# JOURNAL OF ATHLETIC TRAINING

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

Dear NATA Members and Friends:

We are pleased to present the annual Supplement to the *Journal of Athletic Training*. This Supplement contains abstracts presented at the 2016 NATA Clinical Symposia & AT Expo in Baltimore, Maryland 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 Maryland 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

Scott Sailor, EdD, ATC
President, NATA

Dear Colleagues:

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

We would also like to take this opportunity to extend a special thanks to the all of the NATA Foundation staff and especially Velma Meza and Shelley Tims, NATA Foundation Director, 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: Michelle Boling, PhD, ATC; Steven Broglio, PhD, ATC; Thomas Buckley, EdD, ATC; Kenneth Cameron, PhD, MPH, ATC; Jeff Driban, PhD, ATC, CSCS; Jennifer Earl-Boehm, PhD, ATC; Kellie Huxel-Bliven, PhD, ATC; Blaine Long, PhD, AT, ATC; Stephanie Mazerolle, PhD, ATC; Brendan McDermott, PhD, ATC; Melanie McGrath, PhD, ATC; Sara Nottingham, EdD, ATC; Erik Wikstrom, PhD, ATC, LAT; and Cathleen Brown Crowell, 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 Baltimore. 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

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## Awards



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# The Medal for Distinguished Athletic Training Research


## Thomas W. Kaminski, PhD, ATC, FNATA, FACSM, RFSA
## University of Delaware


Tom Kaminski's interest in athletic training began in 7th grade, when he fortuitously began reading the Cramer First Aider magazine, which he found in the office of the head football coach/athletic director, Mr. Dave Ball. From that point on, Kaminski served as the student manager for the high school football team and implemented the knowledge learned from the Cramer First Aider to assist injured athletes. By the time he was a senior, he was certain about pursuing a career in athletic training.

Kaminski took his skill set to Marietta College, where he had been recruited to play baseball but found his time dedicated to athletic training much more enlightening and so went on to earn his bachelor of science degree in sports medicine. In 1985 he completed his master of science degree in athletic training at the University of Arizona. Several years later, while working as the head athletic trainer at Alfred University, he began to think about pursuing his doctorate and was encouraged by Dave Perrin, PhD, ATC, FNATA, FACSM, whom he met at the kickoff conference for the *Journal of Sport Rehabilitation* in 1991. Kaminski received his doctorate in sports medicine from the University of Virginia in 1996.

Kaminski's research assessing ankle instability started at the University of Virginia and continued at the University of Florida, where he also served as an athletic trainer for the university's women's soccer team. There he quickly also became interested in the study of concussions, particularly in female soccer athletes.

Kaminski is now an educator, administrator, and researcher at the University of Delaware, where his favorite classes to teach are "Upper and Lower Extremity Orthopaedic Evaluation" and "Evidence-Based Sports Medicine." The most gratifying aspect of his job is his interaction with students. He particularly appreciates the 2-way street: being able to teach his students while simultaneously learning from them.

When asked to share some advice for athletic trainers, he stated that they must always take the initiative to learn. There are always opportunities to learn, and squandering those opportunities is wasteful. Athletic trainers must also be open minded. In clinical practice, it is easy to become complacent, but athletic trainers must strive to practice using evidence-based methods.

In Kaminski's personal life, he enjoys being outdoors. That includes landscaping his yardplaying golf, and going to the beach near his home in Delaware. Kaminski thanks his mentors Paul Spear, RN, ATC, PA; Dave Perrin; his many athletic trainer friends and colleagues, including former Virginia classmates Carl Mattacola, PhD, ATC; FNATA; Kevin Guskiewicz, PhD, ATC, FNATA, FACSM; and Jay Hertel, PhD, ATC, FNATA, FACSM; along with his wife Sue, his son Adam, and his daughter Leigh. Kaminski is humbled by this honor and grateful to share this award with the previous recipients.

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


## Jeffrey B. Driban, PhD, ATC, CSCS
## Tufts Medical Center and Tufts University School of Medicine


Jeffrey Driban's career in athletic training took root while he was a high school athlete. After arriving at the University of Delaware and meeting with staff members from the athletic training program, he determined that his future belonged in sports medicine. Driban graduated in 2001 with his bachelor of science degree in athletic training. After graduation, he pursued both his master's degree and doctorate in kinesiology at Temple University, where he worked in the Department of Orthopaedics with patients who had osteoarthritis. The unmet needs of this patient population have now become Driban's primary research focus.

