Cross-sectional. **Setting:** University recreational facility. **Patients or Other Participants:** A total of 222 Division I collegiate athletes took part in a larger study investigating factors related to sport injury risk and performance. Of those, 163 had complete strength and balance data (87 males, 76 females; age = 19.72 ± 1.37 yrs; height = 177.42 ± 15.83 cm; weight = 75.25 ± 14.63 kg). **Interventions:** Strength of hip extensors (EX), abductors (ABD), internal rotators (IR), external rotators (ER) were measured bilaterally using a handheld dynamometer secured with straps. Three 5-second trials of maximal voluntary isometric contractions were conducted. The average force was normalized to body mass. The Y Balance Test Kit was used to measure reach distances in the anterior (YBTA), posterior medial (YBTPM), and posterior lateral (YBTPL) directions bilaterally. The average of 3 trials was normalized to leg length. A combined score (YBTCOM) for each leg was determined by averaging the normalized distances of the three directions. **Main Outcome Measures:** Paired-samples t-tests were conducted to reveal side-to-side differences in hip strength. Since the right side was significantly stronger than the left on some measures (EX $p < .001$, ER $p = .002$), the right side was used for all further analyses. Pearson's product-moment correlations were then used to assess the relationships among all strength and YBT performance variables. Level of significance was $p \leq 0.05$ for all statistical analyses. **Results:** There were significant but weak, positive correlations between ABD ($r = .252$, $p = .001$), ER ($r = .333$, $p < .001$), IR ($r = .198$, $p = .013$) and the YBTPL reach direction, between ABD ($r = .253$, $p = .001$), EX ($r = .278$, $p < .001$) and YBTPM reach direction, between EX ($r = .170$, $p = .033$) and YBTA reach direction, and between ABD ($r = .226$, $p = .004$), ER ($r = .299$, $p < .001$), IR ($r = .163$, $p = .040$) and YBTCOM. The averages scores of our sample are consistent with previous research (YBTA = 61 ± 6%, YBTPL = 99 ± 1%,YBTPM = 100 ± 1%, YBTc = 88 ± 7%) (ABD = 43 ± 9%, EX 36 ± 12%, ER 14 ± 4%, IR 15 ± 4%) **Conclusions:** Similar to previous studies, the findings of the current study suggests dynamic balance is only weakly related to hip strength. While strength of the hip abductors, extensors, and rotators should not be overlooked, future research should investigate additional factors such as flexibility or proprioception that have a greater influence on dynamic balance performance.

The Relationship Between Trunk Kinematics and the Dynamic Postural Stability Index

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Context: The inability to maintain trunk position during landing tasks has been established as a risk factor for lower extremity (LE) injury. Decreased trunk forward flexion and increased lateral flexion (LF) are indicators of risky movement patterns negatively affecting the ability to maintain or return the body's center of mass over a base of support during dynamic tasks. Establishing the relationship between trunk kinematics and dynamic postural stability, measured with the Dynamic Postural Stability Index (DPSI), is an important first step in determining the role of trunk kinematics on balance during sport-specific activities. **Objective:** To determine the relationship between trunk kinematics and DPSI, during forward (FJL) and sideways (SJL) jump landings. **Design:** Descriptive cohort study **Setting:** Sports medicine research laboratory **Patients or Other Participants:** A total of 20 healthy and physically active males and females (age: 24.0 ± 2.8 years, height: 173.0 ± 10.5 cm, weight: 70.1 ± 12.6 kg) participated. **Interventions:** Trunk kinematics and ground reaction forces were collected at 250Hz and 1500Hz, respectively, utilizing a passive marker set with a motion capture system and force plate. Subjects performed a minimum of three practice trials and five successful test trials for each JL. The FJL was assessed at 40% of the subject's height with a 30.48cm hurdle at the midpoint of the distance; SJL was assessed at 33% of the subject's height and a 15.24cm hurdle. Subjects jumped off two-feet, landing only on the dominant leg, and maintained balance for five-seconds following landing. **Main Outcome Measures:** Trunk kinematics (absolute values of forward flexion/extension [FFE], and LF) were assessed at initial contact (IC), 150ms prior to and 150ms following IC, and as total excursion (TE=max-min) during the landing phase of JL. Thorax angles were calculated relative to the global coordinate system, spine angles relative to the pelvis. For both tasks, DPSI composite and component scores in the anterior/posterior (APSI), medial/lateral (MLSI), and vertical (VSI) were calculated. All data were assessed for normality. If normally distributed, Pearson correlation coefficients were calculated; if normality was violated, Spearman Rho correlation coefficients were calculated. Significance level of <0.050 was established a priori. **Results:** During the FJL significant positive correlations were observed between APSI and spine FFE at IC ($r = 0.450$, $p = 0.046$). Additionally, MLSI was significantly positively correlated with: spine LF TE, thorax LF TE, and FFE TE, ($r = 0.514$-0.724, $p < 0.050$). No significant correlations were observed during SJL. **Conclusions:** These results demonstrate that during FJL decrements in DPSI are related to increased movement away from a neutral spine position in the direction of FFE and LF. The identification of these characteristics should help guide future research to determine the relationship between these trunk kinematics and proper landing mechanics. Once this relationship has been established the role of trunk kinematics on balance during sport-specific tasks can be properly addressed.

Modifying Sagittal Trunk Stability Alters Lower Extremity Biomechanics in Multiple Planes During Single-Leg Landings

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Context: Modifying sagittal plane trunk biomechanics has been reported to influence risks of non-contact ACL injuries during sharp decelerating motions by altering sagittal plane lower extremity biomechanics. However whether modifying sagittal plane trunk stability influences multi-plane lower extremity biomechanics remains unclear. **Objective:** To investigate the influence of modifying sagittal plane sacrum-thorax stability on lower extremity kinetics and kinematics in multiple planes during single-leg landings. **Design:** Repeated-measures. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Eighteen recreationally active healthy females (20.2 ± 1.2 years, 52.7 ± 7.1 kg, 158.0 ± 6.4 cm). **Interventions:** Participants performed single-leg landing from a 30 cm box in three different styles: 1) Self-Selected Landings (SSL), 2) forceful Breath-Exhaling Landing (BEL), 3) enhanced Trunk Stability Landings (TSL). In BEL, participants had a mouthpiece with a small hole so that they could increase their transverse abdominis activities by forcefully exhaling their breath during landing. In TSL, a straight cardboard bar was secured externally from participants' sacrum to thorax posteriorly using an elastic bandage while they performed forceful breath exhaling and tried to align their spine to the cardboard bar during landings. An electromagnetic tracking system and force plate recorded 3D biomechanical data. Repeated-measures ANOVAs and post-hoc Bonferroni corrections compared landing styles. **Main Outcome**

Measures: Sagittal, transverse, and frontal hip, knee, and ankle joint angles and net joint moments at peak vertical ground reaction force. **Results:** As compared with SSL, hip extensor moment in TSL increased significantly (-134.7 ± 52.7 Nm in SSL vs -153.3 ± 51.0 Nm in TSL, $p = 0.016$) but knee extensor moments in BEL ($p = 0.001$) and TSL ($p = 0.016$) were lesser than that in SSL (SSL: 83.0 ± 31.3 Nm, BEL: 65.9 ± 32.5 Nm, TSL: 66.5 ± 21.9 Nm). No other joint moments differed across landing styles. Hip flexion in BEL (25.7 ± 5.2°) was significantly greater than SSL (23.6 ± 5.2°) and TSL (21.8 ± 8.1°) (both $p < 0.05$), respectively with a trend ($p = 0.07$) toward greater hip abducted position in TSL (-4.4 ± 7.2°) than SSL (-2.2 ± 7.1°). The knee joint was closer to neutral in TSL in both transverse (0.3 ± 4.5°, $p < 0.05$) and frontal planes (0.3 ± 6.0°, $p < 0.01$) than in SSL and BEL, which were more externally rotated (SSL: -1.2 ± 4.7°, BEL: -1.2 ± 4.7°) and varus positions (SSL: 1.3 ± 5.5°, BEL: 0.9 ± 5.7°) respectively. **Conclusions:** Modifying sagittal plane sacrum-thorax stability during single-leg landings alters sagittal, transverse, and frontal plane lower extremity kinetics and kinematics at peak vertical ground reaction force. Practitioners should recognize that when they design ACL injury prevention programs, modifying trunk stability and posture can influence multi-planar lower extremity biomechanics and affect noncontact ACL injury risk during physical activity.

Influence of Hip Strength on Lower Extremity Kinematics Differs Among Functional Tasks

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Context: Decreased hip strength is theorized to decrease control of the lower extremity during dynamic tasks, increasing the risk of knee injuries. However, the influence of hip strength on lower extremity joint motion remains unclear as research examining this relationship reports conflicting results. There is a lack of understanding whether the role of hip strength is consistent in controlling joint motion across functional tasks. **Objective:** To examine the influence of isokinetic hip strength on landing kinematics during a jump-cut (JC) task, jump-landing (JL) task, single-leg landing (SLL) task, and a single-leg squat (SLS). **Design:** Descriptive laboratory. **Setting:** Research Laboratory. **Patients or Other Participants:** Forty participants (20 females, 20 males: 21.6 ± 1.9 yrs, 173.3 ± 9.0 cm, 79.0 ± 12.3 kg) volunteered to participate. **Interventions:** An isokinetic dynamometer was used to assess concentric (CON) and eccentric (ECC) torque of the hip abductors (ABD), external rotators (ER), and extensors (EXT) across five trials at $60° \cdot s^{-1}$. A three-dimensional motion analysis system integrated with a force plate was used to collect hip and knee kinematics of the dominant stance leg during five trials of a JL task, SLL task, JC task, and a SLS. **Main Outcome Measures:** Peak CON and ECC torque were separately averaged across the middle three trials for each direction and normalized to body weight (%BW). Frontal and transverse plane peak hip and knee joint angles and joint excursions (peak minus IC) during the deceleration phase of the functional tasks were used for analyses. Separate step-wise, linear regressions determined the extent to which hip strength predicted hip and knee kinematics during each task, in males and females. **Results:** In females, less CON EXT strength (2.1 ± 0.5% BW) predicted greater peak knee valgus (-8.1 ± 4.1°, $R^2 = 0.225$, $P = 0.035$) and hip internal rotation (13.2 ± 9.7°, $R^2 = 0.220$, $P = 0.037$) during the JL, greater peak hip internal rotation (9.8 ± 10.6°, $R^2 = 0.332$, $P = 0.008$) and knee valgus excursion (-2.1 ± 2.0°, $R^2 = 0.231$, $P = 0.032$) during the SLL, and greater peak hip internal rotation (10.1 ± 7.3°, $R^2 = 0.240$, $P = 0.028$) during the SLS. Less ECC ER strength (0.7 ± 0.2% BW) predicted greater hip internal rotation excursion during the JL (14.3 ± 4.9°, $R^2 = 0.202$, $P = 0.047$), and greater peak hip internal rotation during the SLS (10.1 ± 7.3°, $R^2 = 0.240$, $P = 0.028$). Less ECC ABD strength (1.4 ± 0.3% BW) predicted less knee valgus excursion during the JC (-2.6 ± 2.6°, $R^2 = 0.286$, $P = 0.015$). In males, Less CON EXT strength (2.1 ± 0.5% BW) predicted greater peak knee internal rotation during the JC (10.4 ± 5.9°, $R^2 = 0.328$, $P = 0.008$), greater hip adduction peak (8.6 ± 8.5°, $R^2 = 0.225$, $P = 0.035$) and excursion (13.2 ± 6.8°, $R^2 = 0.285$, $P = 0.015$) during the SLL. **Conclusions:** CON EXT was a consistent predictor of lower extremity kinematics in males and females. However, its influence on specific joint motions, along with other hip strength measures, was not consistent across the functional tasks. Identifying these relationships may provide a better understanding of the role hip strength plays in controlling lower extremity motion.

Effectiveness of Rotator Discs on Hip Rotation Range of Motion, Strength, and Function in Dancers

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Context: Hip injuries in dancers are common due to demand of hip rotator ROM, strength, and function. Functional therapeutic hip techniques to improve rotator flexibility, strength, and function can decrease potential injury. **Objective:** Determine the effectiveness of functional dance techniques on hip rotation range of motion, strength, and functional dance movement. **Design:** Repeated-measures crossover design. **Setting:** University Laboratory. **Patients or Other Participants:** Sixteen healthy female dance majors completed the study. **Interventions:** Participants were formally trained on eleven functional disc rotation exercises 3x/week for 2 weeks and then performed 3x/week for 12 weeks in dance technique classes. **Main Outcome Measures:** Goniometric bilateral prone hip external rotation (ER) and internal rotation (IR) passive ROM (PROM) and AROM was measured. Bilateral seated hip ER and IR isometric manual muscle testing strength was assessed. Functional dance hip ER movement was assessed in three movement phases: Adagio, Grande Allegro, and Petite Allegro. Repeated measures analysis of variance assessed each outcome measure independently at baseline, 4 week, 8 weeks, and 12 weeks. **Results:** Left ER AROM ($P = 0.017$), left ER PROM ($P = 0.002$), right ER AROM ($P = 0.02$), and right ER PROM ($P = 0.022$) showed significant changes over 12 weeks. Pairwise comparisons revealed significantly greater left ER AROM at week 12 (41.1° ± 7.9) to week 4 (34.5° ± 9.7; $P = 0.016$) and week 8 (36.4° ± 7.9; $P = 0.004$). Left ER PROM exhibited significantly greater range at week 12 (48.4° ± 10.9) compared to baseline (41.2° ± 10.4; $P = 0.023$) and week 4 (41.7° ± 9.0; $P = 0.02$). Right ER AROM exhibited significantly greater range at week 12 (45.4° ± 6.7) compared to week 4 (41.0° ± 7.9; $P = 0.03$). Right ER PROM exhibited significantly greater range at week 12 (52.2° ± 7.4) compared to week 4(46.6° ± 7.1; $P = 0.011$). Right IR PROM showed significant changes($P = 0.022$) over 12 weeks and revealed significantly greater motion at week 8 (49.4° ± 10.7; $P = 0.016$) and week 12 (49.9° ± 10.8; $P = 0.016$) compared to baseline (45.9° ± 10.8). No significant changes were shown for left IR AROM, left IR PROM, or right IR AROM. Left ER ($P < 0.001$) and right ER ($P < 0.001$) manual muscle test showed significant changes over 12 weeks. Pairwise comparisons revealed significantly greater left ER strength at week 12 (4.75 ± 0.4) compared to baseline (4.19 ± 0.4; $P = 0.003$) and significantly greater right ER strength at week 12 (4.75 ± 0.4) compared to baseline (4.13 ± 0.34; $P = 0.001$). Dance functional movement displayed significant changes over time for Adagio ($P < 0.001$), Grande Allegro ($P < 0.001$), and Petite Allegro ($P < 0.001$) movement phases. Pairwise comparisons revealed significantly increasing Adagio scores across all testing: baseline (6.33 ± 4.8) to week 4 (8.7 ± 4.9; $P = 0.007$), to week 8 (12.4 ± 6.3; $P < 0.001$), and to week 12 (61 ± 4.4; $P < 0.001$); week 4 (8.7 ± 4.9) to week 8 (12.4 ± 6.3; $P = 0.001$), and to week 12 (61 ± 4.4; $P < 0.001$); and week 8 (12.4 ± 6.3) to week 12 (61 ± 4.4; $P = 0.002$). Grande Allegro showed significant greater scores from baseline (1.5 ± 1.9) to week 12 (6.6 ± 3.0; $P < 0.001$), week 4 (1.9 ± 2.8) to week 12 (6.6 ± 3.0; $P < 0.001$), and week 8 (2.4 ± 2.6) to week 12 (6.6 ± 3.0; $P < 0.001$). Petite Allegro showed significant greater scores from baseline (13.8 ± 5.4) to week 12 (24.2 ± 6.7; $P < 0.001$), week 4 (9.1 ± 7.8) to week 8 (14.1 ± 9.0; $P < 0.001$), week 4 (9.1 ± 7.8) to week 12 (24.2 ± 6.7; $P < 0.001$), and week 8 (14.1 ± 9.0) to week 12 (24.2 ± 6.7; $P = 0.001$). **Conclusions:** Functional dance techniques augmented with rotator discs increases hip ER motion, IR PROM, ER strength, IR strength, and dance functional movement influencing potential injuries.

Acute Increases in Ankle Dorsiflexion Range of Motion Alter Knee Mechanics in Active College Age Females

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Context: A large knee adductor moment during landing is a purported risk factor for non-contact anterior cruciate ligament (ACL) injuries. Less passive ankle dorsiflexion (DF) range-of-motion (ROM) has been correlated with greater knee adductor moments during landing in female athletes. However, it is unknown if increasing passive ankle dorsiflexion mitigates deleterious moments at the more proximal knee joint. **Objective:** To examine if increasing ankle DF ROM acutely will alter the knee adductor moment in athletic college-age women. **Design:** Within subject repeated-measures. **Setting:** University Biomechanics Laboratory. **Patients or Other Participants:** Nine college-age females (age = 19.9 ± 1.4 yrs, height = 168.7 ± 8.7 cm, mass = 61.3 ± 8.6 kg) who participate in high impact landing activities a minimum of three times per week. Exclusion criteria: recent history of lower extremity (LE) surgery or injury that resulted in time lost from activity. **Interventions:** Open chain ankle DF (OC) was measured with a goniometer. Closed chain DF (CC) was measured with an inclinometer on the anterior tibia. Participants performed 3 trials of a drop jump task off of a box normalized to maximum vertical jump height. 3D marker data were collected at 120 Hz with a 14 camera Vicon system (Vicon Inc. Oxford, UK). Kinetic data were collected at 960 Hz on an AMTI force plate (AMTI Corp. Watertown, MA). Bilateral ankle dorsiflexion was then increased with standard manual therapy techniques: talo-crural and talo-calcaneal joint mobilization, soleus soft tissue mobilization and gentle intermittent calf stretching all performed over a 15 minute period. Kinematic and kinetic data were recollected during the drop jump after the intervention. Data were tracked in Vicon, filtered with a 4th order low-pass Butterworth filter with a cutoff frequency of 12 Hz, and processed with a visual 3D model (C-motion Inc, Germantown, MD). An inverse dynamics procedure was used to calculate internal joint moments. **Main Outcome Measures:** Dependent variables were right-side lower extremity peak knee adductor moments in the first 20% of stance phase and at mid-stance (i.e., point of maximum ankle dorsiflexion angle during landing). Paired t-tests were used to analyze pre-post differences in both dependent variables. **Results:** Both open and closed chain ankle dorsiflexion increased after the manual therapy intervention (OC; Pre: 11.4 ± 4.4, Post 15.8 ± 4.6, $p < 0.01$; CC; Pre: 37.6 ± 6.3, Post 40.6 ± 6.4, $p < 0.01$). Peak knee adductor moments decreased post-intervention during first 20% of landing (Pre: 6.4 ± 14.0 N-m, Post 3.1 ± 12.4 N-m, $p < 0.01$), but not at mid-stance (Pre: -0.4 ± 12.5 N-m, Post -4.5 ± 8.2 N-m, $p = 0.06$). **Conclusions:** Increasing ankle DF acutely decreased internal knee adductor moments in the first 20% of stance phase in a general population of active, college-age women. Therefore, increasing ankle DF may be a component of mitigating deleterious knee joint moments during landing.