Currently, Driban is looking at why individuals develop osteoarthritis and why a subset of these people develop advanced disease in as little as 1 year after injury. The most notable catalyst responsible for the rapid onset of osteoarthritis appears to be a new knee injury involving the meniscus or bone. By understanding the changes that occur before radiographic progression is evident, it may someday be possible to delay the onset of osteoarthritis or limit its severity. The National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health supports his current work.

Beyond his research, Driban also tries to raise awareness about osteoarthritis and promote primary and secondary prevention strategies for physically active individuals as the Chair of the Athletic Trainers' Osteoarthritis Consortium, an NATA representative in the Osteoarthritis Action Alliance, and Chair of the Alliance's Osteoarthritis Prevention Work Group. He noted that osteoarthritis is no longer considered a disease of the elderly and that some of our patients in sports medicine may be at risk for living more than half their lives with this chronic and disabling disease. Fortunately, there are steps we can take to reduce the risk of osteoarthritis among our patients.

The most enjoyable aspects of Driban's job include his dynamic schedule, his desire to seek answers to research questions, and the opportunity to work with clinicians and researchers in a variety of fields. Expanding on the subject of collaboration, Driban explained that neither group can operate in a vacuum. Researchers find the evidence and clinicians offer novel discoveries and valuable feedback. To deliver the best patient care, it is essential for all parties to keep open minds and participate in ongoing dialogues. When asked what advice he would give to aspiring athletic trainers, Driban stated, "they should try everything." For students to be certain about their career choice, they must have first-hand exposure

to the responsibilities of the position. They'll find appealing aspects they didn't expect and others they don't wish to pursue, but both avenues provide useful information.

In his personal life, Driban enjoys running, reading for leisure, sampling different types of beer, watching baseball games, and any chance to spend time with family and friends. He extends special thanks to his great mentors from the University of Delaware: Mike Higgins, PhD, PT, ATC, CSCS; Keith Handling, MS, PT, ATC; Joan Couch, ATC; Barry Miller, PhD; and David Barlow, PhD, who consistently challenged him to be a critical thinker. He also recognizes Mike Sitler, EdD, ATC, FNATA; Buz Swanik, PhD, ATC; Easwaran Balasubramanian, MD; and Mary Barbe, PhD, for giving him the opportunity to work in the field of osteoarthritis. Tim McAlindon, MD, MPH, taught him to become a better researcher. He appreciates Will Harvey, MD, MSc, FACR; Chenchen Wang, MD; Grace Lo, MD, MSc; Lori Lyn Price, MAS; Charles Eaton, MD; Jennie Hootman, PhD, ATC, FNATA, FACSM; the research assistants in the Division of Rheumatology; and all of his colleagues in the Osteoarthritis Initiative. He thanks his collaborators Ken Cameron, PhD, MPH, ATC; Joe Hart, PhD, ATC; Brian Pietrosimone, PhD, ATC; and Nicole Cattano, PhD, ATC, for always providing him with useful perspectives. Marje Albohm, MS, ATC; Doug Weiss, ATC; Paul Ullucci, Jr, PhD, DPT, ATC; Frank George, PT, AT; and Marie Mancini, ATC, contributed to his growth as an athletic trainer. He also noted the continuous support from his parents and brother. Furthermore, he acknowledges and recognizes his wife, Morgan, who has heard every talk that he has given in the past 4 years, stating that "some days she knows the research better than I do." Finally, Driban thanks the NATA Foundation and EATA for their support during his graduate and doctoral research, which helped provide the basis for his research in osteoarthritis and the current award.

NATA RESEARCH & EDUCATION FOUNDATION

## 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

**Lindsey Lepley, PhD, ATC**
**University of Connecticut**

Lindsey Lepley's desire to pursue a bachelor's degree in athletic training began at Grand Valley State University, after a meeting with then Head Athletic Trainer Todd Jager, ATC. She truly admired Jager's devotion to the field of athletic training and his dedication to the athletes he cared for, especially in light of his battle with a glioblastoma multiforme brain tumor. Lepley credits Jager's determination as the inspiration that helped develop her deep passion for athletic training.

After graduation, Lepley continued her education at the University of Virginia, where she earned her master's of education degree in kinesiology. She grew professionally under the direction of outstanding mentorship while at UVA. After working as an outreach athletic trainer at the Atlantic Coast Athletic Club under the clinical mentorship of Amy Boyer MPT, ATC, Lepley's passion for sports medicine research and desire to influence clinical care through evidence-based medicine drove her to pursue a doctoral degree in kinesiology at the University of Michigan. After graduating in 2014, she went to the University of Kentucky for a postdoctoral fellowship in muscle mechanics. Currently, Lepley is an assistant professor at the University of Connecticut, where she studies the neuromuscular deficits that result from traumatic joint injury in hopes of developing innovative rehabilitation therapies capable of restoring muscle function. This research agenda stems directly from a clinical problem that she faced as a clinician in trying to successfully restore muscle function following traumatic joint injury. Lepley admits that she did not anticipate having a career that concentrates on research, but she has found immense pleasure in her work. The most gratifying part of her job is interacting with and educating graduate students about innovative approaches to neuromuscular research. She is a member of various professional organizations including the NATA, American College of Sports Medicine, American Society of Biomechanics, and Athletic Trainers' Osteoarthritis Consortium.

Outside the workplace, Lepley enjoys outdoor activities such as kayaking, hiking, and spending time with her golden retriever, Maggie. She is also quick to state that her husband, Adam, is her "better half," providing her with unwavering support and being the best possible partner in both her personal and professional lives: "He truly is a keeper."

Lepley is very grateful for the unparalleled mentorship she has had throughout her career. In particular, she recognizes Brian Hatzel, PhD, ATC, at Grand Valley State University, on whom she relied for a foundational education. At the University of Virginia, Lindsey feels very fortunate to have trained under Brian Pietrosimone, PhD, ATC; Jay Hertel, PhD, ATC, FNATA, FACSM; Chris Ingersoll, PhD, ATC, FNATA, FACSM; Joe Hart, PhD, ATC, FNATA; and Sue Saliba, PhD, PT, ATC, FNATA, and she thanks

them for their scientific insight and constant encouragement. Lepley shares this award with her doctoral mentor and "academic mother," Riann Palmieri-Smith, PhD, ATC. Lepley acknowledges that she would not be the researcher or person she is today without Palmieri-Smith's guidance and enthusiasm. Lepley also recognizes her postdoctoral mentor, Tim Butterfield, PhD, ATC, FACSM, who "took a chance" on her when she had no training in animal models and continually pushes her to ask challenging questions. Lepley feels fortunate to have worked with such genuinely good people and excellent scientists. Lastly, she thanks her brother, sister, and parents for their unconditional support.

## 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.

## Knee Evidence-Based Forum: Maximizing Muscle Strength After Anterior Cruciate Ligament Reconstruction: New Insights to a Clinical Challenge

Thursday, June 23, 2016, 8:00AM-9:00AM, Room 314; Moderator: Brian Pietrosimone, PhD, ATC
Discussants: Riann Palmieri-Smith, PhD, ATC; Lindsey Lepley, PhD, ATC

# Free Communications, Oral Presentations: Functioning After an Anterior Cruciate Ligament Injury

Thursday, June 23, 2016, 9:15AM-10:15AM, Room 314; Moderator: David Bell, PhD, ATC

### Relationships of Functional Tests Following ACL Reconstruction: A Factor Analysis of the Lower Extremity Assessment Protocol

Hertel J, DiFabio M, Slater LV, Hart JM: University of Virginia, Charlottesville, VA