Analgesic Cream and Static Stretching on Temperature, Sensation of Pressure, and Hamstring Flexibility

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Context: It is common for health care professionals to use analgesic creams. When applied, however, there is conflicting evidence on their physiological benefits. Some suggest they alter skin sensitivity, tissue temperature, and tissue extensibility following application. In a recent study however, it was indicated an analgesic cream (FlexAll 454®) had no influence on skin sensitivity, tissue temperature, or tissue extensibility immediately following application. **Objective:** Our objective was to determine if an analgesic cream influences skin temperature, sensation of pressure, and passive hip flexion range of motion (ROM) in subjects possessing less than 90° of passive hip ROM immediately following and at 15 minutes following application. **Design:** A 3x4 double-blind crossover design guided data collection. Independent variables were time (baseline, immediately post-application, and 15 minutes post application) and treatment (3cc analgesic cream and stretching, 3cc placebo cream and stretching, no cream and stretching, and no stretching or cream (control). **Setting:** Laboratory. **Patients or Other Participants:** Twenty recreationally active subjects with less than 90° of passive hip ROM (male = 10, age = 21.2 ± 0.63 years, ht = 176.53 ± 8.9 cm, mass = 82.19 ± 16.36 kg: female = 10, age = 21.1 ± 0.74 years, ht = 170.18 ± 12.62 cm, mass = 67.86 ± 14.28 kg) volunteered. **Interventions:** Subjects were randomly assigned to a treatment order. Subjects were then positioned supine on a table with their hips and non-dominant leg secured. We then measured skin temperature, sensation of pressure, and passive hip

flexion ROM of the dominant leg. Skin surface temperature was measured with a surface copper-constant thermocouple at the mid-belly of the hamstring muscle group. Sensations of pressure measures were established using Simmons-Weinstein monofilaments. We measured passive hip flexion ROM by applying a bubble inclinometer to the subject's thigh and passively flexing their hip to their end ROM. Immediately following baseline measures, subjects received 1 of the 4 treatments before three 30-second passive hamstring stretches. Immediately following and at 15 minutes following the third stretch, all post-treatment measures were performed. **Main Outcome Measures:** Skin temperature (°C), sensation of pressure (g), and ROM (°). **Results:** Hip flexion ROM increased from baseline ($F_{2,32}$ = 31.50; $P < .001$). The analgesic cream decreased skin temperature immediately following and at 15 minutes following application (30.15 ± 1.18°C, 29.35 ± 1.01°C, 29.61 ± 1.09°C, respectively; $P < .05$). The placebo cream also decreased skin temperature following application but temperature returned to baseline at 15 minutes post-application (30.55 ± 1.17°C 29.72 ± 0.97°C, 30.27 ± 0.68°C; $P < .05$, respectively). Skin surface temperature did not differ between the no cream or control across time ($P > .05$). Sensation of pressure did not change for the no cream, control, or placebo ($P > .05$) but decreased post application (4.13 ± 0.12) and at 15 minutes post application (3.94 ± 0.27) with the analgesic cream. **Conclusions:** Analgesic creams appear to produce a minor decrease in skin surface temperature and sensation of pressure for up to 15 minutes following application but does not influence passive hip flexion ROM in individuals who have less than 90° of hamstring flexibility.

A Comparison of PNF and Static Stretching on Hamstring Flexibility

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Context: Hamstring flexibility is important for enhanced sport performance and preventing muscular and postural imbalances and injury. Studies comparing proprioceptive neuromuscular facilitation (PNF) stretching techniques with conventional static stretching regimes have shown some superiority of the PNF techniques. However, the type of PNF varied and only short duration static stretches were examined. The literature is lacking as to the effects of longer duration static stretching. **Objective:** To compare the effectiveness of long duration static stretching and the slow-reversal-hold-relax (SRHR) PNF technique on hamstring flexibility. **Design:** Stratified controlled trial with repeated measures. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Fourteen healthy and recreationally active males and females (age = 20.2 ± 1.5 years, height = 166.8 ± 8.1 cm, mass = 65.3 ± 12.0 kg) with decreased hamstring flexibility volunteered. Decreased hamstring flexibility was determined as having a 10° or greater deficit from full knee extension during a passive knee extension test (PKET). **Interventions:** Subjects were stratified according to their baseline PKET scores and randomly assigned within strata in a single blind fashion to one of two treatment groups; a static stretching (SS) group and a SRHR group. For each subject, one leg was randomly assigned to be the treatment leg and the contralateral limb was assigned as the control leg. Subjects in the SS group reported to the lab three days per week and received 30-min of passive hip flexion with an extended knee while seated and relaxed using a knee immobilizer and pulley system. Subjects in the SRHR group also reported to the lab three days per week and received five repetitions of a typical SRHR routine. For each subject, the control limb remained relaxed and in the neutral position during all stretching sessions. **Main Outcome Measures:** Immediately prior to and following the three week flexibility program, a PKET was performed bilaterally. With the subject supine, a polyvinylchloride pipe apparatus was used to maintain the test hip in 90° of flexion while the knee was passively extended. Three measurements were taken with a Saunders® digital inclinometer and the mean of the three measurements was used in the analysis. **Results:** A repeated measures analysis of variance revealed a significant Test main effect ($F_{1,12}$ = 63.02, $p = .001$), as the ROM at post test (78.01 ± 9.36°) was greater than at pretest (61.08 ± 8.96°) independent of treatment or leg. However, neither stretching protocol was effective for improving range of motion ($F_{1,12}$ = .68, $p = .425$). **Conclusions:** Similar increases in ROM were observed in both treatment groups and in both the treatment and control limbs. It is possible that the three week stretching period was insufficient to allow for true physiological changes to occur. The data also suggest that external influences also might have played a role in flexibility.

Acute Effects of Whole-Body Vibration on Functional Joint Stability During a Land and Cut Task

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Context: Whole-body vibration (WBV) is a unique exercise modality designed to increase athletic performance. As a neurophysiological training stimulus, WBV has been reported to effectively improve muscle strength and power. No clear consensus has been reached, however, regarding the efficacy of WBV as a viable neuromuscular training stimulus and insufficient knowledge exists on the effect it has on functional joint stability. **Objective:** To examine the acute effects of WBV on functional joint stability in the lower extremity during a single leg land and side-step cutting task. **Design:** Repeated Measures design. **Setting:** Sports Medicine Research Lab. **Patients or Other Participants:** Thirty healthy participants (15 males, age: 23.0 ± 1.70, height: 70.51 ± 1.99 cm, weight: 177.72 ± 31.65 lbs and 15 females, age: 21.92 ± 2.33, height: 67.68 ± 2.34 cm, weight: 146.0 ± 21.04 lbs) volunteered to participate in the study. **Interventions:** Participants first completed a 5-minute warm-up on a cycle ergometer followed by a 5-minute standardized stretching regimen. Participants then had lower extremity joint kinematic and kinetic data recorded during execution of a single leg land and side-step cutting task using a 10 camera, 3D motion analysis system. Five cutting tasks were performed before and after exposure to a WBV therapy. WBV therapy consisted of the participants maintaining a half-squat position in 30° of knee flexion with both legs on the vibration platform (frequency of 30 Hz and low amplitude (2-4 mm) for 6 bouts of 60 seconds with a 2-minute recovery interval between each bout. **Main Outcome Measures:** Hip flexion, knee flexion and hip rotation angle at initial contact (°); peak hip rotation, knee flexion, abduction, and internal rotation angle during contact (°); peak hip flexion, internal rotation, knee abduction and internal rotation moment during contact (Nm/kg); and ground contact time (secs). A repeated measures ANOVA was used to analyze the pre to post-test measures on all subjects and determine if a gender effect was evident. **Results:** The results revealed no statistically significant gender effect with respect to pre versus post-test measures on all variables [Wilks' $\Lambda = 0.551$, $F = 0.690$, $P = 0.741$] or gender by time effect [Wilks' $\Lambda = 0.433$, $F = 1.109$, $P = 0.437$], but a significant main effect within subjects for time [Wilks' $\Lambda = 0.119$, $F = 6.291$, $P = 0.002$] was identified. Follow-up univariate tests revealed a significant interaction for time for hip flexion at initial contact [$p = 0.012$], knee flexion at initial contact [$p = 0.33$], and peak hip internal rotation [$p = 0.18$]. Specifically hip and knee flexion at initial contact increased and peak hip internal rotation decreased post WBV. **Conclusions:** This data provides evidence to suggest that WBV had an effect on the hip and knee kinematics in the sagittal plane on initial contact. This finding is pertinent due to the relationship between landing mechanics at initial contact and risk for lower extremity injury. Further research is warranted regarding the effects long term WBV therapy has on functional joint stability.

Immediate Effects of Therapeutic Tapings in Individuals With Patellofemoral Pain During Functional Task Performance

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Context: Patellofemoral pain (PFP) is a common source of decreased physical activity level as well as sports performance. A variety of therapeutic taping techniques have been used as interventions to treat PFP; however, the ability of taping to influence muscle function and lower extremity movement patterns in this population has not been widely studied. **Objective:** To compare the effects of McConnell taping (MT) and kinesiology taping (KT) on pain as well as muscle activation (EMG) and 3-dimentional (3D) hip, knee, and ankle kinematics during walking. **Design:** Randomized cross-over study. **Setting:** Laboratory. **Patients or Other Participants:** Thirteen individuals (8M/5F, age = 23.39 ± 4.68 years, height = 172.92 ± 9.88 cm, mass = 70.46 ± 13.66 kg, Kujala = 60.69 ± 10.43) with a history of PFP participated in this study. **Interventions:** Each participant was randomly assigned to one of the following taping techniques on separate testing days: KT, MT, or sham taping (ST). **Main Outcome Measures:** Perceived pain during a single leg squat (SLS) was assessed using the 10-cm visual analogue scale (VAS). Participants walked at a self-selected pace across a 30 foot walkway while 3D lower extremity kinematics and muscle activation were assessed during loading phase of gait. 3D hip, knee, and ankle kinematics were measured using 8-infrared cameras motion analysis system while EMG of Vastus Medialis (VM), Vastus Lateralis (VL), Gluteus Medius (GM), and Biceps Femoris (BF) were measured using a wireless EMG system. Root mean squared EMG was then calculated and normalized using maximal isometric contractions (NrmsEMG). All measurements were made prior to tape application and 60 minutes following

application of the taping condition. Separate 3 (Tape) X 2 (Time) ANOVAs with repeated measures were used to assess differences in pre- and post-taping pain, kinematics, and muscle activation between taping conditions. Significant interactions were followed up using Sidak's post-hoc analysis. **Results:** VAS values were significantly lesser in the post-taping condition regardless of technique compared to the pre-taping condition ($F(1,12) = 34.95$, $P < 0.01$). There were no differences in NrmsEMG of VM ($F(2,11) = 0.04$, $P = .961$), VL ($F(2,11) = 2.41$, $P = .111$), GM ($F(2,11) = 0.19$, $P = .825$), or BF ($F(2,11) = 2.24$, $P = .128$) during loading phase of gait. No significant differences were observed in the 3D kinematics of ankle, knee, and hip during loading phase of gait. **Conclusions:** KT and MT had no significant impact on lower extremity biomechanics or muscle activation while walking despite participants reporting a reduction in pain during SLS. Clinicians may consider using taping techniques such as those presented in this study to assist in pain reduction prior to initiation of function rehabilitation with the goal of improving lower extremity movement patterns. However, their benefits remain questionable due to similar reductions in pain with ST.

The Effects of a Foot-Toe Orthosis on Dynamic Balance and Hallux Valgus Angle

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Context: Decreased balance has been identified as a risk factor for lower extremity injury in physically active individuals. Previous research has investigated the effects of orthotics, textured insoles and textured surfaces on static and dynamic measures of balance. However, the impact of a foot-toe orthosis on dynamic balance in the physically active population remains unclear. **Objective:** To determine the effects of a foot-toe orthosis on dynamic balance and hallux valgus angle in healthy, physically active individuals. **Design:** Randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Sixty-three (30 males, 33 females) healthy, recreationally active collegiate-aged participants were randomly allocated to either the foot-toe orthosis and control shoe (FTO, n = 24, age = 21.83 ± 1.74, height = 171.24 ± 6.61 cm, mass = 71.84 ± 13.96 kg), the control shoe only (SO, n = 21, age = 21.19 ± 1.44, height = 174.78 ± 11.63 cm, mass = 77.50 ± 19.82 kg), or the true control (CO, n = 18, age = 21.72 ± 1.13, height = 171.45 ± 8.18 cm, mass = 72.32 ± 11.91) group). **Interventions:** After baseline testing and random allocation, participants in the intervention groups were provided instructions for wear, a detailed plan outlining the habituation period, and a time log to record duration of wear time. Subjects in the intervention groups then wore the foot-toe orthosis and/or control shoes with activities of daily living for a total of four weeks including an initial habituation week and three weeks of wear daily wear. **Main Outcome Measures:** The instrumented version of the SEBT known as the Lower Quarter Y-Balance Test (YBT-LQ) was used to quantify dynamic balance composite score at baseline and follow-up. The composite score consisted of the mean of three trials in each of the anterior, posteromedial, and posterolateral reach directions. Reaches were normalized for leg length. To assess the hallux valgus angle, the examiner palpated and marked the skin at the location of the 1st metatarsophalangeal joint, and also marked the longitudinal axis of the phalanges and 1st metatarsal bone. Separate ANCOVAs were utilized to determine between group differences in post-intervention composite YBT-LQ scores and hallux valgus angle after controlling for pre-intervention between group differences. **Results:** After adjusting for pre-intervention scores, there was a significant between group difference in post-intervention, scores on the YBT-LQ ($F(2,126) = 12.04$, $P = 0.001$. Pairwise comparisons for revealed that the FTO group was significantly increased ($p = .001$) from the CON group and there was a significant increase ($p = .034$) between the SO and the CON groups. It was also revealed that the FTO group was significantly increased ($p = .007$) from the SO group. The ANCOVA revealed no significant differences ($p = .380$) in hallux valgus angle between any of the groups. **Conclusions:** Four weeks of intervention with a foot-toe orthosis and the control shoe may significantly improve dynamic balance in a young and healthy collegiate population. These findings suggest a novel intervention to increase balance and potentially alter risk of injury.

Lower Body Kinematic Comparison Between Front and Back Squats in Response to Different Loads

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Context: The back and front squat have been the most popular strengthening exercise. The proper squat technique and the changes between two squats in the lumbar spine and lower extremity joints in response to load mass are still unclear. **Objective:** To compare the kinematics of the lumbar spine, hip and knee for the front and back squat exercises in response to different loads. **Design:** Descriptive. **Setting:** University motion-analysis laboratory. **Patients or Other Participants:** Eight varsity male lifters (age = 20 ± 0.8 years; height = 185 ± 7 cm; weight = 106.6 ± 13.6 kg) participated. Participants had at least five years of weightlifting experience with the front and back squat. **Interventions:** Independent variables were types of the squat exercise (front squat, back squat), different levels of load (65%, 75%, and 85% of 1 repetition maximum (RM)). All subjects performed a total of 192 trials (8 subjects x 2 squats x 3 loads x 4 trials).The order of both squats and load masses were randomly assigned to reduce the order effect. A standard two-dimensional kinematic analysis was conducted with Ariel Performance Analysis System (APAS) software and the digital filter function (x = 08 Hz / y = 08 Hz) was applied for reduction of the data noise. **Main Outcome Measures:** The primary outcomes were the joint angle and joint velocity at the lumbar spine, hip and knee joints in the sagittal plane during front and back squats. A two-way [squat (2) x loads (3)] ANOVA with repeated measures were performed and Bonferroni adjustment was applied for a pairwise comparison in presence of a significant interaction. **Results:** There were no significant interaction or main effects between squat and load for the angular displacement ($p > .05$). A significant difference was observed in the main effect ($p = 0.001$) of the squat type. The back squat showed a significantly greater mean posterior trunk inclination angle (46.0 ± 3.9°) than the front squat (35.8 ± 7.1°). The back squat had a significant less knee flexion angle ($p = 0.001$) (110.3 ± 6.9°) than the front squat (116.9 ± 9.8°). No significant interaction or main effects between squat and load of the angular velocity were observed in the lumbar spine, the hip and knee joints. However, there was a significant difference in main effect of squat type for the angular velocity at the lumbar spine. The lumbar spine of the back squat had a significantly greater mean angular velocity ($p = 0.03$) (67.09 ± 59.01°/s) than the front squat exercise (15.42 ± 16.87°/s). **Conclusions:** The result of study suggests the importance of prescribing strengthening exercise targeting the trunk stability in the back squat for experienced weight lifters because back squat had a significant greater posterior inclination angle and less knee flexion angle while angle of lumbar spine did not change significantly, which showed that the lifting technique was not compromised during the back squat exercise.

Sprint Training Methods in NCAA Division III Collegiate Soccer Players

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Context: The production of various speed-enhancement devices has increased to produce varied high-speed actions impacting performance and actions requiring maximal speed, acceleration, or agility. A gap does lie between speed training as far as what techniques more effectively correct or enhance sprint kinematics because all sports differ in the physiological demands of an athlete during competition. **Objective:** To compare and assess sprint time during the acceleration and maximal velocity phase of a sprint. The study determined if kinematic factor differences exist between assisted sprint training (AST), resisted sprint training (RST), and free sprint training (FST). **Setting:** Controlled research laboratory setting. **Patients or Other Participants:** Thirty-seven NCAA Division III soccer athletes (age = 19.11 ± 1.05 yrs, height = 171.76 ± 8.74 cm, mass = 67.85 ± 8.61 kg) were tested. Interventions: Subjects underwent a six-week, 12-session training program using their assigned training modality (assisted sprint training, resisted sprint training, and free sprint training). The training progression started with 10-meter (m) sprints and ended with 60-meter sprints. Pre- and post-tests of measured three 36.6m sprints with split times measurements taken at 9.1m, 18.3m, and 36.6m. **Main Outcome Measures:** Sprints were recorded by video, Brower Timing Systems electronically calculated sprint time at the 9.1m, 18.3m and 36.6m split time, and Dartfish ProSuite 7 was used to calculate stride length and stride frequency. **Results:** Chronbach alpha coefficients indicated high random variability between steps and stride frequency, as well as, time and stride length. Running from start to 9.1 m mark (time) was significant for all groups combined $F(1, 34) = 34.0$, $p < .001$, partial $eta^2 = .500$, a very large

effect between type of training (groups) not significant $F(2, 34) = 2.0$, $p = .147$, partial $eta^2 = .107$, a moderate effect 9.1 m to 18.3 m mark (time) was significant for all groups combined ($F(1, 34) = 4.2$, $p = .049$, partial $eta^2 = .108$, a moderately large effect). Between type of training (groups) was not significant $F(2, 34) = 0.2$, $p = .1837$, partial $eta^2 = .010$, a small effect. 18.3 m to 36.6 m mark (time) was significant for all groups combined ($F(1, 34) = 47.9$, $p < .001$, partial $eta^2 = .585$, a very large effect). Between types of training (groups) was not significant ($F(2, 34) = 0.4$, $p = .666$, partial $eta^2 = .024$, a small effect). Start to 36.6 m mark (time) was significant for all groups combined ($F(1, 34) = 100.3$, $p < .0001$, partial $eta^2 = .747$, an extremely large effect). Between types of training (groups) was not significant ($F(2, 34) = 0.1$, $p = .903$, partial $eta^2 = .006$, a very small effect). **Conclusions:** Our findings revealed that the use of external training devices did decrease sprint times after a 36.6 m run, but not significant as compared to subjects who completed free sprint training. Sprint speed development may be based on so many factors that it can be highly difficult to pinpoint where and how training throughout different stages of a sprint optimizes improved performance.