**Context:** In the months after ACL reconstruction (ACLR), deficits are often present in muscle strength and endurance and functional performance. These deficits may be assessed using a variety of tests, however it is unknown if common tests provide redundant or unique information. **Objective:** To determine if a battery of tests, the Lower Extremity Assessment Protocol (LEAP), to assess function after ACLR provide unique or redundant information. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 76 ACLR patients (41F, 35M; age = 21.8 ± 8.4 years; months post-surgery = 6.9 ± 3.1; IKDC = 81.4 ± 13) participated. **Interventions:** Participants completed the LEAP for their reconstructed and contralateral uninjured limbs. **Main Outcome Measures:** Assessments included: isokinetic knee extension and flexion strength at 90°/s and 180°/s (peak torque, average torque, average work, average power); isometric knee flexion and extension strength and endurance (MVIC peak torque, %fatigue during a 30s isometric contraction); drop landing assessed with the Landing Error Scoring System (LESS); balance during 10s of unipedal quiet standing (center of pressure velocity and area); and hopping tasks (distance for single, triple, and crossover hops, and time to hop 6m). Two exploratory factor analyses, one for reconstructed and one for healthy limbs, utilizing varimax rotation and retaining factors with eigenvalues>1.0, were performed to classify dependent variables into categories. Pearson's r correlations were calculated between all measures loading within a retained factor and interpreted as weak($r < 0.3$), moderate($0.3 < r < 0.7$), or strong($r > 0.7$). **Results:** The ACLR involved limbs had a five factor solution (cumulative variance explained = 83.8%) with measures loading as expected within their specific domains with the exception of LESS score which loaded with extension strength measures. The factors were: 1) flexion strength (eigenvalue = 8.3, variance explained = 30.6%), 2) extension strength and LESS (eigenvalue = 7.7, variance explained = 28.4%), 3) hopping (eigenvalue = 3.3, variance explained = 12.1%), 4) balance (eigenvalue = 1.9, variance explained = 7.0%), and 5) flexion and extension endurance (eigenvalue = 1.5, variance explained = 5.7%). All measures within factors were moderately to strongly correlated. The contralateral limbs also yielded a five factor solution (cumulative variance explained = 82.5%) with measures loading as expected within their specific domains with the exception of LESS score which loaded with the flexion and extension endurance measures. The factors were: 1) flexion strength (eigenvalue = 8.0, variance explained = 29.5%), 2) extension strength (eigenvalue = 6.7, variance explained = 27.7%), 3) hopping (eigenvalue = 3.9, variance explained = 14.3%), 4) balance (eigenvalue = 1.9, variance explained = 7.0%), and 5) flexion and extension endurance and LESS (eigenvalue = 1.8, variance explained = 6.8%). All measures within factors were moderately to strongly correlated with the exception of factor 5 which demonstrated weak correlations. **Conclusions:** Isokinetic and isometric strength, hopping, balance, and isometric endurance tests provided unique information in ACLR and contralateral healthy limbs, however due to considerable shared variance between measures within each domain there is redundancy within categories. Some LEAP tests and measures may be candidates for elimination while still providing a comprehensive functional assessment of ACLR patients.

### Concentric Quadriceps Rate of Force Development and Patient-reported Symptoms After ACL Reconstruction

McGrath ML, Rhoads AM, Rosen AB: University of Nebraska, Omaha, NE

**Context:** ACL injury and reconstruction place patients at high risk of developing knee osteoarthritis (OA). Current evidence suggests that quadriceps weakness is associated with the development of knee OA, but less is known about how altered neuromuscular characteristics, including time to peak torque (TTPT) or rate of force development (RFD), are related to knee OA symptoms. Even less is known about quadriceps TTPT, RFD and patient-reported knee function during the early years following ACL surgery. **Objective:** Determine the relationship between concentric quadriceps TTPT and RFD and patient-reported symptoms following ACL reconstruction. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four patients with a history of single, unilateral ACL reconstruction who had been cleared by a physician for full, unrestricted activity (13M,11F; 26.5 ± 7.2years, 78.1 ± 16.4kg, 173.7 ± 9.6cm, 6.3 ± 3.8years since surgery). **Interventions:** An isokinetic dynamometer was used to assess bilateral concentric quadriceps torque at 60 and 180°/s. Five repetitions of each speed were performed on each leg, and repetitions 2-4 were used for analysis. Participants completed the Knee Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee Subjective Knee Form (IKDC) to determine current knee-related symptoms including pain, swelling, stiffness, and overall function. **Main Outcome Measures:** The IKDC and KOOS were scored as a percentage with 100% indicating full function. TTPT (ms) was calculated