SportsMetrics™ Training Improves Power and Landing in High School Rowers

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Context: Successful rowing competition requires leg power, back strength, cardiovascular endurance, and balance. Performance capabilities vary between experienced and inexperienced rowers. SportsMetrics™ training improves lower limb alignment, hamstring peak torque, and vertical jump height; however, this training has not been used in rowing and may have different outcomes based on experience level. **Objective:** To compare the effects of a 6 week SportsMetrics™ training program on vertical jump height (VJH), Y Balance Test (YBT), and drop jump between novice and varsity high school rowers. **Design:** Cross sectional **Setting:** High school training facility **Patients or Other Participants:** 52 (31 varsity; 21 novice) high school rowers participated. Varsity rowers were defined as a returning; any new rower was considered novice. **Interventions:** Participants completed 6 weeks of SportsMetrics™ (2 1-hour sessions/week) in a gymnasium. Any participant missing more than 2 training sessions was removed. Repeated measures ANOVA assessed differences pre to post training and between groups. Independent t tests assessed differences in age, weight, and height between groups. **Main Outcome Measures:** Pre and post training assessment included VJH, YBT composite score (CS) and reach asymmetry (ASY), and drop jump performance (knee separation). Three countermovement vertical jump heights were measured with a tape measure fixed to the wall; the maximum trial was used for comparison. Three anterior (ANT), posteromedial (PM), and posterolateral (PL) reaches were performed for the YBT. The maximum reach in each direction for each limb was used to compute a single CS:(RANT + LANT/2) + (RPM + LPM/2) + (RPL + LPL/2)/3*LL. ANT ASY was calculated as the absolute value of difference between the maximum ANT reach on the left and right leg. The SportsMetrics™ Valgus Digitizer software was used to compute knee separation during the pre-landing, landing, and take off phases of a drop jump. **Results:** Varsity rowers were significantly older than novice rowers (mean ± SD: 16.4 ± 0.8 vs. 14.5 ± 0.7 years; $p < 0.0001$); however, weight (mean ± SD: 62.0 ± 9.0 vs. 58.6 ± 5.4 cm; $p = 0.14$) and height (mean ± SD: 1.7 ± 0.1 vs. 1.7 ± 0.1 m; $p = 0.37$) were the same between groups. VJH significantly improved pre to post training (mean ± SD: 29.0 ± 7.1 vs. 32.0 ± 5.1 cm; $p = 0.001$) and knee separation significantly increased pre to post training at the pre-landing (mean ± SD: 58.2 ± 12.5 vs. 68.7 ± 7.4%; $p < 0.001$), landing (mean ± SD: 49.4 ± 18.2 vs. 66.3 ± 14.2%; $p < 0.001$), and take off (mean ± SD: 47.8 ± 18.4 vs. 64.8 ± 13.8%; $p < 0.001$) phases of the jump; there was no effect for group. There was no difference between varsity and novice pre to post training in YBT CS (100 ± 0 vs. 100 ± 0%; $p = 0.35$) or ANT ASY (mean ± SD: 2.6 ± 1.8 vs. 4.3 ± 6.3; $p = 0.38$). **Conclusions:** SportsMetrics™ training improved vertical jump height regardless of experience level; suggesting rowers had more leg power following training. YBT was not affected by training. Following training drop jump knee separation increased to greater than 60%; indicating training reduced serious knee injury risk.

Non-Traumatic Hip Pain in a Middle Distance Runner: A Case Report

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Background: A 19 year old female Cross Country and Track and Field athlete reported deep achy pain in her right hip and groin area with running beginning in March of 2012, that went unreported due to its intermittent nature. The pain subsided during the summer months, returning in August of 2012 as training began. At its worst, the pain was reported at 7/10. She reported clicking in the anterior aspect of her hip without gross deformity. Although she had full hip ROM, she had increased pain in active hip flexion, extension and internal and external rotation at end ranges. She demonstrated a mild decrease in hip strength in all ROM, as well as decreased strength with right knee extension when compared bilaterally. She did not have any previous history of lower extremity injury, reports a regular menstrual cycle and maintained a well-balanced diet. **Differential Diagnosis:** Hip labral pathology, femoroacetabular impingment (FAI), femoral neck stress fracture, snapping hip syndrome, osteochondral defect (OCD), osteoporosis. **Treatment:** Radiographic evaluation 1 week after her complaint in August revealed a CAM lesion on the femoral neck. A MRI confirmed FAI, in addition to a poorly-defined labral tear of the superior anterior labrum, and slight greater trochanteric bursitis, without any signs of OCDs. She opted to postpone surgical intervention until the end of her competitive season. After 12 weeks of rehabilitation and cross training, she was able to run in both the indoor and outdoor Track and Field seasons, with her pain ranging from 3-6/10 after races. At the end of the outdoor season, a MRI arthrogram was completed, which reconfirmed all previous findings and discovered the presence of a pincer lesion. At this time she underwent a right hip arthroscopy to repair the right hip labral tear, CAM and pincer lesion osteoplasty and iliopsoas tendon release. She was cleared for full activity 19 weeks post-surgery and was participating fully until she began exhibiting similar symptoms in her left hip in August of 2014. **Uniqueness:** FAI is not often seen in female distance runners. Hip injuries make up approximately 3.3-11.5% of all lower extremity injuries in long distance runners, with more prevalent injuries including muscle strains and iliotibial band pathologies. FAIs are more common in football, basketball and hockey due to the high velocity change of direction. FAIs commonly present bilaterally, with only 26.1% of subjects experiencing bilateral hip pain, and are seen more in young male and middle aged female populations. Combined, CAM and pincer lesions often cause OCDs within the hip joint, making surgical intervention imperative to preserve quality of life. Due to the absence of OCDs in her right hip joint, conservative treatment became a viable option. **Conclusions:** Due to the repetitive nature of distance running, labral tears are not uncommon in elite athletes, but impingement is often misdiagnosed, demonstrated by the lack of research in this population. This may be due to the unidirectional movements in runners, which may not always elicit symptoms of a FAI. It is important for clinicians to understand all possible signs and symptoms of FAIs in runners, due to the potential long term ramifications. Although she had a successful surgery of the right hip, she began experiencing similar pain in her left hip. Understanding FAIs are often bilateral, will improve early recognition and treatment to improve long term outcomes. FAIs are not necessarily season ending, but it is important to identify the contraindications for conservative treatment.

Femoroacetabular Impingement With Surgically Repaired Anterior and Posterior Labral Tears in a Middle Aged Physically Active Male: A Case Report

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Background: This report documents a right hip arthroscopy with synovectomy, labral refixation, capsular repair, and cam and rim osteoplasty in 43-year-old (height = 175 cm, weight = 75 kg) male. The patient began experiencing right hip pain and joint catching at approximately age 41. Over time, he began experiencing increasing episodes of sudden and severe joint pain with hip internal rotation and flexion in weight and non-weight bearing activities, loss of hip rotation (internal, external) and an antalgic gait while walking for exercise (5-miles daily). Initially referred to an athletic trainer/physical therapist, he was treated for capsular tightness and soft tissue restrictions with no resolution of symptoms. Unable to manage the pain and motion restrictions, he was evaluated by an orthopedic surgeon. He was diagnosed with femoroacetabular impingement (FAI) syndrome with a right cam lesion and was referred to an FAI specialist. Additional radiographs demonstrated mild hip joint osteoarthrosis. A bilateral CT scan without contrast demonstrated bilateral acetabula subchondral cystic changes with synovial herniation pits and osseous protuberance along the lateral femoral head neck junctions, joint space narrowing, and osteophyte formation along the femoral heads. The remaining medical history was unremarkable. **Differential Diagnosis:** Femoral neck stress fracture, capsulitis, iliopsoas tendinitis, lumbar/sacroiliac dysfunction, groin strain, piriformis syndrome. **Treatment:** After conservative treatment of stretching and modalities without resolve, the patient underwent

a fluoroscopic-guided right hip arthrogram with subsequent pain relief. These results suggested the need for surgical intervention. Hip arthroscopy with labral debridement vs. possible repair, and femoral head osteoplasty was conducted. An intraportal capsulotomy was completed along with a synovectomy. Part of the labrum was unreconstructed and debrided. A pincer labral repair was achieved. Chondral surfaces were moderately disrupted. The anterior capsule overlying the CAM was identified and a T-capsulotomy was performed. Postoperatively, a Newport lite hip orthosis (Orthomerica, Orlando, FL) was prescribed along with 90° hip flexion restriction, toe touch weight bearing, and the use of cold compression therapy PRN. Two weeks postoperatively, outpatient physical therapy was initiated. Four weeks postoperatively the patient began weight bearing as tolerated progressing to full weight bearing with a cane at 5-weeks and full weight bearing with no assistive devices at 6-weeks. Sixteen weeks post-operatively the patient was discharged from therapy and returned to walking for exercise. **Uniqueness:** Characterized by abnormal contact between the femur and acetabulum; FAI is often caused by a deformity of the femoral head or acetabulum. Commonly diagnosed during the earlier decades of life, FAI is prevalent in high-level, physically active athletes engaged in sports with repeated hip internal rotation and flexion movements (ie, ice hockey goalie). These movements in conjunction with the deformity disrupt the anterior labrum, requiring an osteoplasty with labral debridement/repair. In this case; the middle age patient presented with bilateral cam (femoral head) and pincer (acetabulum rim) lesions. Due to limited repeated hip internal rotation and flexion at a high level as an adolescent/young adult, the patient was asymptomatic until his fourth decade of life. Aging and increased hip movement as he engaged in physical activity (ie., walking for exercise) resulted in not only capsular damage, but an anterior and posterior labrum tear; which is uncommon in the literature. **Conclusions:** Femoroacetabular impingement is a rare condition in middle age adults where the primary activity is singular plane movements. With increasing prevalence in the athletic population, athletic trainers must remain diligent when evaluating patients and consider a wide range of differential diagnose; including those not typical for a population. Understanding the etiology and epidemiology of sport or age specific conditions improves not only the management of condition, but the patient's quality of life.

Non-Traumatic Posterior Inferior Labrum Tear in a 16-Year-Old Female: A Case Report

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Background: A 16-year-old female softball player and swimmer with no incident to injury complained of gradual shoulder pain anteriorly and posteriorly for approximately 5 months with a sudden increase in pain the previous week. She complained of having troubles reaching up high as well as reaching her arm behind her back. She was previously diagnosed with rotator cuff tendonitis during the 4-5 months before seeing the Athletic Trainer, however, did not report to therapy as prescribed due to schedule restraints. **Differential Diagnosis:** Rotator cuff tendonitis, Rotator cuff tear, Bursitis, Impingement **Treatment:** Radiographs of her right shoulder were normal. Physician evaluation denied any positive testing to instability or labral pathology and was diagnosed with rotator cuff tendonitis and scapular dyskinesis. Physical therapy with her Athletic Trainer and anti-inflammatories were prescribed with only minimal improvement in her range of motion, but no changes in pain. She received an injection in her subacromial space and glenohumeral space, but again, did not relieve any pain. A MRI arthorogram was then obtained revealing a nondisplaced tear of the posterior inferior labrum with no other abnormalities. Upon evaluation of her shoulder under anesthesia, she had full range of motion in all planes, but showed a 2+ anteriorly and posteriorly for instability. An arthroscopic posterior labral repair was performed with minimal capsulorrhaphy. She was placed in an abduction sling for one month with unlimited use of her elbow and wrist. Two-weeks post-surgical repair, rehabilitation was started with her Athletic Trainer consisting of gentle range of motion exercises and elbow and wrist strengthening until physical therapy was scheduled. At six weeks, she went to physical therapy, but due to having full motion, she didn't return until eight weeks, when more aggressive strengthening could

be started. She has had no pain since shortly after surgery, demonstrated full range of motion, and did not report back to formal therapy due to meeting all her strength requirements, but continued with a home exercise program. **Uniqueness:** Labrum tears are more commonly seen as superior labrum anterior-posterior (SLAP) tears or anterior inferior (Bankart) tears. Additionally, posterior labral tears are usually associated with an acute injury attributed to a fall, dislocation, or subluxation episode. The athlete had no traumatic episode to cause injury, and additionally, symptoms were not consistent with a labral tear, more specifically to the posterior shoulder. In regards to instability, it is less common than anterior instability, only occurring in about 2% to 12% of all instability cases. The physician was unable to find any instability in his evaluation, until she was under anesthesia. **Conclusions:** This overhead athlete experienced symptoms consistent with rotator cuff tendonitis, however, when extensive treatment and therapy proved unsuccessful, further testing revealed a posterior inferior labrum tear. Athletes with consistent shoulder pain showing no improvement should consider further evaluation and testing for possible labral involvement.

Osteitis Pubis in a 30-Year-Old Recreational Runner: A Case Report

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Background: A 30-year-old female recreational runner presented with pain in the groin, hip adductors, rectus abdominis, and the inguinal ligament. The pain had been lingering for several years. Over the past several months, the pain increased with activities of daily living. Initially, running, biking, and long walks caused mild pain in the groin, similar to a groin strain. Over time, the pain spread and became more intense. Previous history revealed the pain started four years prior. After the birth of her third child, the pain increased to a point she could not perform her daily tasks, such as grocery shopping, and she was unable to hold her children. Upon examination by the athletic trainer, she displayed normal gait, level iliac crests, and normal lumbar curve. Palpation revealed no swelling, demonstrated tenderness over her right adductors and in medial thigh near the pudendal region, with no pain in her left hip. She had a negative Valsalva. Normal hip ROM was noted. She was referred to follow-up with her family physician. **Differential Diagnosis:** Hip adductor strain, hernia, pudendal nerve irritation. **Treatment:** The patient's family physician performed an injection for a suspected pudendal nerve irritation. Effects on the pain lasted one day. Neurontin was prescribed, causing her pain to increase. A CT scan showed a potential spigelian hernia, nothing noteworthy, but she was referred to a pelvic specialist. The patient instead sought a second opinion to follow-up with the spigelian hernia. An ultrasound performed by the physician did not show a hernia, so an MRI was ordered for further diagnosis. The MRI showed arthritis in the pubic symphysis with edema in the parasymphyseal region, but no hernia was discovered. A diagnosis of osteitis pubis was made. The physician performed a guided ultrasound injection of 2cc of Celestone into the joint of the pubic symphysis after numbing the area with lidocaine. The patient's pain increased after the first injection. At the two week follow-up appointment she received a second injection using the ultrasound, lidocaine, and 1.5cc of Kenalog. Two months later, the patient had another follow-up exam. The second injection allowed her to be pain free for about six weeks, before intermittent pain returned. A third injection was performed using ultrasound, lidocaine, and 1cc of Kenalog with an additional 0.5 cc of Kenalog at the anterior end of the capsule. By her next exam, her pain was sporadic and did not warrant another injection. A home exercise program with gradual resistance was recommended. Aquatic rehab and massage were used for her rehabilitation. **Uniqueness:** The predisposing factor for this injury was child birth. Through the birth of her second and third child, it was theorized she suffered pubic diastasis. When she started to exercise, her pubic symphysis became inflamed and arthritis set into the joint. **Conclusions:** This case presents an interesting view of a postpartum female that, through pregnancy, developed an unstable pelvis. When she returned to her desired activity level, running 5K-10K races, the instability caused pain that presented as strained muscles. Athletic Trainers should be aware of the risks of postpartum exercise, allowing enough recovery time for the ligaments to return to normal at the pubic symphysis. Knowing how to distinguish a strained muscle from osteitis pubis can improve recovery time and will help prevent injuries in this population of women.

Fibrous Dysplasia With a Femoral Neck Stress Fracture in a DI Volleyball Player

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Background: An 18 year old female DI Volleyball player, with no previous medical history of hip pain or injury, began complaining of L hip pain with activity, which was resolved with rest, starting September, 2013. Evaluation by the athletic training staff and team physician was unremarkable, but L hip flexor tightness was noted in the iliopsoas and rectus femoris along with overall gluteal weakness. At this time the patient started a treatment and rehabilitation program for flexibility and symptom management. The patient continued full participation during the competitive season, with no significant changes in the pain during activity, and immediate resolution with rest. After conclusion of the competitive season, the patient reported increased pain in the hip, especially with sports-specific activity. Six month status-post initial onset of pain, the patient consulted with the team physician when X-rays and an MRI were taken yielding unremarkable results. The patient was told to continue the past plan of care with increased rest. The patient continued the plan of care with no improvement, and decided to receive a second opinion with another orthopedist. **Differential Diagnosis:** Hip flexor tendinopathy or strain, acetabular labrum tear, femoral acetabular impingement from a CAM or Pincer Lesion, femoral stress fractures. **Treatment:** Through the second opinion, an MRI-A was ordered April, 2014 yielding a diagnosis of Fibrous Dysplasia with a femoral neck stress fracture. Consultation with the team physician confirmed the diagnosis, and surgery was performed three weeks later, with a lesion biopsy and internal fixation via side plate and hip screw for reinforcement. The results of the biopsy were unremarkable. At the 6 week follow-up the patient had complaints of groin pain with activity and evaluation revealed pain at end range hip internal rotation. Despite this, the patient was cleared to resume full activity with self-monitoring of her symptoms. Another follow up occurred July, 2014, because of continued increased pain in the groin with activity. With the increase in pain at this time, the patient was held from activity, and the physician performed an injection before starting the patient on Fosamax for pain relief. **Uniqueness:** Fibrous Dysplasia is a rare genetic disorder in which normal bone is destroyed and replaced with much softer fibrous tissue, making it susceptible to injury. The Fibrous Dysplasia Foundation reported that approximately 1 in every 30-60,000 people in a normal population suffer from hip fibrous dysplasia. It remains hard to develop a definitive number of occurrences because, as Mohan et al. reported, determining the true number of incidences is difficult because many patients are asymptomatic. Moretti et al. reported that among 29 patients with Fibrous Dysplasia, those who opted for surgery were pain free and resumed full activity at a mean of 3.3 months. In this case, the patient has yet to resume full activity status-post 5.5 months. **Conclusions:** This case involved an 18 year old DI female volleyball player who began complaining of L hip pain, leading to a diagnosis of Fibrous Dysplasia with a femoral neck stress fracture, causing her to opt for surgery. Post-operative, the patient suffered from groin pain, which continues to prevent her from resuming her athletic activities. It is important to note that it is not possible for an athletic trainer or physician to evaluate for Fibrous Dysplasia. Despite that, a complete evaluation of a patients symptoms and functionality, paired with the use of advanced imaging, such as MRI-A, help determine a proper diagnosis. Additionally, despite being rare, a diagnosis of Fibrous Dysplasia is possible for our patients, but further research is needed on the disease to discover its true effects and the best treatment options.

Non-Contact Avulsion Fracture of Anterior Superior Iliac Spine in High School Football Player

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Background: Sixteen year-old high school male outside linebacker was doing conditioning drill, 10 x 40 yard sprints. Patient was on his last sprint when he immediately fell to the ground and subsequently was unable to lift his right hip three inches from ground. Patient stated he felt a pop on the anterior portion of right hip. Patient did not have any previous history of injury to this area however had experienced hip flexor muscle tightness. Upon on-field evaluation, patient was point tender along anterior superior iliac crest with definite crepitus. There were no obvious discolorations or deformity and no immediate profuse inflammation. Mild contraction of hip flexor muscles were felt but no motion was seen. Patient had increased pain and apprehension with testing but experienced the majority of his pain with resisted hip flexion. **Differential Diagnosis:** Hip flexor muscle group strain, quadriceps muscle group strain, avulsion fracture at hip flexor tendon origin, and/or fracture of anterior superior iliac spine. **Treatment:** Initial treatment included RICE, thus we applied ice, compression wrap to help with immobilization, and gave him crutches. Patient referred to an orthopedic surgeon specializing in pediatric patients. X-Ray imaging was done in three views; anterior to posterior, pelvis, and lateral view. Images revealed a minimally displaced avulsion fracture of the anterior superior iliac spine of right pelvis. Physician did not recommend surgery, patient was instructed to continue the use of crutches for 7-10 days post injury and begin touchdown weight bearing as tolerated. For pain control the physician prescribed 75mg of Voltaren to be taken twice a day and 50 mg of Tramadol to be taken every 6 hours for seven days. Patient was then instructed to begin extensive rehabilitation with the athletic trainers at his high school. Cryotherapy, specifically the Game Ready and ice packs were used to

reduce the risk of edema, muscle spasms, and vasodilation thus reducing pain for 10 days post injury. Rehabilitation exercises were administered to focus on weight bearing, range of motion, strength, agility and speed. We increased weight bearing by 25%, 50%, 75% and then 100% for seven days until the patient was able to ambulate without crutches. We continued with weight bearing exercises while adding specific quadriceps strengthening exercises such as straight leg raises, "tin mans", and short arc quad sets. Agility drills included dot drills, line drills, karaokes, and sprints. Twenty days post injury patient was able to return to practice participating in only non-contact drills. Then at day 27, patient was able to return to full practice without restrictions using pain as a guide. He was also instructed to continue wearing ace wrap for the season to help with support of the joint. **Uniqueness:** This was a unique case because of the mechanism of injury. Non-contact avulsion fractures of the hip flexor muscles are rarely seen in athletes at the high school level. This was also a unique case because of the site of the avulsion fracture as well as how quickly the athlete returned to play with no further issues. Typically, avulsions fractures of the hip are seen at the ischial tuberosity with a return to play close to eight weeks post injury. **Conclusions:** Since avulsion fractures of the hip and pelvis are rare in pediatric patients, this case is important to note the importance of x-ray imaging to determine a positive diagnosis. Clinically, it is important to continue to diagnosis a patient holistically to ensure the reduction of misdiagnosing in the high school setting. The patient has returned to full participation with no further restraints due to the avulsion fracture.

Avulsion Fracture of the Gracilis in an Adolescent Swimmer

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Background: A 15-year old male interscholastic swimmer with no prior history of groin pathology was participating in dry land training when he reported feeling a pop while internally rotating his right hip during a pivot motion. Initially treated as an adductor strain, the patient returned to physical activity. Seven days later while pushing off the bottom of the pool, he performed a motion similar to the breaststroke kick. During the adduction motion he felt a pop in his right groin. He experienced immediate pain followed by ecchymosis in his right upper groin near the inguinal crease. His umbilicus was approximately 2 inches below water level when he adducted his legs, bringing to question the contribution buoyancy should have made in the etiology of this injury. **Differential Diagnosis:** Groin strain, sports hernia, osteitis pubis. **Treatment:** The athlete was taken to a physician for evaluation. Ultrasound revealed a normal adductor longus, brevis, and magnus. The gracilis showed a hyperechoic area in the proximal muscle and an avulsion of the attachment of the apophysis of the origin. Physician diagnosed the injury as right adductor tendonitis/gracilis apophysitis. The patient was referred for strengthening and flexibility rehabilitation for six weeks. The initial assessment described the athletes' right iliac crest and PSIS as being significantly higher than the left, a dysfunctional right SI joint, and limited hip, quadriceps, and hamstring flexibility. Treatment included light stretching of adductors, piriformis, hamstrings and IT band, with joint soft tissue mobilizations of the pelvis and surrounding soft tissue. Modalities included ultrasound administered near the avulsion at 1MHz 0.8 W/cm² for 8 minutes and IFC stim with ice for 15 min throughout the duration of therapy. During the first week of therapy the patient was not allowed to participate in swimming. The return-to-activity progression was as follows: weeks two and three he was allowed to use his upper body only; week four he performed limited kicking with his stroke; week six the patient returned to swimming but was limited due to pain. The patient was discharged from therapy after 16 visits. **Uniqueness:** The original mechanism of injury was caused by internal hip rotation on a planted pivot foot, uncommon for groin strains. The most common mechanism of injury for the secondary avulsion injury is eccentric overload, however this was not the case for this swimmer. The gracilis avulsion occurred while non-weight bearing in a pool. His body weight, being affected by buoyancy, should have reduced the amount of tension on the muscles by approximately 50 percent. Therefore, his concentric muscle action should not have produced the amount of force necessary to avulse the gracilis. **Conclusions:** A paucity of literature indicates gracilis avulsion fractures are rare in swimmers. Both conditions in this athlete reported unique mechanisms of injury for sustaining a groin strain or avulsion. Athletic trainers should be aware of the potential for avulsion fractures regardless of the sport or mechanism of injury reported.

The Evaluation and Treatment of Ankle Impingement Syndrome in a Youth Competitive Diver: A Case Report

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Background: This case involves a 15 year old elite female diver presenting with right lateral ankle pain for approximately 3 months. No specific incident of trauma or mechanism of injury was reported. Her symptoms progressively worsened causing an antalgic gait and the inability to perform at a high level. An evaluation was performed by an athletic trainer and sports medicine physician. Due to increased pain and decreased AROM, a three view ankle X-ray series was ordered. The results were negative showing normal morphology of the tibia and fibula as well as no foreign body visualized at the ankle joint. The athlete was placed in a walking boot and instructed to refrain from diving for 2 weeks. At the 2 week follow-up visit, she complained of continued pain. The athlete then demonstrated a positive Molloy-Bendall test for ankle impingement syndrome (AIS). This clinical test has 95% sensitivity and 88% specificity and is performed by pinching the synovium in the joint line and applying extreme dorsiflexion. An MRI was ordered and the findings were unremarkable. **Differential Diagnosis:** Anterior talofibular ligament sprain, anterior inferior tibiofibular ligament sprain, stress fracture, Salter Harris fracture, peroneal tertius tendonitis, accessory ossicle, synovitis. **Treatment:** After a total of 6 weeks of rest the athlete was still having complications and then was sent to our orthopedic surgeon for a consultation. Arthroscopic ankle surgery was then performed to examine the anterolateral right ankle joint. The anterolateral soft tissue was impinged and the debridement of a Bassett lesion (accessory anterior inferior tibiofibular ligament) was performed. Physical therapy was prescribed to the tolerance of the athlete and without limitations. Ankle isometrics were performed with gradual progression of AROM. Resistance exercises with the focus on eccentric control were performed in addition to proprioceptive awareness training. When full ankle AROM was restored, an evaluation using slow-motion biomechanical analysis was performed with 2 high speed cameras. The athlete was instructed to mimic her approach on a raised platform as if she were diving. The data confirmed strength deficits bilaterally and she also demonstrated the inability to maintain a plantarflexed position with the right ankle collapsing laterally. Her protocol was adjusted to focus on appropriate motor recruitment patterns in order to withstand increased plantarflexion loads before leaving the platform. **Uniqueness:** High speed cameras can be reduced to speeds of one hundred frames per second, giving clinician's visual data of faulty mechanics that may not be seen by the human eye. Published studies are limited to AIS in the sport of dance and age-specific information is not available. Given this athlete's age, skill, and sport it was vital that the high speed slow-motion cameras were incorporated to better understand the biomechanics of her diving approach to eliminate future injuries. **Conclusions:** AIS leads to restricted ankle motion, progressive damage to the ankle, and chronic pain. These injuries occur due to osseous or soft-tissue abnormalities secondary to repetitive trauma to the ankle joint. This novel use of slow-motion biomechanical analysis has not been demonstrated previously. Through the use of this tool, a proper sport-specific protocol was tailored to prevent repetitive microtrauma to the ankle joint. Future research should focus on the use of slow-motion photography in the evaluation of elite athletes suffering from AIS. She has since returned to competitive diving without any reservations.

A Rare, Proximal Tibial Diametaphyseal Stress Fracture in a 12-Year-Old Sprinter

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Background: A 12-year-old male, middle school 400-meter runner and jumper presented with complaints of left knee pain localized over his tibial tuberosity. He had no previous history of knee pain, and had been participating in practices for eleven days. The athlete was 1.67 m tall, 66.3 kg, and reported undergoing a "growth-spurt" over the winter. This was his first time competing in middle school athletics and his first time running track. Upon initial evaluation, the patient reported that he had done no training prior to the season and had a 4/10 pain while running, 3/10 pain upon palpation of his tibial tuberosity, no known MOI, and no night pain. He had full knee and hip ROM compared bilaterally and manual muscle testing revealed 5/5 quadriceps strength compared bilaterally. He was told to rest over the weekend and follow with the ATC. Upon re-evaluation, three days later, he still complained of pain over his tibial tuberosity and was removed from running and jumping activities for two weeks. He was allowed to continue core workouts with the team as well as swim at his parents' health club during his removal from running. He returned to grass conditioning 17 days after initial evaluation utilizing a 15%, incremental increase running progression every other day. The first day he walked for 25.5 min and ran for 4.5 min during the 30-minute practice. At the end of the week he reported 1/10 pain while running. Twenty-four days after his initial complaint, he reported a 6/10 pain over his tibial tuberosity with painful swelling over the pes anserine attachment following a 6-hour car ride over the weekend. He was then referred to University of Kentucky Orthopaedic Surgery and Sports

Medicine. **Differential Diagnosis:** Tibial tuberosity traction apophysitis, pes anserine tendonitis/bursitis, tibial stress fracture. **Treatment:** Anterior/Posterior and lateral x-rays taken 28 days after initial evaluation showed a proximal stress fracture to the tibial diametaphyseal junction. At this time he was placed in a DonJoy (Vista, CA) T-ROM brace locked at 0 degrees of extension and strict non-weight bearing on crutches until his follow up in three weeks. Follow up x-rays showed callous formation and healing of the fracture. He was no longer point tender over the tibial tuberosity or pes anserine attachment and was allowed to unlock his brace and wean to full weight bearing. X-rays 84 days post showed continued healing and maturation of the periosteal callous and he was allowed to begin cross training. The patient was allowed to return to running 119 days post when x-rays showed complete healing with subtle periosteal thickening. **Uniqueness:** Stress fractures are rare in adolescents, with the proximal portion of the tibial diaphysis being the most common site for lower extremity stress fractures. In this particular case, the location of the lesion at the proximal tibial diametaphysis is extremely rare. A PubMed and Medline search revealed no other reported cases of stress fractures of this nature. **Conclusions:** As young athletes become more specialized in their chosen sports, their training volume continues to increase. Overuse injuries are common in young athletes, but stress related injuries are not. In this case, due to its location, the diametaphyseal stress fracture presented as a tibial tuberosity traction apophysitis, which is a common overuse injury in young athletes. Although a rare age and location for stress fractures, differential diagnosis of pain at the diametaphysis should include stress reactions in adolescent athletes.

Non-Contact Salter-Harris IV Proximal Tibial Fracture in an Adolescent Football Player

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Background: A 15-year-old male football player complained of anterior left knee pain after a celebratory chest bump. He was a 5'3", 204lb freshman with no previous knee injuries. Upon initial evaluation, the athlete was supine with an obvious deformity and edema to the left anterior knee. Athlete reported his knee did not twist, but when he landed he felt a "pop" and immediate pain causing him to fall to the ground. Upon visual inspection gross deformity of the anterior knee was apparent. Knee palpation was limited secondary to pain, but did reveal abnormal alignment of the tibial tuberosity and an ill-defined joint line. The fibular head was not palpable due to edema. Knee ROM was not assessed. The athlete was able to actively dorsiflex and plantarflex his ankle and toes, and had full sensation of his entire lower extremity. Capillary refill and dorsal pedal pulse were strong and equal when compared bilaterally. **Differential Diagnoses:** Tibial tuberosity avulsion fracture, proximal tibial epiphyseal injury, knee dislocation. **Treatment:** The athlete's lower leg was splinted with two moldable splints and an elastic bandage, and was transported via ambulance to the emergency department. Radiographs revealed a fracture of the left knee extending through the anterior aspect of the lateral tibial plateau and through the metaphysis indicating a type IV Salter-Harris fracture. He was admitted to the pediatric orthopaedics department and was monitored overnight. The following day, he underwent an open reduction, internal fixation of the tibial plateau injury. The surgery required two 2.7mm interfragmentary compression screws in the subchondral region and one 3.5mm interfragmentary compression screw through the distal tuberosity. He was released 24hrs post-surgery in a post-operative brace locked in extension and permitted to weight bear as tolerated. Forty-six days post-surgery, he was cleared to begin rehabilitation for passive and active range of motion, as well as light stretching. His brace remained locked in extension for ambulation but could be unlocked for therapy and when seated. Strengthening exercises were restricted until the patient achieved full ROM. Radiographic evidence of periosteal healing was noted on follow-up x-rays at this time. Sixty-eight days post-surgery, x-rays revealed continued fracture healing both across the joint and the tibial tubercle. There was no evidence of a step-off deformity in the joint line and the physis was intact. At this time the athlete was permitted to unlock the brace for ambulation. Ninety-six days post-surgery, the athlete was removed from the brace and cleared to gradually return to conditioning with the football team; however, no contact sports or heavy lifting were permitted as the fracture line remained evident on x-rays. One hundred-seventeen days post-surgery, the athlete was pain free, demonstrated full ROM and good strength, and was cleared for return to activity. The athlete was able to complete the following football season without incident; however he may undergo surgery for painful hardware in the near future. **Uniqueness:** Proximal tibial physeal fractures account for 0.6 to 2.1% of all physeal injuries. This low incidence can be attributed to the intrinsic anatomical stability of the proximal tibial epiphyseal/physeal region. Salter-Harris Type IV fractures of the proximal tibia usually occur in adolescent basketball players when initiating a lay-up or track athletes during high and long jump activities. While flexion-avulsion is a commonly seen mechanism in type IV Salter-Harris fractures of the proximal tibia, a history of Osgood-Schlatter disease is usually present. In the present case, the athlete had no history of Osgood-Schlatter disease. **Conclusions:** When working with adolescent athletes suspicion of physeal injuries should be high; however, with appropriate management and gradual return to loading successful healing and return to activity can be achieved.

Impaction Fracture of the Cuboid and Multiple Tarsal Bony Contusions in a 22 Year Old Division III Football Offensive Lineman

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Background: Patient is a 22 year old offensive lineman who reported to the AT clinic following a football game complaining of right foot pain. Patient stated that while blocking a player he rolled his ankle. He had immediate pain and soreness in the lateral midfoot but was able to continue playing in the game. Patient complained of discomfort in the lateral midfoot during the toe-off phase of gait. Upon evaluation patient presented with mild swelling over the lateral midfoot, point tenderness over the 5th metatarsal, cuboid, and peroneal tendons. Pain was present during AROM during ankle inversion and eversion. Manual muscle testing revealed pain and weakness during ankle inversion (4/5) and eversion (4/5) and no pain or strength deficits were present. **Differential Diagnosis:** Cuboid fracture, 5th metatarsal fracture, peroneal tendon strain, peroneal tendon tear, lateral ankle sprain, midfoot sprain, bone contusion. **Treatment:** Patient was placed in a walking boot with full weight bearing status after evaluation. Patient reported for a follow up evaluation 2 days following the injury with a complaint of tenderness over the lateral midfoot with weight bearing and a marked increase in pain and tenderness over the 5th metatarsal. The patient was referred for an x-ray. X-ray was negative and patient was instructed to remain in the walking boot and that he could participate as tolerated once he had decreased pain and tenderness over the 5th metatarsal. Five days following the injury the patient returned to practice as tolerated and had no marked increase in pain or point tenderness. Seven days post injury the patient participated in his team's game with minimal pain and discomfort. Three weeks post injury (10/2/13) the patient had a follow up appointment with physician at which time an MRI was ordered due to continued soreness and point tenderness over the 5th metatarsal. MRI revealed impaction fracture of the cuboid and bony contusions along the lateral margin of the calcaneocuboid joint, middle cuneiform, talar neck, navicular, and 3rd and 4th metatarsal heads. Patient was instructed to refrain from football activity and was partial weight bearing in a walking boot for 2 weeks and then progressed to full weight bearing in the walking boot for 8 weeks. Patient followed up with physician 2 months (2/3/14) post initial MRI and presented with slight tenderness over the peroneal tendon and cuboid bone. A follow up MRI was ordered to rule out a tear of the peroneal tendon. MRI revealed that the impaction fracture and bony contusions were almost healed and some flattening of the peroneal brevis tendon was present but no evidence of a tear. The patient was to start a rehabilitation program and follow up with the physician in 3 weeks. Patient performed rehab program that focused on strength, flexibility, and stability with his athletic trainer. At the follow up (3/19/14) it was decided that surgical intervention would be done since the patient had failed conservative treatment. Ankle arthroscopy with extensive debridement and peroneal tenosynovectomy was performed in April 2014. Patient was cleared for gradual return to football in August 2014. **Uniqueness:** AP, lateral, and oblique x-ray views are usually sufficient to diagnose cuboid fractures but our patient had a negative x-ray, returned to competition, and fracture was diagnosed 3 weeks after the initial injury via MRI. Injuries involving the cuboid often involve the 4th and 5th metatarsals and this patient had involvement of the 3rd and 4th metatarsals. **Conclusions:** Despite initial imaging being negative and the patient progressing to return to play, although decreased, lingering symptoms need to be further investigated. Delay in recognition and proper treatment of initial injury is important for proper management and outcomes.

Acute Lateral Compartment Syndrome With Excision of the Peroneals in a Collegiate Football Player

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Background: The patient (age = 22yr, ht = 190 cm, wt = 117.48 cm) was a male collegiate football player (defensive end), with no history of hematologic disorders. He reported "spraining his ankle" during football practice but finished practice. He was evaluated after practice and presented with lateral ankle pain and swelling. His swelling dissipated and he was noted to have a peroneal nerve to be out, with 1st web space lack of sensation as well as the inability to evert or dorsiflex his ankle or great toe. The patients swelling had subsided and his pain was better, however, one day later the patient developed significant symptoms, increasing pain that was unremitting, ecchymosis around the fibular head, and he became febrile. **Differential Diagnosis:** Acute compartment syndrome, lateral ankle sprain, syndesmosis sprain, fibular head fracture. **Treatment:** The patient was initially treated conservatively in a long leg boot immobilizer and monitored with progressive symptoms. He was emergently transported to the hospital for evaluation and taken immediately to the operating room for an emergency anterior and lateral fasciotomy of the right lower extremity. The patient had a complete release of the anterior and lateral compartments with debridement and evacuation of a hematoma in the lateral compartment. The superficial peroneal nerve was unable to be identified and evidence of "dusky-looking" muscular tissue was present throughout the lateral compartment. A wound VAC and suction seal were placed and the patient was admitted for continued monitoring. In addition, an x-ray and MRI of the right knee and ankle presented a fracture of the posterior malleolus and a lateral meniscus tear. The patient underwent a second operation two days later. The lateral compartment remained dusky and there appeared to be no movement of the musculature. The

patient was febrile and it was decided to remove the lateral compartment. The necrotic peroneal musculature was debrided of nonviable tissue. The peroneal nerve was left intact; however, a nerve stimulator produced no activity. Three days later, the patient underwent a third operation in which the remaining lateral compartment was excised. Nine days after his first operation, the patient underwent a final irrigation and debridement, and closure of the wound. He was discharged with noted sensation in the deep and superficial peroneal regions of the foot, with paresthesia present in the deep peroneal nerve distribution. No ankle or toe dorsiflexion was present. Three months post injury the patient showed signs of muscle activation with dorsiflexion. The patient began running and jumping four months post injury, however, knee pain limited his progression and he underwent a right knee menisectomy. Nerve sensation and 1st toe movement gradually returned and he participated "non-contact" in spring football practice eight months post injury. The patient returned to full football participation one year post injury with no complications; however, he sustained a career ending ACL tear in the left knee half way through the football season. **Uniqueness:** There are only twenty seven cases of lateral compartment syndrome documented. Of those, only one case documented the excision of the peroneals. This collegiate athlete was able to return to full function and activity, despite the lack of the main everters of the ankle. **Conclusions:** While acute compartment syndrome is not unheard of, it typically is isolated to the anterior compartment. With the occurrence of an inversion ankle sprain, the lateral compartment should be considered as well, and early detection is key.