as the time from contraction onset to peak torque. RFD (Nm/s) was measured as the torque at three timepoints from the onset of contraction (30ms, 50ms, 100ms), divided by the time in seconds. TTPT and RFD30, RFD50, and RFD100 were calculated at 60 and 180°/s for each limb (involved and uninvolved). Paired t-tests examined differences in TTPT and RFD variables between the involved and uninvolved limbs. Pearson correlations were calculated between subjective measures and TTPT and RFD variables on each limb ($\alpha \leq 0.05$). **Results:** The involved limb had significantly greater RFD at 60°/s compared to the uninvolved limb (RFD30inv = 3442.6 ± 1971.7Nm/s, RFD30uninv = 2722.0 ± 1968.6Nm/s; t23 = 2.27, p = 0.033; RFD50inv = 2437.3 ± 1291.0Nm/s, RFD50uninv = 1910.7 ± 1350.3Nm/s; t23 = 2.36, p = 0.027; RFD100inv = 1083.4 ± 540.4Nm/s, RFD100uninv = 899.5 ± 573.2Nm/s; t23 = 2.10, p = 0.047). No significant correlations were found between subjective variables (KOOS, IKDC) and TTPT and RFD of either limb. Small-to-moderate correlations were found on the involved limb for time since surgery (6.3 ± 3.8years) and RFD30inv (r = -0.410, p = 0.047) and RFD50inv (r = -0.409, p = 0.047). No correlations existed between time since surgery and the uninvolved limb. **Conclusions:** RFD was impaired relative to the uninvolved limb, suggesting altered neuromuscular function years after surgery. There does not appear to be any relationship between TTPT or RFD and subjective measures of function after ACL reconstruction. The small-to-moderate, negative relationships between RFD and time since surgery suggest that RFD improves (becomes shorter) as time since surgery increases. Altered neuromuscular function may play a role in the development of post-traumatic knee OA, thus addressing RFD may be important following ACL injury.

## Pre-surgical and Post-surgical Quadriceps Strength and Knee Pain as Predictors of Readiness to Return-to-Activity Following Anterior Cruciate Ligament Reconstruction

Lepley AS, Cormier ML, Gribble PA, Pietrosimone B: University of Connecticut, Storrs, CT; University of Kentucky, Lexington, KY; University of North Carolina, Chapel Hill, NC

**Context:** Currently, only 63% of individuals return to pre-injury activity levels following anterior cruciate ligament reconstruction (ACLr). The current treatment paradigm following ACLr focuses on optimizing physical factors, such as maximizing muscle function and minimizing pain. However, the interaction between physical and psychological function, such as perceived ability to return-to-activity, is not well understood. A patient's readiness to return-to-activity measures their perceived ability, or confidence, to complete functional tasks, and is likely influenced by physical deficiencies connected with the injury. Understanding how physical function associates with readiness to return-to-activity may aid clinicians in creating optimal therapeutic approaches to maximize outcomes and return-to-play following ACLr. **Objective:** Examine the contributions of pre-surgical and post-surgical quadriceps strength and levels of pain on readiness to return-to-activity in patients following ACLr. **Design:** Descriptive laboratory study. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Twenty ACL injured patients scheduled to undergo ACLr (11 females/9 males; 20.9 ± 4.4 yrs; 1.72 ± 0.07m; 75.9 ± 12.2kg) volunteered. **Interventions:** Injured limb quadriceps strength and perceived knee pain were collected pre-surgery (37.1 ± 15.3 days post-injury) and when patients were cleared for unrestricted activity. Patient's readiness to return-to-activity was also evaluated when cleared (28.3 ± 2.9 months post-surgery). **Main Outcome Measures:** Quadriceps strength was assessed via maximal voluntary isometric contractions (MVIC) normalized to body mass (Nm/kg) and performed at 90° of knee flexion in an isokinetic dynamometer. Perceived pain was assessed using the Pain subscale of the Knee Injury and Osteoarthritis Outcome Score (KOOS). Readiness to return-to-activity was measured using the ACL-Return to Sport after Injury scale (ACL-RSI). Pearson product moment correlations were performed to determine the association ACL-RSI has with MVIC and KOOS-Pain at each time point. Separate stepwise hierarchal multiple linear regression analyses were performed to examine the amount of variance in ACL-RSI that could be explained by the variance in the MVIC and KOOS-Pain at each time point. Alpha level was set a priori at $P < 0.05$. **Results:** Pre-surgical MVIC did not significantly associate with ACL-RSI (r = 0.32;P = 0.15). Pre-surgical KOOS-Pain (r = 0.56,P = 0.01) significantly correlated with ACL-RSI. The overall regression model significantly predicted 31% of the variance in ACL-RSI (R2 = 0.316, P = 0.01; ACL-RSI = 1.63KOOS-Pain-14.39). Post-surgical MVIC (r = 0.60,P = 0.01) and KOOS-Pain (r = 0.52,P = 0.01) significantly associated with ACL-RSI. The overall regression model significantly predicted 36% of the variance in ACL-RSI (R2 = 0.362, P = 0.02; ACL-RSI = 22.95MVIC + 0.14KOOS-Pain-3.73). **Conclusions:** Patients with lesser pre- and post-operative pain, and greater post-operative quadriceps strength, report a greater readiness to return-to-activity when cleared for unrestricted activity. Clinically, minimizing pre- and post-surgical pain, and maximizing post-surgical quadriceps strength, may facilitate a patient's perceived ability to return-to-activity. From a psychological perspective, ACLr patients may perceive they are more ready to return-to-activity when they are stronger and experience less pain. Screening for, and treating pre-surgical pain may provide a clinical marker to increase likelihood of return-to-activity.