Treatment of a Maissoneuve Fracture in a Collegiate Softball Player

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Background: Athlete was a 21 year old collegiate softball player. She was sliding into second base during a game when her cleat stuck into the clay, forcing her right ankle into external rotation and plantar flexion. She felt a pop and had immediate pain. Athlete attempted to take a step, but felt increased pain and fell back to the ground. Pain level was 6/10 at rest and 8/10 when trying to move the ankle. There was no obvious deformity. Swelling was noted on the medial, lateral, and anterior ankle. Point tenderness was noted over the anterior tibiofibular ligament, syndesmotic space, distal fibula proximal to the lateral malleolus, deltoid ligament, and proximal fibula about 2 inches distal to the fibular head. Range of motion was limited in plantar flexion, dorsiflexion, inversion, and eversion. Manual muscle testing was not performed due to the pain level. Squeeze test was positive and bump test was negative. Athlete denies any previous injury to the right ankle. **Differential Diagnosis:** Syndesmotic ankle sprain, distal fibula fracture, deltoid ligament sprain, proximal fibula fracture, Maissoneuve fracture. **Treatment:** Athlete was referred to the team physician. X-rays revealed a Maissoneuve fracture. Conservative and surgical treatments were discussed. The athlete chose a surgical treatment. The athlete was treated with Game Ready®, milking massage, and pain and inflammation control modalities for 1 week until her surgery date. The surgeon drilled a guide pin medial to lateral through the distal tibia and fibula. A Biomet Sports Medicine ZipTight Fixation system was inserted laterally using the guide pin. The device was locked along the medial tibia and the button tightened laterally. This was done at both the proximal and distal incision points. Once the devices were locked into place, the surgeon checked the integrity and position of the syndesmotic joint. The guide pin was removed and incision sites were sutured. The athlete returned after 1 week for suture removal. The incision looked good. She was instructed to remain non-weight bearing until her next follow up appointment, but was allowed to work on range of motion. At 6 weeks post-op the athlete was allowed to begin partial weight-bearing status as well as strengthening exercises. At 10 weeks post-op, the athlete was allowed to begin full weight bearing and continue rehabilitation. The athlete began jogging and agility work at 16 weeks with no problems and wore a brace for most activities. At 20 weeks, the athlete returned to most softball activities. Running and jumping were still limited at this point. At 24 weeks, the athlete is sprinting, jumping, and participating in softball with no problems. **Uniqueness:** Maissoneuve fractures account for about 5% of all surgically treated ankle fractures. The standard surgical treatment for this injury includes anatomical reduction of the sydesmosis using pins in the tibia and fibula to stabilize the syndesmotic joint. This surgery requires an additional surgery weeks later to remove the pins. However, in this case the surgeon utilized a unique surgical device called the ZipTight fixations system. This device stabilizes the ankle joint and remains in the joint providing long lasting stability even after the joint has healed. This can eliminate an additional surgery and allow the athlete to return to play more rapidly. **Conclusions:** When a syndesmotic injury is present, x-rays should be obtained of the proximal fibula to rule out a Maissoneuve fracture. The syndesmotic joint must be stabilized as soon as possible in order for proper healing of the fibula to occur. The ZipTight fixation system appears to provide good outcomes without the need for an additional surgery to remove the pins.

Progressive Rehabilitation of a Grade II Open Tibia and Fibula Fracture in a Division 1 Collegiate Soccer Player

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Background: A 20 year old Caucasian male soccer player sustained a direct impact to the middle posterior lower leg during a scheduled spring team practice. The patient was playing defensive left back, on a dry natural grass surface, when his teammate kicked his posterior leg while trying to steal the ball. The player felt a snapping sensation and immediate pain at his left distal lower leg causing the athlete to collapse. Following the injury, the patient attempted to ambulate when he realized that he had an obvious deformity to his lower leg and was unable to weight bear. Once the athlete's soccer equipment was removed, a full neurovasculature assessment was normal. **Differential Diagnosis:** Open tibia and/or fibula shaft fracture, closed tibia and/or fibula fracture, acute compartment syndrome, serrated laceration **Treatment:** A bony protrusion at the anteromedial lower leg was evident after sock, shin guard, and tape removal which guided initial emergency treatment. The injury site was stabilized using a vacuum splint which immobilized the patient from the distal femur to the foot. He was transported to a local hospital by EMS where radiograph imaging confirmed the presence of a grade 2 open distal tibia and closed fibula fracture. Approximately 45 minutes after the time of initial injury, the tibia was manually relocated. Within 3 hours of injury, the patient underwent surgical intervention which included an intramedullary nail fixation of the left tibia. The patient began partial weight bearing the day following surgery using a walking boot and crutches. Within one week he was able to ambulate in a walking boot without crutches for short distances and in two weeks the patient was able to hold a single leg balance on the affected leg for approximately 20 seconds. By post-operative week 6, the patient was able to utilize the Alter-G® at 70% body weight for gait mechanics while jogging. At six weeks, he also began general sport specific skills such as passing for short distances and juggling the ball. Post-operative weeks 10 through 12 focused on jogging mechanics with full body weight impact and jumping exercises on a mini trampoline. At 16 weeks the patient began sport specific agility workouts and at 25 weeks, the patient was cleared to return to full soccer participation. The patient underwent an elective surgery at 26 weeks post-surgery to remove the three interlocking screws from his left tibia. He was non-weight bearing for approximately 10 days following hardware removal and returned to full game play 30 weeks after initial injury. Uniqueness: With the use of an intramedullary nail fixation in the tibia, the patient was able to weight bear immediately following surgery. Research indicates that with intramedullary fixation of an open tibia fracture it generally takes approximately 20-24 months for a full bony union to form and patients generally complain of pain in the involved ankle and knee. This patient was able to return to play with minimal complaints of pain and no inhibition in ROM, strength, or stability of the left ankle or knee. **Conclusions:** The patient underwent immediate surgery for fixation of his left open tibia fracture with no fixation of his fractured fibula. He was able to begin sport specific activities within 16 weeks of injury and returned to play at 25 weeks post-surgery. With appropriate acute treatment, surgery, and post-operative interventions a Division 1 soccer player was able to return to elite competition following an open tibia-fibula fracture.

The Rare Presence of an Accessory Soleus Muscle Strain in a Male Division I Collegiate Track Sprinter

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Background: A healthy 21 year old Division I collegiate track sprinter presented with burning pain and minimal swelling in the posteromedial aspect of his right ankle in the beginning of his indoor competitive season. His pain was worst with toe-off and was described as "different from any ankle injury previously sustained." Despite the pain, his athletic trainer measured full range of motion and strength. After three weeks of therapeutic rehabilitation and treatment, symptoms were not resolved and physician referral was warranted. Upon physician examination, a Magnetic Resonance Image (MRI) was ordered to rule out an injury to the flexor hallicus longus tendon. The MRI revealed inflammation around the medial malleolus and along the flexor hallicus longus, but no structural abnormalities were present. The physician recommended continued running with treatment to reduce inflammation. After seven weeks of conservative treatment pain had increased and the athlete was now unable to push off of the starting blocks. This prompted the physician to revisit the previous MRI to ensure that no structural abnormalities were missed. Upon further investigation to the initial MRI, an accessory soleus muscle with a partial tear was discovered. An irregularity was evident at the musculotendinous junction indicative of a partial tear with edema extending to the upper limits of the image. **Differential Diagnosis:** Deltoid Ligament Sprain, Flexor Hallicus Longus Strain, Achilles Tendon Pathology, Du Tarsal Tunnel Syndrome, Soft Tissue Tumor and Medial Malleolus Stress Fracture. **Treatment:** Upon diagnosis of the accessory soleus muscle, extensive research was completed by the physician to determine the best course of action. After an intensive search, the best treatment with a successful outcome was

excision of the muscle. A little over two months after the initial injury, the athlete was prepped to have his accessory muscle removed. During the procedure, the distal attachment of the muscle was discovered at the medial aspect of his ankle, just anterior to the Achilles Tendon, and the proximal attachment was eventually found about half-way up the tibia. After excision, the accessory soleus muscle was measured to be 12 centimeters long. After a minor setback with excessive scar tissue preventing normal dorsiflexion, the athlete was able to return to normal workouts four months post-surgery. At seven months post-surgery, the athlete's current status is full activity with no complications. **Uniqueness:** While the occurrence of an accessory soleus muscle seems to be the most common anatomical variant in the lower leg, it is estimated that this abnormality is only present in about 3% of the population. In most cases, the presence of an accessory soleus muscle is asymptomatic and presents in athletes between the ages of 20 to 30. Few case reports of the presence of an accessory soleus muscle causing an athlete severe discomfort have been documented in literature. Due to the rarity of the level of this condition, effective treatment plans are often delayed. **Conclusions:** Though the presence of a symptomatic accessory soleus muscle is rare, the athletic trainer will be the first person to evaluate the athlete. To ensure the athlete will not experience a delay in effectively returning to competition, it is important for athletic trainers and physicians to pay close attention to the possibility of an accessory soleus pathology.

Division I Collegiate Women's Tennis Player with Chronic Plantar Fasciitis

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Background: A nineteen year old, Division I female tennis player presented with sharp left heel pain that became worse after practice in July 2013. She presented with a history of multiple left ankle sprains and low back pain. Initial evaluation revealed normal postural alignment, limited active dorsiflexion (5-10º), and point tenderness at origin of the plantar fascia. **Differential Diagnosis:** Calcaneal stress fracture, heel spur, and/or plantar fasciitis. **Treatment:** Initial treatment included night splints, stretching of Gastrocnemius/Soleus complex and plantar fascia, molded orthotics, heel lift for left foot, KT tape for plantar fasciitis, arch tape, and strengthening exercises. These were unsuccessful and the team physician was consulted September 2013. X-rays were negative for stress fracture and heel spurs. Patient was referred to an orthopedist October 2013. MRI indicated thickening of plantar fascia and Platelet Rich Plasma (PRP) injections were administered November 2013, followed by a rehabilitation protocol consisting of 3 four week phases. Phase 1 comprised of non-weight bearing for 24 hours, limited activity for 2 days following injection, no anti-inflammatories or modalities, use of a walking boot, ankle ROM exercises, low intensity stretching of Gastrocnemius/Soleus complex and plantar fascia, stationary bike with light resistance, and trunk/hip/knee open kinetic chain strengthening and stretching exercises. Phase 2 comprised of soft tissue mobilization of plantar fascia, standing static stretching of Gastrocnemius/Soleus complex, foot and ankle strengthening exercises, trunk/hip/knee closed kinetic chain strengthening exercises, aquatic training, treadmill walking/elliptical, and balance exercises. Phase 3 comprised of progression from running on flat surface to plyometric/agility training to sport specific training. A second PRP injection was administered January 2014 as the patient continued with the prescribed protocol. The patient was able to compete during the spring season despite pain. She was given custom orthotics March 2014. She saw orthopedist June 2014 for a follow up. Patient was scheduled for a cortisone injection July 2014, but was cancelled due to patient discomfort. Patient sought second opinion from podiatrist, July 2014, who suggested extracorporeal shock wave therapy to promote healing with sound waves guided by high-resolution ultrasound. Patient received therapy August 2014. A new protocol was given which included: no anti-inflammatories or modalities, avoid all physical activity involving affected heel, swimming with a floatation device between legs, wearing rubber soled shoes for ADL's, biking at two weeks post procedure, and elliptical at three weeks post. Follow up appointments were scheduled for September, October, and November 2014. After September appointment, patient was allowed to: run for 10-15 minutes on Alter G at 60% for first week and progress to 95% at fourth week. At week two she was allowed to start with ground strokes while standing still. At week three she started to serve without a jump and was serving normally at week four. While training she continued to be limited to no explosive exercises or lunges but icing and anti-inflammatories were used when needed. After October appointment, patient was allowed to: ease back into playing and moving more after the ball but no competitive play until after November appointment. At week two, she could move front to back and from sideline to sideline on court. While training, she was to complete tennis related activities and treadmill running at 100% for 20-30 minutes. **Uniqueness:** The patient's plantar fascia thickness measured at 8.74 mm, with normal ranges between 2-4 mm. Conservative treatments were unsuccessful, but extracorporeal shock

wave therapy allowed the patient to compete without pain. **Conclusions:** Plantar fasciitis symptoms are typically alleviated with conservative treatment. This case demonstrates that traditional conservative treatments were attempted with no continuous pain relief and that new treatments need to be considered.

Tibial Tubercle Avulsion Fracture in an Adolescent Football Player

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Background: A 15 year-old male football player acquired acute anterior knee injury of his left plant leg after it buckled while attempting a kickoff at practice. On-field inspection revealed obvious deformity of his antero-lateral joint line. There was a bony deformity at the tibial tubercle, and patella was not palpable due to edema. Distal pulses and neurological screen remained uncompromised through repeated exams. A knee immobilizer and crutches were used in immediate transport to hospital. There was no prior history of knee injury, but the athlete endorsed a 2-week history of intermittent mild patellar tendon pain on his left leg. **Differential Diagnosis:** Tibial tubercle fracture, patella dislocation, quadriceps tendon rupture, patella tendon rupture, patella fracture, compartment syndrome. **Treatment:** X-rays in the Emergency Department confirmed type 1B (complete separation) tibial tubercle avulsion fracture of the left leg. The following day the athlete underwent open reduction and internal fixation surgery with two 4mm partially threaded screws with no complications. The athlete was non-weight-bearing with knee immobilizer and wheelchair for 4 weeks. He then began physical therapy and transitioned into a locking hinged knee brace. Physical therapy progression included extensor mechanism strengthening, gait retraining, agility training, plyometric training, and functional activities. Surgeon follow-up occurred at post-op week 2, 5, and 10. The athlete has since continued strength training, agility, and sport specific drills with no complications in preparation to play during the next football season. **Uniqueness:** Tibial tubercle avulsion fractures in adolescents are uncommon and account for less than 1% of all physeal injuries. Additionally, kicking represents only 2% of self-reported mechanism of tibial tubercle avulsion fracture in the current literature. With jumping (32%) and falling onto knee (17%) representing the majority of injury mechanisms. Most documented cases reported utilizing a post-op long leg cast, however; in this case, the athlete was placed in a locked hinged knee brace. Prognosis for most patients is good post-operatively, and athletes generally return to full activity within 4 months. **Conclusions:** Tibial tubercle fractures are uncommon injuries that can cause extensive damage to surrounding tissues. Neurovascular compromise, compartment syndrome, intra-articular damage, and even significant ligamentous damage have been associated with tibial tubercle fractures in adolescence. It is important for health professionals to keep this rare injury on the list of differential diagnoses of the acutely injured knee. Recognition by first responders as a potential vascular emergency is paramount.

Accessory Soleus Extraction in a Male Cross Country Athlete

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Background: This athlete is an 18-year-old male cross-country runner. He had no previous history of lower leg injuries, however, the athlete did mention a history of pain and swelling after running in high school. Athlete presented with similar symptoms after running at Quinnipiac University for about two months. Upon starting his season at Quinnipiac, his mileage was increased from about 50 miles a week to 70-75 miles a week. Athlete was referred to a team physician on October 13th 2013 due to continuation of symptoms. **Differential diagnoses:** retro calcaneal bursitis, a cyst from the peroneal tendon sheath, compartment syndrome, or Achilles tendon tendinopathy. Physical exam with team physician revealed no neurological issues but warranted diagnostic imaging. MRI revealed a possible muscle herniation but due to poor quality, a dynamic ultrasound was ordered on November 7th 2013. Review of imaging showed an accessory soleus muscle present in the right lower leg, which was entrapping the neurovascular bundle. The athlete consulted various specialists who all came to the same conclusion of a symptomatic accessory soleus muscle in the right lower leg. The physician discussed both conservative and surgical options with the athlete. **Treatment:** The athlete decided to have the accessory soleus surgically removed in January of 2014. Post-operatively, the athlete had an extensive rehabilitation program, interacting with several health care professionals, to regain strength, stability, and function of his ankle and lower leg. He was non-weight bearing on crutches and in a boot until February 4th 2014. During this time he worked to decrease pain and inflammation and to regain ankle range of motion. On February 24th, the athlete was cleared to begin weight bearing as tolerated with arch supports. Extensive gait training was required for this athlete to return to normal gait. Throughout his rehabilitation, the athlete complained of pain posterior to his right medial malleolus. On March 24th 2014 the team physician diagnosed the athlete with posterior tibialis tendinitis. The pain persisted through the following weeks and on May 9th 2014, MRI imaging showed a stress fracture in his right lower leg just posterior to the medial malleolus, which prohibited him from progressing to running until July 2014. Other complications such as posterior tibialis tendonitis inhibited the athlete from competing this cross-country season. As of October 2014 the athlete is running about 20-25 miles per week. **Uniqueness:** only about 6% of the population has an accessory soleus muscle (1). About 2.77% of the population with an accessory soleus muscle is within the athletic population (2). **Conclusions:** This case of an accessory soleus extraction was complicated. It shows us clinicians the importance of communication and documentation when many different health care professionals are working with the same athlete. Conservative rehabilitation was significant in this case in an attempt to avoid further injury and complications. However, this athlete is very competitive and determined to get back to running, which created a compliance issue. It is unknown if the athlete's compliance effected the treatment outcome. References: (1) Mukish, Prikesht, Pierre-Yves Reybet-Degat, Alexandre Demangel, Pierre Trouilloud, and Emmanuel Baulot. "Accessory Soleus Muscle: A Difficult Diagnosis: A Case Report and a Review of the Literature." European Journal Orthopedic Surgery, Traumatology (2012). Springer-Verlag. Web. (2) Rossi, F., and S. Dragoni. "Symptomatic Accessory Soleus Muscle: Report of 18 Cases in Athletes." (2005). Pubmed. Web. 13 Nov. 2014. <Pubmed.gov>.

Comparison of Load Cell Dynamometer to an Isokinetic Device for Measurement of Quadriceps Strength

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Context: Current practices in athletic training emphasize assessment of muscular strength. Isokinetic testing, while considered the gold standard in strength assessment, may not be readily available due to space and financial limitations, particularly in traditional athletic training settings. In the absence of an isokinetic assessment, many clinicians perform manual muscle testing, which may not provide adequate strength information when assessing larger muscle groups. Finding an objective measure of strength that has both financial and space economy would allow athletic trainers another option for strength assessment. Load Cell Dynamometers (LCD) have been demonstrated in previous studies to have excellent reliability, but validity has not yet been demonstrated. **Objective:** The objective of this study was to determine the validity of a LCD for strength assessment of the quadriceps musculature compared to an isokinetic testing device. **Design:** Prospective, cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-six (10 male, 16 female) health, active participants (19.8 ± 1.2 yrs, 171.5 ± 8.4 cm, 71.8 ± 2.7 kg) volunteered for the study. **Interventions:** Participants completed two testing sessions to assess quadriceps strength, one session using the LCD and the other using the isokinetic strength assessment. All participants completed a LCD assessment under static conditions with the knee placed at 60 degrees of flexion, while an isokinetic strength assessment was performed at angular velocities of 180°/second and 60°/second. **Main Outcome Measures:** Isometric peak force generated was recorded over three trials for the LCD. Peak torque was recorded at 180°/second and 60°/second over six trials for the isokinetic strength assessment at each speed. Maximal peak force and peak torque generated by the quadriceps were used in data analysis. Both right and left limbs were tested and data for each limb was pooled for a total of 52 data sets. Pearson correlation coefficients were calculated to assess the relationship between LCD and isokinetic device at 180°/second and 60°/second. Strength of correlation was judged based on r of 0.9 to 1 as very strong, values between 0.7 and 0.9 as strong, and values between 0.5 and 0.7 the strength of correlation was moderate. **Results:** Data demonstrated a strong correlation ($r = 0.704$, $P < 0.000$) between the LCD and the isokinetic strength assessment at 180°/second. There was a moderate correlation ($r = 0.614$, $P < 0.000$) observed between the load cell dynamometer and the isokinetic assessment at 60°/second. **Conclusions:** This study demonstrated the LCD had a moderate to strong correlation to the isokinetic strength assessment. These results indicate the load cell dynamometer as an acceptable alternative to isokinetic strength assessment for the quadriceps musculature. Clinicians may be able to use the load cell dynamometer as a less expensive measure of quadriceps strength in their patient populations.

Awareness of Post-Traumatic Osteoarthritis in Certified Athletic Trainers: Influence of Experience and Previous Injury

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Context: Roughly half of all severe knee injuries progress to post-traumatic osteoarthritis (PTOA) within 12 years among young, physically active individuals. PTOA is characterized by a rapid onset of cartilage degeneration and early disability. Preventing PTOA requires early intervention following injury. While athletic trainers (ATs) are optimally positioned to treat and prevent PTOA, their current awareness of PTOA is unclear. **Objective:** To determine 1) if ATs can correctly define osteoarthritis and 2) the percentage of ATs who are aware of PTOA. We also assessed how years of ATC experience and personal history of anterior cruciate ligament (ACL) injury, meniscus injury, or arthritis diagnosis affect PTOA awareness. **Design:** Cross-sectional. **Setting:** Web-based population survey. **Patients or Other Participants:** 437 of 2,000 (22%) ATs responded to the survey (40% male, 45% female, 15% missing; 38% = 1-10, 26% = 11-20, 21% = >20 years ATC experience, 15% = missing). **Interventions:** The Knowledge and Perceptions of Knee Osteoarthritis Survey (KPOA) was administered to 2,000 randomly sampled ATs from all National Athletic Trainers' Association districts. **Main Outcome Measures:** ATs were asked to identify the definition of osteoarthritis out of seven possible choices (included distractor definitions for osteoporosis, sarcopenia, and rheumatoid arthritis). Participants were also asked if they were "aware of the condition of PTOA" and if they had a history of ACL injury, meniscus injury, or arthritis. Chi-square analyses ($\alpha \leq 0.05$)

were used to determine the interactions among injury/arthritis history, years of ATC experience, and PTOA awareness. **Results:** Of the 437 respondents, 85% chose the correct definition of osteoarthritis. There were 361 ATs (18%) who responded to the awareness of PTOA question, 60% of whom indicated they were aware of PTOA. Futhermore,17%, 30%, and 26% of respondents reported a history of ACL injury, meniscal injury, or arthritis, respectively. Awareness of PTOA did not differ between ATs who sustained ACL (62% vs. 60%, $\chi 2 = 0.082$, $P = 0.78$) or meniscal (66% vs. 58%, $\chi 2 = 1.66$, $P = 0.20$) injuries compared to ATs without these injuries. However, a higher percentage of ATs diagnosed with arthritis were aware of PTOA compared to those without arthritis (71% vs. 57%, $\chi 2 = 5.25$, $P = 0.02$). ATs with >20 years of experience displayed the highest awareness of PTOA (74%) while ATs with 1-5 years of experience (53%) displayed the lowest awareness ($\chi 2 = 13.571$, $P = 0.009$). **Conclusions:** While most ATs recognize osteoarthritis, only 60% are aware of the PTOA phenotype. ATs with more experience are more likely to be aware of PTOA than less experienced ATs. While a diagnosis of arthritis increases PTOA awareness, a history of ACL or meniscal injury does not. Given the critical role of ATs in treating and prevention PTOA, enhanced efforts are necessary to improve formal AT education with respect to PTOA to improve patient care and long term musculoskeletal outcomes.

Perception of Knee Osteoarthritis as a Major Health Concern Among Certified Athletic Trainers: Implications for Education and Treatment of Knee Injury

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Context: Knee osteoarthritis (KOA) is one of the five leading causes of disability in the United States. Although KOA is typically diagnosed at a median age of 55, younger people who sustain a traumatic knee injury are at high risk for developing KOA earlier in life. The KOA disease process likely begins early following acute injury and remains undetected until KOA has progressed to cause structural joint changes. Athletic Trainers (ATs) are healthcare professionals well-positioned to implement early treatments and educate patients about KOA risk following injury. As ATs seek to improve clinical methods to enhance long-term patient outcomes, it is fundamental to understand AT perceptions of KOA including current practices aimed at KOA prevention. **Objective:** To determine if ATs perceive KOA as a major health concern and how their perceptions of KOA may be associated with patient education and treatment following knee injury. **Design:** Cross-sectional. **Setting:** Web-based population survey. **Patients or Other Participants:** In total, 437 out of 2000 (21.9%) ATs responded to the survey (40.5% male, 44.6% female; years AT experience: 37.6% = 1-10, 16.6% = 11-15, 20.6% = >20, 37.4 ± 10.2 years old; 15.3% = did not indicate demographics). **Interventions:** A customized survey, entitled The Knowledge and Perceptions of Knee Osteoarthritis Survey (KPOA), was administered to 2000 randomly sampled ATs from all National Athletic Trainers' Association districts. **Main Outcome Measures:** ATs' responses of whether KOA is a major health problem were categorized into "overall agree" vs. "overall disagree." ATs were asked (yes/no): 1) if it was 'appropriate' to explain risk of KOA to patients with knee injuries, 2) if they explain the risk of KOA to patients following ACL or meniscus injury, and 3) if they provide strategies to decrease future risk of KOA. Frequencies and Chi-square tests ($\alpha \leq 0.05$) were performed to determine interactions in perceptions of KOA as a major health concern and questions 1-3. **Results:** Overall, 61.2% of ATs agreed and 37.1% disagreed (1.6% did not know) that KOA was a major health concern. The perception of KOA as a major health concern (agree vs disagree) did not influence the percentage of ATs indicating that they: 1) thought it was appropriate to explain KOA risk (98.1% vs 95.1% $\chi 2 = 3.11$, $P = 0.08$), 2) explained the risk of KOA following ACL (72.6% vs 69.3% $\chi 2 = 0.472$, $P = 0.49$), or meniscus injury (78.8% vs 85.4% $\chi 2 = 2.57$, $P = 0.13$), and 3) provided strategies to decrease risk of KOA post injury (70% vs 74.1% $\chi 2 = 0.753$, $P = 0.39$). **Conclusions:** ATs' perceptions of KOA as a major health concern did not influence clinical education/treatment strategies to decrease KOA risk. A large proportion of ATs are not providing education (~15-30%) or treatment strategies (~26-30%) to decrease KOA risk following knee injury. It is important to educate ATs about the impact of KOA and ways to prevent KOA development in patients.

The Anterolateral Ligament in 41 Paired Human Cadavers

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Context: The anterolateral ligament of the knee has recently received significant attention in anatomical studies. The anterolateral ligament has been identified in up to 97% of unpaired cadaveric knees. This ligament is believed to assist in limiting excessive internal rotation of the knee, which could make it an important accessory stabilizer. Segund fractures, an avulsion of the distal anterolateral ligament insertion, has been implicated in 75% of anterior cruciate ligament ruptures. However, the anterolateral ligament has not been identified in bilateral knees. **Objective:** To identify the anterolateral ligament in the paired knees of cadavers. **Design:** A descriptive study design was used. **Setting:** Medical School Cadaver Laboratory. **Patients or Other Participants:** Forty-one paired knees (female = 13, mean age = 80.9 years; male = 28, mean age = 77.3 years) were dissected to confirm the presence of the anterolateral ligament and its proximal and distal attachments. **Interventions:** The origin of the anterolateral ligament was identified by gross dissection in 41 knees bilaterally. The approach of each dissection was to visualize the anterolateral ligament attachment sites from the anteromedial lip of the lateral femoral epicondyle proximally to the anterolateral aspect of the tibial condyle distally. The anterolateral ligament demonstrated an oblique, anteroinferior course from the femoral site just proximal to the popliteal tendon to the anterolateral aspect of the proximal tibia, superior to a horizontal line connecting the fibular head and Gerdy's tubercle. The anterolateral ligament was shown to insert with the coronary ligament and the tibiofemoral joint capsule to the anterior horn of the lateral meniscus and enveloped the inferior lateral geniculate artery. Its attachment on the anterolateral tibia was found to be distinct from the iliotibial band. **Main Outcome Measures:** The presence or absence of the anterolateral ligament was determined in paired cadavers. Once identified, the knee was internally rotated at 0° and 90° of knee flexion to confirm the integrity of the ALL. **Results:** The anterolateral ligament was identified in 81 of 82 (97.561%) of knees and was present bilaterally in each of the 13 female specimens (26 knees) and in all but one knee of the male cadavers (55/56) or 98.2%. **Conclusions:** Our data confirm that the anterolateral ligament is a distinct capsiloligamentous band prevalent in the majority of human knees. The anterolateral ligament insertion may be linked to Segund fractures, commonly associated with anterior cruciate ligament rupture. This anterolateral ligament should not be overlooked in the physical examination and diagnosis of rotary instabilities of the knee and is worthy of further biomechanical study.

Deactivation Strategies for Knee Joint Compliance Differs Among Athletes With Varying Conditioning Histories

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Context: Maintaining functional joint performance and stability is dependent on the ability to appropriately regulate stiffness, while preparing and reacting to joint loads. Anecdotal evidence suggests controlled columnar buckling, through reactive inhibition of muscles, may be an effective strategy for dissipating forces in the sagittal plane and preventing injury. However, it is unclear whether rehabilitation or conditioning techniques might alter an individual's neuromuscular strategy through their ability to reactively inhibit their musculature. **Objective:** To assess the effect of conditioning history on the ability to reactively inhibit the knee musculature during a knee perturbation. **Design:** Case control. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Forty-two male collegiate athletes (20.1 ± 1.3 yrs, 73.0 ± 12.0 kg, 176.4 ± 6.2 cm) with no history of knee injury volunteered for this study. Subjects included endurance athletes (END, 15 cross-country runners), power-trained athletes (PWR, 12 sprinters), and 15 recreational athletes (CON). **Interventions:** Subjects were tested on a customized stiffness assessment device that generated a rapid 40° flexion perturbation to the knee. Subjects were asked to pre-contract to 85% maximum voluntary contraction (MVC) and reactively inhibit and relax in response to a sudden perturbation. Knee position and torque were synchronized with EMG from the vastus medialis (VM), vastus lateralis (VL), medial hamstrings (MH), and lateral hamstrings (LH) at 2400 Hz. **Main Outcome Measures:** Short-range (0-4°) and total (0-40°) knee stiffness (Nm/deg/kg) was calculated as the change in torque over change in position (Δtorque/Δposition). EMG

activation was quantified as the normalized peak (%MVC), time-to-peak (ms), and area under the curve (%ms) prior to (PRE, -250 to 0ms) and following the perturbation (POST-1, 0-250ms; POST-2, 250-500ms). Differences between groups and muscles for stiffness and EMG were assessed using factorial analyses of variance. **Results:** No between-group differences were detected for knee stiffness, peak, or time-to-peak EMG. A significant muscle by group interaction effect was observed for EMG area ($F_{6,117} = 2.862$, $p = 0.012$).The END group had greater VL activation than PWR throughout all time periods (PRE 8.49 ± 2.25 %ms, POST-1 12.2 ± 4.82 %ms, POST-2 5.00 ± 3.39 %ms, $p = 0.040$). Furthermore, the CON group had increased LH activity compared to MH ($p < 0.001$). **Conclusions:** Despite no group differences in knee joint compliance, END athletes were less effective at deactivating VL activity than PWR. These results suggest that power athletes might be best at dissipating loads through a strategy of compliance; although this is unclear as all groups displayed equal stiffness values. Future research should investigate if power-based conditioning & rehabilitation protocols may be suitable for preventing knee injuries.

Osteoclastoma in a Female Collegiate Cross Country Runner

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Background: A 22 yr. old varsity female cross–country runner complained of anterior knee pain consistent with patellofemoral syndrome (PFS). The pain began 4 months earlier and was diagnosed by an orthopedic surgeon as PFS and was referred for therapy. She completed 2 months of therapy at a physical therapy clinic during her summer vacation. Discharge notes recorded a mild loss of strength in her R hip rotators (4+/5) and knee extensors (4+/5), but her prognosis was considered 'good'. After returning to campus, she reported to the athletic training room due to continuing pain and the inability to participate in running activities. Subsequent evaluation revealed mild anterior knee effusion, significant weakness (2/5) in her R quadriceps and a pain score of 6/10 at her anterior knee. Girth measurements of her affected leg revealed 5cm deficiency as compared bilaterally. The knee demonstrated excessive tibial ER with concurrent laxity of her posteromedial capsule. Her gait was assisted by her ability to project her right leg anteriorly with the knee flexed and pulling her R leg forward with the assistance of her knee flexors. Rehabilitation focused on correcting gait patterns, improving quadriceps function and reducing pain. Due to continued unexplained loss of muscle strength and significant pain following prolonged treatment, a decision was made to refer her to rule out underlying co-morbid issues if quadriceps function did not show improvement within 2 weeks. **Differential Diagnosis:** Arthrogenic quadricep inhibition, PFS, tumor, posteromedial capsule laxity **Treatment:** Although quadriceps function and gait improved, the patient was referred to university health services due to prolonged pain and continued concern for the prior unexplained loss of muscle function. She was referred for blood testing and a MRI. The blood testing demonstrated abnormalities with high levels of alkaline phosphatase, total bilirubin and direct bilirubin. High alkaline phosphatase levels can indicate bone disorders such as cancer while high bilirubin values often indicate a high rate of RBC destruction and turnover. The MRI revealed an aggressive 7cm inhomogeneous intramedullary lesion in her distal femoral metaphysis. Immediate referral was made to an orthopedic oncologist. Based on the MRI and follow-up x-rays, the condition was diagnosed as a giant cell bone tumor or osteoclastoma. She was immobilized, placed on crutches and scheduled for surgery. The patient requested that surgery be delayed to avoid missing classes, to which the physician agreed. A few weeks later, she experienced a femoral fracture through the tumor site following a fall. Four days later, the tumor was removed and bone grafting was used to replace the excised tumor. The fracture was reinforced with a metal plate. She was immobilized in extension and NWB for 8 weeks. Afterwards, rehabilitation began focusing on ROM and gradual strengthening. The fracture and graft healed and a return to running was considered. **Uniqueness:** Osteoclastomas account for less than 10 percent of all tumors but make up to 25 percent of all benign tumors. Osteoclastomas normally occur in the distal ends of long bones. The benign forms are the only bone tumor that is more common in females. Pain is the most common symptom, often due to the fracture of the affected bone. Other symptoms include local effusion and restricted ROM. **Conclusions:** PFS is a commonly diagnosed pathology while osteoclastomas are a rare condition. As part of the diagnostic process, clinicians need to consider the duration of patient symptoms and refer patients when therapy appears ineffective. Clinicians need to consider co-morbid pathologies and recognize potential symptoms and signs that may indicate non-orthopedic conditions.

Medial Patellofemoral Ligament Double Avulsion Repair in a Collegiate Football Player

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Background: An 18-year-old male collegiate football player with no previous medical history of knee injury suffered an acute left patellofemoral dislocation during preseason practice. After the patella was reduced by a physician, an initial examination identified point tenderness and lack of function of the left vastus medialis obliquus as well as medial instability of the patella. The preliminary diagnosis was a vastus medialis obliquus strain secondary to a patellofemoral dislocation. **Differential Diagnosis:** Possible diagnoses included vastus medialis obliquus strain/avulsion, femoral contusion, plica syndrome, patellofemoral dislocation/subluxation, ACL sprain, and medial patellofemoral ligament sprain/avulsion. **Treatment:** An MRI revealed an avulsion of the left medial patellofemoral ligament at its insertion on the medial patella as well as significant lateral patellar tilt and chondromalacia of the left patella. Arthroscopic surgery was conducted to perform a lateral release as well as debridement of the medial and lateral gutters, suprapatellar pouch and articulating surface of the patella. An open repair was performed to repair the medial patellofemoral ligament. During the procedure, physicians discovered the medial patellofemoral ligament had also been avulsed from its femoral insertion. To correct the avulsions, the ligament was secured down to both attachment sites using anchors and sutures, and also removed two intraarticular loose bodies. The patient was initially placed in a knee immobilizer and used crutches for 6 weeks. The initial stage of rehabilitation consisted of 4 or more sessions per week focusing on decreasing pain and swelling while increasing strength and range of motion. Due to the medial patellofemoral ligament's integration into the fibers of the

vastus medialis obliquus, great caution was taken to initially regain knee flexion and quadriceps strength in order to maintain the integrity of the newly repaired ligament. The patient was limited to 45 degrees of knee flexion until week 4 and did not perform closed-chain quadriceps exercises such as leg press or squats until week 9. Patellofemoral joint mobilizations were used to help ensure proper patellofemoral tracking. Balance and proprioception exercises such as single leg stance were utilized to address any balance concerns. Currently, the patient is three months post-operation and has regained full ROM and most of his strength. The patient has recently progressed to jogging and will begin agility drills that focus on lateral movements at 4 months post-operation. Because the patient is missing the entire season, his progression has been intentionally slowed down to ensure proper healing of the ligament. The patient is on schedule to be cleared for full participation in time for spring practice. **Uniqueness:** The uniqueness of this case lies in the nature of the injury. Because the medial patellofemoral ligament has several attachment sites, it is possible for the ligament to avulse from one site and still hold enough force to cause a subsequent avulsion from another site. However, this injury is rare and not well documented in the literature. It is also important to note that this injury occurred during normal sport related drills. The avulsions were not a result of an unusual mechanism which makes the injury more unique. **Conclusions:** Patellofemoral dislocations are common in athletics, but the structural damage caused will vary from case to case. The medial patellofemoral ligament is commonly injured in patellofemoral dislocations. Because the medial patellofemoral ligament provides about 50% of medial stability to the patella, damage to this ligament will predispose an individual to subsequent patellofemoral dislocations. Although treatments of multiple avulsions of the medial patellofemoral ligament are not well documented in the literature, open repair of a singular avulsion of the same ligament has shown to be successful in preventing subsequent dislocations.

Open Partial Excision of the Proximal Patellar Tendon and Distal Patella in a Former Collegiate Soccer Player

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Background: A 30 year-old male presented with a 9 year history of anterior knee pain dating back to his time as a Division I soccer player. During this time, he was diagnosed with patellar tendinopathy and treated by his university's athletic training staff. Treatment included periods of rest and activity modification, instrument-assisted soft tissue mobilization (Graston technique), various modalities and extensive rehabilitation. Following his collegiate career, the patient continued to experience severe anterior knee pain which interrupted his ADLs and prevented him from being recreationally active. Due to his prolonged and worsening symptoms, he sought the advice of our athletic training staff. Upon examination, he presented with mild swelling at the patellar tendon and significant point tenderness at the inferior patellar pole and proximal patellar tendon. After discussion with the patient, he was referred to an orthopedic surgeon for further evaluation. **Differential Diagnosis:** Patellofemoral pain syndrome, patellar tendinopathy, osteochondral defect, meniscus tear. **Treatment:** The physician's examination confirmed the presence of patellar tendinopathy, with no other pathology suspected. X-rays were negative for bony abnormalities. The physician presented surgical and conservative treatment options, and the patient decided to proceed with surgery. He underwent a diagnostic arthroscopy and no ligamentous injury, meniscal injury, or articular defects were detected. The scope was then removed and an incision approximately 2 inches in length was centered at the inferior pole of the patella and extended distally until the patellar tendon was exposed. A 7x8mm bone block was excised from the inferior pole of the patella along with the corresponding 1cm of the proximal patellar tendon. According to operative notes, this section of the tendon was observed to be "slightly avascular and degenerative," and also corresponded with the patient's most painful area. Following closure and dressing of surgical site, compression hose and a knee immobilizer were applied. Patient was released to go home the same day as surgery and permitted to weight bear as tolerated with crutches and knee immobilizer. At his 2-day follow-up with the physician, he was instructed in a home exercise program consisting of basic ROM and strengthening exercises. The following week, he began formal rehabilitation which followed the physician's ACL reconstruction rehabilitation protocol. He met weekly with the athletic training staff and was also highly compliant with his home exercise program, performing it up to 4 times per day. He was cleared to begin a walk-run progression at 5 months post-operative, and at 11 months post-operative, is recreationally active with no pain or functional limitations. **Uniqueness:** Most tendinopathies will resolve over time with rest and a combination of the treatments described above. The uniqueness of this case lies in patient's prolonged symptoms and the physician's recommendation for operative management. Due to the rareness of the surgery, very little is known regarding appropriate post-operative rehabilitation and subsequent timeline for return to athletic activity. In this case, the physician recommended that the patient follow his ACL reconstruction rehabilitation protocol, with the exception of waiting until month 5 to begin a running progression. This was done in order to minimize the potential for reoccurrence of symptoms. **Conclusions:** While patellar tendinopathy is a common condition in active populations, the duration and progression of this patient's symptoms are not. For cases that do not resolve with extensive conservative management, surgical excision of the involved tissues may be an option. Additionally, a post-operative rehabilitation protocol similar to that used after ACL reconstruction may be appropriate. This patient's compliance played a large role in his successful outcome. Clinicians should be aware of this procedure and recognize its potential for success in motivated patients.

Patella Ossification Avulsion Fracture in a Division I Women's Basketball Athlete

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Background: Twenty-one year old women's basketball athlete attempted a layup on the baseline during the second half of the conference semifinal. She landed on a flexed right knee, with weight distributed posteriorly to her foot, causing her knee to buckle. Initial evaluation revealed that her patella was shifted superiorly, with significant swelling medial, lateral and distal to the patella. The athlete was point tender along the inferior angle of the patella and the patellar tendon. Range of motion testing yielded limited knee flexion due to extreme pain. Special Tests performed revealed (-) Lachman's, (-) Valgus/Varus, (-) Mcmurray's, (+) Patellar Glide for pain and hypermobility, (+) Patellar Tilt for pain and hypermobility. The patient has a history of a left ACL reconstruction approximately one year prior. **Differential Diagnosis:** Patellar tendon rupture, patella dislocation. **Treatment:** Radiograph and MRI revealed an avulsion fracture of an unknown preexisting ossification on the inferior angle of the right patella. Surgical repair was performed to approximate the patellar tendon to the patella. The athlete was non weight bearing with crutches and a knee immobilizer in extension. The first 4 weeks of rehabilitation focused on regaining range of motion with heel slides and wall slides. Strengthening exercises were initiated to minimize atrophy with quad sets, heel digs, and with Russian electrical stimulation. Patient was progressed to AROM and 4-way straight leg raises by week 4. Passive knee flexion exercises, in a brace, and minimal resistance bike began week 6. By week 12, the patient was at full ROM and had restored gait mechanics; patient was also progressed to jogging. Cardio conditioning and strength and agility programs were also implemented at this time. Quadriceps strengthening and closed-kinetic chain exercises were began at week 12 onwards until the patient was cleared to participate in team offseason activities after week 20. **Uniqueness:** The combination of two separate injuries/conditions in a 21 year old athlete is unique as patella tendon ruptures are common in people over the age of 50. What compounds the uniqueness is the etiology of the patella tendon rupture. The athletes' aggressive rehabilitation of her left ACL reconstruction a year prior may have caused her to compensate with her right leg. This could have stimulated the growth of an ossification, due to Wolff's law, where the tendon attaches at the inferior angle of the right patella. When she landed on her right leg after her layup, landing with a flexed knee and her weight shifted posteriorly a strong eccentric contraction of the quadriceps was induced. This contraction produced enough force to cause an avulsion fracture of the ossification off of the patella's inferior pole. **Conclusions:** Athletic trainers should be aware of compensatory motions associated with injuries resulting in altered weight bearing and subsequently gait. These compensations may lead to structural deformations putting the athlete at risk for other injuries. Despite the severity of the injury, he athlete was able to return to participation within 7 months of the initial injury. Relevant Evidence: No relevant evidence.

Atypical Hyaline Cartilage Neoplasm in an Adolescent Basketball Athlete

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Background: Athlete is a 12 year-old male junior high basketball player. The athlete presented to the Athletic Trainer (AT) in February with lateral ankle pain. He was referred for further medical evaluation and was diagnosed with a left fibular growth plate injury. Athlete was in a cast and boot for approximately 12 weeks. During rehabilitation, athlete complained of significant hamstring tightness with increasing patella pain and antalgic gait. After consulting with the athlete's parents, he was referred for x-ray which indicated 4mm calcification near the intercondylar notch. A follow up MRI showed a 3.2 cm solid enhancing mass located in the proximal tibial metaphysis. A CT scan was then ordered which confirmed the diagnosis of a lytic lesion with chondroid matrix in the proximal tibia. **Differential Diagnosis:** Bone fragment, Chondroblastoma, Enchondroma Protuberans, Clear Cell Sarcoma, Infection **Treatment:** The athlete was scheduled for surgery to excise the mass approximately 2 months after initial symptoms were reported. The mass was 3.2 cm in diameter however a 5 x 3 x 3 cm piece of bone tissue was removed during surgery. The mass was sent for further evaluation. The pathology report indicated an atypical hyaline cartilage neoplasm. It was noted on the report that the tumor appeared to be entrapping host bone which caused concern about the histological features of the tibia. Athlete was non-weight bearing for six weeks and then progressed to limited walking with a brace for six more weeks. Athlete began physical therapy which consisted of range of motion and strengthening exercises. The athlete was permitted to begin weight bearing activities 6 weeks post-surgery and was allowed to swim for cardiovascular exercise. The athlete was released to resume running and normal activities

12 weeks after surgery. A full body scan will be conducted 3 months post return to play. **Uniqueness:** Low grade benign cartilaginous neoplasms are typically asymptomatic and treatment is generally observation only. Diagnosis can be difficult with these lesions when compared to the apparent clinical, radiographic, and pathological findings of high grade lesions. These types of low grade lesions may be seen in all age groups but incidence peaks in patients in their 20s. The case was unrelated to the initial injury however given the circumstances involved with rehabilitation, the symptoms indicated a need for further evaluation. The involved physicians described the case as extremely challenging and unique due to the atypical histologic and radiographic features. More importantly, the athlete could be at risk for local recurrence. Of note, the athlete was previously treated for an osteochondroma of the right wrist two years prior. **Conclusions:** This case highlights the treatment of an atypical hyaline cartilage neoplasm. The athlete has returned to full activity with no complications aside from general soreness due to the increased activity following months of inactivity. Furthermore, this case highlights the importance of follow up care for unrelated symptoms during the AT's initial injury evaluation and treatment. It also demonstrates the importance of the use of a variety of diagnostic imaging, but ATs need to continue to conduct a thorough clinical examination based on the patient's signs and symptoms.

Bilateral Popliteal Artery Entrapment Syndrome Versus Compartment Syndrome in a Female Collegiate Distance Runner: A Case Report

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Background: A 20 year old female collegiate distance runner underwent a right-sided fasciotmy for presumed compartment syndrome without any improvement. Almost two years post fasciotmy, the patient continued to report tightness, pain, and swelling in her calves and feet when running long distances and up hills. This prevented her from competition and adequate conditioning. She was referred to a vascular specialist due to ongoing pain. Bilateral popliteal artery entrapment syndrome was identified. The surgeon believed that she never had compartment syndrome. **Differential Diagnosis:** Compartment syndrome, popliteal artery entrapment syndrome, popliteal artery aneurysm, popliteal artery cystic adventitial disease, deep venous thrombosis, stress fracture, vascular syndromes, **Treatment:** MRI was completed and normal but given her symptoms she underwent a dynamic angiogram for verification and diagnosis of bilateral popliteal artery entrapment syndrome. It was determined that she had complete occlusion of the left popliteal artery and almost complete occlusion on the right side with provocative maneuvers during angiography. The patient underwent bilateral decompression surgery. The fascia was excised and the heads of the gastrocnemius muscles were divided with electrocautery. Bilateral popliteal arteries were mobilized during the procedure. Due to the difficulty of tissue healing in this area she underwent a second surgery 3 months later for bilateral hypertrophic scarring and eschar. A bilateral popliteal scar release was performed with local tissue rearrangement. **Uniqueness:** The true incident of popliteal artery entrapment syndrome is still unknown. Popliteal artery entrapment syndrome can result in limb-threatening ischemia and claudication in young adults. Having a greater awareness of this as a possible diagnosis can improve clinical assessment and diagnosis. In addition, rehabilitation precautions post operatively can be difficult due to location of scarring and added care should be taken. **Conclusions:** Compartment syndrome in distance athletes is widely diagnosed and often without complete resolution of symptoms even years later. Popliteal artery entrapment syndrome occurs from compression or occlusion of the popliteal artery due to an abnormal relationship with the heads of the gastrocnemius or less commonly with the popliteus muscle. Increasing the awareness of popliteal artery entrapment syndrome is increasing its frequency of diagnosis. Medical professionals should be encouraged to explore differential diagnoses and vascular integrity based on clinical findings when additional arterial damage is indicated.

Average Swing Volume During Practice and Competition in Collegiate Volleyball Athletes

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Context: Volleyball is one of the fastest growing sports worldwide. Previous medical literature has documented that shoulder injuries are common. The repetitive overhead swinging motion performed when attacking and serving the ball may result in overuse injuries. In baseball, the volume of pitches is monitored as there is a positive relationship with upper extremity injuries. Limited information exists on the number of overhead swings that occur during volleyball practices and games. **Objective:** This study recorded the number of overhead volleyball swings that occur during practice and compared it to games volumes in female collegiate athletes to provide typical values during both events and to assist in designing return to sport programs. **Design:** Cross-sectional **Setting:** Gymnasium **Patients or Other Participants:** Data was collected from 14 women Division I collegiate volleyball athletes during practice and games (Age = 20 ± 1, Height = 1.8 ± 7.6 m, Mass = 74.6 ± 10.0 kg). All volunteers read and signed approved consent forms prior to data collection. **Interventions:** All athletes participated in normal practice and games at the direction of the coaching staff. Overhead swings were counted by visual observation and divided into serves and attacks for all 14 athletes. Serve was recorded when athlete attempted to start play by hitting the ball over the net from the end-line. An attack was recorded any other time an athlete was hit a ball with a forceful overhead motion. All activity was recorded using a standard video camera that was used to confirm visually observed counts and in place when a researcher could not be available during practice. **Main Outcome Measures:** Total swings equaled the number of attacks plus the number of serves that were recorded. Each of these three variables was the primary dependent measures. The independent measure was event either game or practice. The data were analyzed with three independent Mann-Whitney non-parametric tests as the data was not normally distributed with significance set at $P \leq 0.05$. **Results:** There were 473 athlete exposures recorded during practice and 168 athlete exposures were recorded during games. Total swings during practice (49 ± 35) was greater than during games (35 ± 24, $P < 0.001$). Serves during practice (24 ± 23) was greater than during games (10 ± 11, $P < 0.001$). Attacks during practice (25 ± 22) and games (25 ± 19) did not differ ($P = 0.93$). **Conclusions:** The total number of overhead swings as well as attacks and serves provides coaches and health care professionals with data to design return to volleyball programs based on both practice and game data. The data suggests that twice as many serves are occurring during practice compared to game which may place an athlete at risk for injury depending on their position and role on the team. The next step for this research would be to see if certain positions swing more than others.

Functional Motion Identification With a Novel Inertial Measurement Unit

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Context: Pitch count solely accounts for repetitions performed during competition. The value frequently underestimates total number of pitches thrown by an athlete over the duration of a season. It is impractical to record every throw during a practice, therefore a need exists for a device that can readily identify and quantify throwing motions from other activities. **Objective:** This study evaluated the accuracy of a device entitled the Shoulder Motion Acquisition, Recognition and Tracking Inertial Measurement Unit (SMART-IMU) in identifying and quantifying baseball throwing motions and volleyball serving motions. **Design:** Single blind cross sectional study. **Setting:** Clinical Laboratory. **Patients or Other Participants:** A convenience sample of 14 healthy individuals including nine males and five females (Height = 1.735 ± 0.115 m, Mass = 76.643 ± 14.286 kg, Age = 25.357 ± 7.448 years) without a history of shoulder surgery or shoulder pain volunteered and consented to participate. Nine subjects had participated or were currently participating in overhead throwing sports in high school or college. **Intervention:** The SMART-IMU was applied to each subject over the proximal deltoid tuberosity of the dominant arm. The device was fixated with a hook and loop elastic strap. Each subject performed eight repetitions of seven common shoulder exercises followed by sixteen overhead throws and sixteen volleyball serves into a net. The order of exercises was identical for all subjects. The 3 dimensional data of position, direction, and velocity from the SMART-IMU was used to create a pattern recognition classifier using MATLAB Software. Following

the initial data collection session, the same exercises and sport activities were performed in a random order with a random number of repetitions. The engineer creating the pattern recognition algorithm was blinded to the repetition count and order of activities during this session. The pattern recognition classifier was applied to the random portion of the data to determine accuracy of quantifying and differentiating baseball throws and volleyball serves from each other, and other exercises. **Main Outcome Measures:** The actual number of throws and serves recorded by the unblinded investigator from the random portion of the study were compared to the counts and types of motions identified by the SMART-IMU pattern recognition classifier. A simple three by three contingency table of throws, serves, and neither were identified to determine the accuracy. **Results:** The SMART-IMU correctly identified 88/108 throws, 84/97 hits for an overall accuracy of 83% from randomized data sessions. **Conclusions:** The SMART-IMU and associated algorithms were able to differentiate and quantify specific overhead motions with accuracy approaching that of walking pedometers. Further research in the field environment is needed.

Reliability of Isometric and Eccentric Isokinetic Shoulder External Rotation

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Context: Shoulder external rotators are challenged eccentrically throughout the deceleration phase of throwing which is thought to contribute to overuse injuries. In order to evaluate the effectiveness of intervention programs as well as identify deficits, reliable and responsive measures of isometric and eccentric shoulder external rotation are necessary. Previously isometric measures have only tested in a single position and eccentric measures have not been found to have high reliability. **Objective:** To examine the between day reliability of multiple-angle isometric and eccentric isokinetic testing of shoulder external rotation. **Design:** Repeated measures study design. **Setting:** Clinical laboratory. **Patients or Other Participants:** Convenience sample of 10 healthy subjects (age 30 ± 12 years, height: 166 ± 13 cm, mass: 72 ± 10 kg) volunteered and consent for this study. **Interventions:** Each subject was tested on two occasions one week apart on an isokinetic dynamometer (Cybex Norm). The subject was seated and the shoulder was positioned with the arm abducted to 60° in the scapular plane. Measurements for isometric external rotation (ER) strength were taken at seven angles throughout the range of motion for shoulder external rotation (ER 45°, ER 30°, ER 15°, 0°, IR 15°, IR 30°, IR 45°). Dynamic eccentric shoulder strength was measured isokinetically at 60°/sec over the same 100° arc from 50° of external rotation to 50° of internal rotation for 6 repetitions. **Main Outcome Measures:** Average isometric peak torque of shoulder external rotation at 7 angles was measured. The average total work and peak torque of dynamic eccentric shoulder external rotation were also measured. Work was defined as the area under the curve and calculated as the average angular impulse (Nm*s) using the trapezoidal method in Microsoft Excel. Intraclass correlation coefficients (ICC) and standard error of measurements (SEM) were determined for each outcome measure using a two-way random model in SPSS version 18. **Results:** Between day reliability for isometric shoulder external rotation at each angle produced all ICC's $\geq$ 0.90 with a SEM $\leq$ 2.5 Nm. Dynamic eccentric shoulder external rotation total work produced an ICC $\geq$ 0.97 SEM $\leq$ 2.0 Nm*s as peak torque produced ICC $\geq$ 0.97 and a SEM $\leq$ 1.3 Nm. **Conclusions:** Isometric shoulder external rotation at multiple angles and dynamic eccentric peak torque and total work with arm at 60° abduction can be reliably measured in healthy subjects. The testing position of 60° of abduction may not place the arm in a functional overhead position but provides a reliable and perhaps safer environment for testing. The low standard error of measure suggests this measurement approach will be responsive to intervention studies in the future and would provide a responsive measure to detect minimal shoulder external rotation deficits throughout a wide arc of shoulder motion.

Frequency of Acute and Overuse Hip Injuries in the High School Athlete

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Context: With the participation of young adults in high school sports on the rise, so are the occurrence of acute and overuse hip injuries. The hip is involved in lower-extremity movements that include walking, running, jumping, and standing. As athletic trainers learn more about the hip and common injuries that can affect this joint, it will be easier to make an accurate assessment of the problem. There is little to no information available for athletic trainers to refer to on the occurrence of acute and overuse hip injuries in high school sports and the sports these injuries are most likely to occur. Research on hip injuries in the high school athlete should help athletic trainers be aware of what to look for during their examination and decrease the chance of a misdiagnosis. This will enable proper treatment of the athlete and provide quality patient care. **Objective:** To identify the frequency of acute and overuse hip injuries and the sports in which these hip injuries are most prevalent. **Design:** Descriptive epidemiology study. **Main Outcome Measures:** Using an Internet-based data-collection tool, Reporting Information Online (RIO), certified athletic trainers from 100 nationally representative US high schools reported athlete-exposure and injury data for athletes from 20 sports during the 2005/06–2011/12 academic years. The outcome of interest in this study was hip injuries. **Results:** From 2005/06 to 2011/12, certified athletic trainers reported 1,246 hip injuries. Acute hip injuries were found to occur more than overuse hip injuries. Acute injuries occurred more in high school males at 96.4% compared to high school girls' at 88.5%. Overuse hip injuries occurred in high school males at 17% compared to high school girls' at 18%. The most commonly occurring acute hip injury was muscle strain (59%), followed by hip contusions, also known as a hip pointer (19.4%). The most common overuse hip injury was bursitis (1.7%), followed by stress fractures (.2%). Football was found to produce the most hip injuries at 40.7%, followed by soccer at 19.2% and track and field at 13%. **Conclusions:** Athletic trainers can teach athletes practices to protect themselves in situations where hip injuries occur the most. This should be done by educating the athlete on ways to properly prevent or manage the injuries that might occur. Athletic trainers should emphasize the importance of a proper warm-up to high school athletes, coaches, and parents. Decreasing these hip injuries at an early age could help reduce the chances of chronic hip injuries in the future.

Limb Symmetry Differences Between Gender and Grade Level in High School Athletes: The FPPE Project

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Context: Recent evidence suggests functional performance differences exist between genders and across grade levels in healthy high school athletes. However, it is unknown if limb symmetry differences accompany these performance changes. **Objective:** To compare lower extremity functional performance limb symmetry between genders and across grade levels in healthy high school athletes for further establishment of functional physical evaluation baseline data. **Design:** Cross-sectional study. **Setting:** High school athletic training facilities. **Patients or Other Participants:** 707 female high school soccer, basketball and lacrosse athletes (15.5±1.2 years, 1.66±0.08 m, 60.8±9.8 kg) and 1,019 male high school football, soccer, basketball and lacrosse athletes (15.9±1.3 years, 1.78±0.09 m, 74.6±15.8 kg). **Interventions:** A functional performance assessment was completed prior to the start of the respective seasons consisting of a single leg anterior reach (SLAR) and an anterior single leg hop for distance (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. For each test, three trials were performed per limb and an average reach and hop distance was calculated for each limb. Distances were normalized to leg length (measured from ASIS to medial malleolus) and hop limb symmetry index (LSI) values were calculated as the ratio of

the lower average distance to the higher average distance. Based on previous literature, symmetric athletes were defined as having an LSI value greater than 85% for the SLHOP and less than a 4 cm difference between limbs for the SLAR. **Main Outcome Measures:** A chi-square between gender and symmetry category (symmetric/asymmetric) and layered by grade level was completed to examine the effect of gender and grade level on presence of SLAR and SLHOP symmetry. **Results**: There was a significant effect for gender for SLAR symmetry ($p<.001$), with 19.4% (range: 16.4%-21.1%) of the females and 30.1% (range: 17.7%-33.1%) of the males presenting with asymmetry. Grade level had no significant impact on SLAR symmetry. There were no statistically significant differences in SLHOP ($p=.063$) LSI between genders or across grade levels. Regardless of grade or gender, 5.9% (range: 3.3%-6.9%) of the high school sample presented with a SLHOP asymmetry. **Conclusions:** These results indicate that a level of hop and reach limb asymmetry exist in a normal high school population. While functional performance (SLHOP or SLAR distance) may change with gender and grade, only SLAR asymmetry was affected by these factors.

Characteristics of Secondary School Athletic Trainers: Salary and Job Satisfaction

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Context: Approximately 55% of secondary schools employ a full-time Athletic Trainer (AT), and with almost 7 million high school athletes participating in sport, a substantial number do not have access to healthcare. However, it is unclear what may deter ATs from selecting employment in this setting. **Objective:** To observe salary and job satisfaction characteristics of secondary school ATs. **Design:** Cross-sectional design. **Setting:** Web-based survey. **Patients or Other Participants:** We recruited participants from Facebook® (4 posts) and Twitter® (60 tweets). Sixty-eight percent of participants completed the survey (256/374, 68%). Participants were predominantly women (n = 201/340, 59.1%; men = 139/340 40.9%) and Caucasian (n = 317/344, 92.2%), were mid to early career (age = 31.9 ± 8.3 y; years of experience = 9.3 ± 7.9 y), earned a Masters degree (n = 205/338, 60.7%; Bachelors = 133/338,39.3%), did not have teaching responsibilities (n = 247/333, 74.2%), and worked an average work week (45.8 ± 18.0 h/wk). **Interventions:** No interventions. **Main Outcome Measure:** We utilized the Employee Job Satisfaction and Engagement instrument from the Society of Human Resources (26 items; 1=very dissatisfied, 5=very dissatisfied). Because we violated both assumptions of normality and heterogeneity, we analyzed the data using non-parametric statistics (separate Kruskal-Wallis one-way analyses of variance and Mann-Whitney U independent samples t-tests). We used multiple linear regression to evaluate the predictive relationship of hours worked per week and salary on overall job satisfaction. Partial data were included for all comparisons. **Results:** We identified significant differences between degree levels on salary ($df = 1$, $\chi2 = 20.580$, $p < 0.001$), whereby those with a masters ($48,271 ± 17,027) earn significantly more than those with a bachelors ($39,263 ± 17,121). We identified significant differences between years of experience on salary ($df = 4$, $\chi2 = 130.231$, $p < 0.001$) with significant differences ($p < 0.001$) between each level of professional progression (0-2 y = $27,481 ± 1,544; 3-8 y = $41,287 ± 1,015; 9-14 y = $50,115 ± 1,711; 15-20 y = $59,946 ± 3,661; >20 y = $60,727 ± 2,979) except between 15-20 y and >20 y. We identified significant differences ($df = 1$, $\chi2 = 35.615$, $p < 0.001$) between the salaries of those who teach ($54,458 ± 2,109) and those who don't ($41,421 ± 1,023). ATs hired by the different agencies resulted in significantly different ($df = 5$, $\chi2 = 67.198$, $p < 0.001$) salaries. ATs hired directly by the school or school district ($55,005 ± 1,665) earn significantly ($p < 0.001$) more than those hired by hospitals (100% at school = $39,206 ± 1,351, part-time at school=$38,620 ± 3,230), clinics (100% at school = $39,744 ± 1,581; part-time at school = $41,750 ± 2,655), or other entities ($37,550 ± 7,285). We did not find any significant differences among salary categories ($df = 3$, $\chi2 = 5.907$, $p = 0.116$), teaching responsibilities ($df = 1$, $\chi2 = 0.001$, $p = 0.999$), or hours worked per week ($df = 5$, $\chi2 = 7.893$, $p = 0.162$) on overall job satisfaction. However, participants demonstrated overall satisfaction with employment (3.7 ± 0.7). We were unable to develop a predictive model ($F2,238 = 2.429$, $p = 0.09$, $R2 = 0.02$), as hours worked per week and salary accounted for only 2% of the variance in job satisfaction. **Conclusions:** Salary of secondary school ATs are dependent upon education, teaching responsibilities, hiring agency and years of experience. Overall job satisfaction was surprisingly not affected by these characteristics and moreover a predictive relationship was not identified.

Longitudinal Changes in Lower Extremity Strength and Range of Motion in Female Youth Soccer Players

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Context: Risk of knee injuries in young female athletes increases with age, appearing to peak during maturation. Changes in hip muscle strength and flexibility during this time have been suggested to contribute to altered dynamic movement patterns that are known to increase risk of knee injuries. Understanding the longitudinal changes in lower extremity strength and flexibility in female youth athletes is needed in order to develop appropriate interventions to reduce the risk of knee injuries. **Objective:** To examine the longitudinal changes in hip strength and range of motion (ROM) in female youth soccer players. **Design:** Longitudinal descriptive study. **Setting:** Field setting. **Patients or Other Participants:** Fourteen female adolescent athletes (14.1 ± 1.1 yrs, 165.8 ± 5.3 cm, 57.5 ± 9.9 kg) volunteered as part of a multi-year risk factor screening project. **Interventions:** Clinical measures of hip strength and ROM were collected annually over three consecutive years. Passive hip internal rotation (IR), external rotation (ER), abduction (ABD), and adduction (ADD) ROM were measured with a digital inclinometer during three trials. Isometric hip IR, ER, ABD, and extension (EXT; knee flexed and extended) strength was evaluated using a hand-held dynamometer during two trials of a 5 second hold. **Main Outcome Measures:** Hip strength was normalized to body weight (%BW) while ROM was recorded to the nearest degree. Separate repeated measures ANOVAs compared hip strength and ROM values across 3 consecutive years ($P < 0.05$). **Results:** Differences in hip ROM were found across the three consecutive years (1 vs. 2 vs. 3) for hip ABD (47.6 ± 8.7° vs. 65.2 ± 10.3° vs. 59.9 ± 12.5°, $P < 0.001$), ADD (26.5 ± 5.5° vs. 23.7 ± 5.3° vs. 20.5 ± 6.9°, $P = 0.009$), IR (35.1 ± 9.7° vs. 38.4 ± 4.5° vs. 44.2 ± 8.5°, $P = 0.001$), and ER (28.0 ± 3.3° vs. 19.6 ± 6.2° vs. 18.7 ± 9.5°, $P < 0.001$). Differences in hip strength were only found for IR (0.16 ± 0.03% BW vs. 0.19 ± 0.03% BW vs. 0.20 ± 0.05% BW, $P = 0.002$) and ER (0.17 ± 0.03% BW vs. 0.20 ± 0.03% BW vs. 0.22 ± 0.04% BW, $P < 0.001$). **Conclusions:** As female youth athletes increase in age, there is an increase in hip IR ROM and ABD ROM with a concomitant decrease in hip ER ROM and ADD ROM. While there was an increase in the relative strength of hip IR and ER, the resulting asymmetries in hip ROM may influence the position of the femur during dynamic activity, decreasing the force producing capabilities of the hip IR and ER muscles. In addition, there was no difference in strength with the primary motions of the posterior-lateral hip muscles (EXT and ABD). Collectively, as female youth athletes mature, the observed changes in hip strength and ROM could negatively influence the neuromuscular control of the hip during dynamic activities, contributing to altered lower extremity mechanics known to increase the risk of knee injuries. Ongoing work includes examining how these changes influence lower extremity mechanics throughout stages of maturation.

Athletic Training Services in Private Secondary Schools

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Context: Athletic training (AT) services in secondary schools have recently been reported to be as high as 70%, but this only extends to the public sector. The extent of AT coverage, solely in the private secondary school setting, has yet to be investigated. This may differ from the public secondary school setting for several reasons, including differences in funding sources. **Objective:** Determine the scope of AT services in private secondary schools. **Design:** Concurrent mixed-methods. **Setting:** Private secondary schools in the United States. **Patients or Other Participants:** 2,045 private secondary schools responded to a survey, yielding representation from all 50 states and Washington DC. Contact information was gathered from the National Center for Education Statistics. **Intervention:** Athletic directors or principals responded to a survey via telephone or email. This instrument has been used previously in a study examining AT services among public secondary schools. Demographics of the schools were collected including number of student-athletes, sports offered, and geographical location. The survey was designed to assess if AT services were available, the level of AT service if it was provided, and in the absence of AT services, who provided care. The survey also evaluated barriers to providing full-time AT services at the secondary school level. **Main Outcome Measures:** Descriptive statistics depict national data. Open-ended questions were analyzed through content analysis. Themes selected were done so with more than 50% representation from respondents. **Results:** Out of all 5,414 private secondary schools in the United States, 2,045 responded to our survey, resulting in a 38% response rate. Of those 2,045 schools, 57% (1,169/2,045) of secondary schools have AT services,

while 84% (280,417/335,814) of all athletes have access to AT services. Out of all respondents, 28% (574/2,045) have full time, 24% (501/2,045) have part time, and 4% (78/2,045) have per diem AT services. 20% (409/2,045) of all respondents have AT services from a hospital or physical therapy clinic. Larger private secondary schools were more likely to have AT services. Barriers to providing AT services in the private sector include budgetary constraints, size of the school (small), coaches viewed as appropriate medical providers due to their first aid and/or CPR certification requirements, and a lack of need for those services as viewed by the administrator interviewed. **Conclusions:** More than half of the surveyed private secondary schools in the United States have some level of AT service; however, only 28% have a full time athletic trainer. This demonstrates a need for increased medical coverage in the private secondary school setting to provide athletes with safe playing environments and an appropriate level of care. Budgetary issues and misconceptions related to the importance of the athletic trainer continue to be barriers to hiring them in the secondary school setting.

Focal Dystonia Secondary to Trauma in an Adolescent Female Athlete

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Background: A 17-year old female high school athlete began experiencing right upper extremity tremors after voluntarily abducting the arm overhead during a field hockey practice. Her previous history included a cervical whiplash injury approximately one year prior and a right acromioclavicular sprain approximately eight months prior. Upon assessment, continued tremors of the trapezius, deltoids, biceps brachii, triceps brachii and forearm muscles were observed. The tremors were associated with generalized pain and a feeling of heaviness in the extremity, as well as nonspecific paresthesia in the forearm and hand. The patient was able to voluntarily move her shoulder, elbow and wrist through a full range of motion however this was done with some difficulty as the tremors continued. No other symptoms were noted and there was nothing else remarkable at that time. The symptoms continued for approximately one hour, at which time the athlete was referred to the emergency department for further evaluation. **Differential Diagnosis:** Spinal cord or brachial plexus neuropathy, focal seizure, carpal tunnel syndrome, complex regional pain syndrome, dyskinesia, Sydenham's chorea and ulegyria. **Treatment:** Upon arrival at the emergency department, the tremors subsided and eventually stopped without intervention. Nothing remarkable was noted upon assessment other than general arm soreness. The patient was diagnosed with a focal seizure and was administered analgesic medication and discharged. The patient continued to experience transient episodes of right upper extremity tremor with right hand paresthesia over the next few days making it difficult for her to hold a field hockey stick during practice and to hold a pencil during class. Therapeutic interventions such as cryotherapy, heat, stretching and massage provided inconsistent results, with symptoms improving on some occasions and worsening on others. The patient was then referred to an orthopedic physician for further assessment. Magnetic resonance imaging revealed a borderline type I Chiari malformation that was not considered pathological. Plain film radiographs, electroencephalography, electromyography and nerve conduction velocity tests were negative. The patient was diagnosed with cervical radiculopathy and was prescribed gabapentin, tizanidine, tramadol and tylenol for muscle relaxation and analgesia. However, she continued to experience transient episodes of tremor, pain and paresthesia from the shoulder to the hand and she was now able voluntarily provoke the symptoms by simply elevating her arm overhead. Once provoked, the symptoms would last approximately 30 minutes followed by a dead arm feeling lasting one to two days. The patient was then referred to a neurologist who diagnosed her with dystonia secondary to trauma following assessment and consultation. The patient began receiving botulinum toxin injections into the affected muscles which has provided symptomatic relief. **Uniqueness:** Dystonia is a unique neurological disorder resulting in sometimes painful abnormal postures, athetosis or tremor that can be initiated by voluntary movements. It results from an abnormality in or damage to the basal ganglia or other movement control regions such as the cerebellum. Secondary or acquired dystonia is the rarest form and refers to dystonia brought on by some identified cause, such as trauma. Our patient was diagnosed with secondary dystonia although she never experienced head trauma. Her neurologist believes that her dystonia was secondary to the cervical and shoulder injuries suffered previously. This is unique in that the trauma did not directly involve the brain and it occurred over six months prior to symptom onset. **Conclusions:** There are no clinical tests for dystonia. Diagnosis is made by ruling out all other potential causes. There is also no cure for dystonia. While not completely resolved, our patient continues to receive botulinum toxin injections which have provided minor symptomatic relief as she is now attempting to play collegiate softball.

Motivation and Perception of Sport Participation in Young Athletes and Their Parents

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Context: Many young athletes and their parents invest significant amounts of time and money in sport participation. Although there are several benefits to sport participation, athlete and parent goals are often unrealistic. **Objective:** The aim of this study is to identify motivation of sport participation and knowledge of statistical potential for collegiate and professional level play among young athletes and their parents. **Design:** Cross-sectional survey. **Setting:** Sports medicine clinic of a children's hospital and online. **Patients or Other Participants:** One hundred and sixty-five pairs of youth athletes (ages 12-18, 55.7% male) and one of their parents. **Interventions:** Paper-based and online surveys were distributed to athletes and a parent in a sports medicine clinic. Online surveys were administered using the Research Electronic Data Capture (REDCap) program. **Main Outcome Measures:** Sport participation data (sport played, number of years played, number of teams played for, etc.), and motivation for sport participation were recorded. Knowledge assessment of collegiate scholarships available and likelihood of attaining collegiate/professional status in their sport was also measured. Comparisons were made between the reports of the youth athletes and the \reports of their parent. **Results:** One hundred and sixty-five consecutive pairs of surveys were administered. Most athletes reported playing their sport to: "Have fun" (88%), "Get fit" (81%), "Win" (56%), "Play in college" (59%), and "Get college scholarship" (56%). Compared to their parents, athlete estimates of percentage of athletes that will play at the collegiate (28.1% vs. 13.6%) and professional levels (12% vs. 4%) and of collegiate athletic scholarships awarded (28.4% vs. 16.3%) in their sport were all significantly greater ($p < .001$). Both parent and athlete estimates were significantly greater than actual numbers ($p < .001$).**Conclusions:** Majority of young athletes play their sport for fun and exercise purposes. However, young athletes and their parents significantly overestimate the likelihood of playing at or beyond the collegiate level, as well as the likelihood of receiving an athletic scholarship in their sport. Unrealistic expectations of potential for future collegiate and professional play may be a strong motivator for sport participation among many young athletes. Increased sport participation and specialization among young athletes has likely led to an increase in traumatic and overuse injuries. Education and counseling from healthcare providers may help keep an athlete's career in perspective and encourage them to seek medical attention when injured as opposed to "playing at all costs" to maximize athletic potential.

Analysis of the Impact of Outreach of Athletic Trainers on Anterior Cruciate Ligament Surgical Referrals

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Context: The model of utilizing athletic trainers (ATs) to provide "outreach" coverage in the secondary school setting, while being hired and supported by an orthopaedic clinic, has become increasingly common. However, the effect of clinical outreach services on orthopeadic referrals has not been well investigated. **Objective:** The purpose of this study was to examine the number of ACL surgeries performed by a university-affiliated sports medicine practice between counties with schools served by an affiliated outreach AT and counties without affiliated outreach ATs. **Design:** Retrospective population-based data analysis and records review **Setting:** Southeastern Metropolitan area and surrounding rural counties **Patients or Other Participants:** Patients (ages 0-22) who had undergone an ACL revision/reconstruction at an instate medical center between 2009-2012 and resided within a 50-mile radius of the sports medicine practice. **Interventions:** Counties within a 50-mile radius of the practice were classified as having affiliated outreach ATs or not. Outpatient services data (CPT codes, patient age, and county of residence) were reviewed from the state Office of Health Policy, to identify the total number of ACL surgeries performed on residents in the specified counties (Population-level-data). Concurrently, a retrospective chart review of ACLs performed by members of the sports medicine practice was conducted to identify patients from the specified counties who had undergone an ACL surgery (Practice-level-data). **Main Outcome Measures:** For the sports medicine practice the ACL operation rate (ACLOR) for counties with affiliated outreach ATs and those without was calculated by normalizing the number of ACLs performed within

a county to the county population for the included age range ((Practice-level ACLs/county population)x10,000). Additionally, the rate ratio was calculated (affiliated outreach ACLOR/without affiliated outreach ACLOR). Finally, the percentage of total ACL surgeries from counties with and without affiliated outreach ATs performed by the sports medicine practice was calculated (Practice-level-data/Population-level-data). **Results:** The ACLOR for counties with affiliated outreach ATs was 7.2 per 10,000 compared to 4.2 per 10,000 for counties without affiliated outreach ATs and a rate ratio of 1.7, (95%CI:1.4-2.7). The sports medicine practice performed 30.3% of ACL reconstructions in counties with affiliated outreach ATs, versus 16.0% in non-affiliated counties. The largest percentage of ACL surgeries performed by the practice was in 14-18 year-olds for both outreach affiliated counties (68.3%) and non-affiliated counties (45.6%). **Conclusions:** For the sports medicine practice the ACLOR for counties with affiliated outreach ATs was nearly two times greater than the ACLOR for counties without affiliated outreach ATs. The impact of outreach ATs was most prominent in 14-18 year-olds where the affiliated practice performed the largest percentage of all ACL surgeries within the region. This data supports that outreach ATs can impact a clinic's referral base, particularly regarding referral of high school age individuals.

Author Index

D

E

F

G

H

I

J

K

L

M

N

O

P

R

W

Y

Z