## Unilateral and Symmetry Measures of Muscle Function as Predictors of Subjective Knee Function in Patients After ACL Reconstruction

Goetschius J, Norte GE, Slater L, Hart JM: University of Virginia, Charlottesville, VA

**Context:** Assessments of muscle strength and single-leg hopping performance are commonly reported in the literature and used to guide clinical care following anterior cruciate ligament reconstruction (ACL-R) surgery. While symmetry measures are most common in clinical practice, unilateral measures may provide valuable insight into knee related function after ACL-R. **Objective:** To evaluate use of unilateral and symmetry measures of quadriceps strength and single-leg hop distance to predict current subjective knee function in patients after ACL reconstruction, and to evaluate differences in measures between participants with low and high subjective knee function. **Design:** Descriptive Laboratory Study **Setting:** Laboratory **Patients or Other Participants:** Sixty-seven young adults who were returning to activity after primary, unilateral ACL-R surgery (6.7 ± 1.4 months post-op, 29F/38M, 19.9 ± 4.5 years, 73.4 ± 16.8 kg, 1.74 ± .10 m). **Interventions:** Participants were referred by orthopaedic surgeon for lower extremity functional testing. Testing included bilateral isokinetic knee extension strength testing (90 degrees/second) and bilateral maximal single-leg hop for distance testing (single-hop). All participants completed the International Knee Documentation Committee subjective knee evaluation form (IKDC). **Main Outcome Measures:** Unilateral peak knee extension torque (Nm) and peak hop distance (m) were calculated for involved and uninvolved limbs, and normalized by participant's mass (kg) and ½ participant's height (m), respectively. Limb symmetry indices (LSI, %) were calculated for strength and hopping using the formula (=Involved/Uninvolved × 100). Variables were separately regressed on IKDC, and differences examined between low-function (IKDC score < 85) and high-function (IKDC score ≥ 85) groups. **Results:** Involved ($R2 = 0.06$, $r = 0.25$, $P = 0.04$) quadriceps strength predicted 6% of the variance in IKDC. Uninvolved ($R2 = 0.05$, $r = 0.22$, $P = 0.07$) and LSI ($R2 = 0.02$, $r = 0.13$, $P = 0.28$) quadriceps strength were not significant predictors of IKDC. Involved ($r = 0.40$, $R2 = 0.16$, $P = 0.001$) and uninvolved ($R2 = 0.07$, $r = 0.26$, $P = 0.03$) hop distance predicted 16% and 7% of the variance in IKDC, respectively. Hop distance LSI predicted 16% of the variance in IKDC ($R2 = 0.16$, $r = 0.40$, $P = .001$). Involved quadriceps strength (high: 1.8 ± 0.4, low: 1.6 ± 0.4, $P = 0.05$), involved hop distance (high: 1.6 ± 0.3, low: 1.3 ± 0.4, $P = 0.01$) and LSI hop distance (high: 0.93 ± 0.08, low: 0.84 ± 0.14, $P = 0.01$) were all greater in the high-function than low-function groups. There were no differences in quadriceps strength LSI (high: 0.71 ± 0.16, low: 0.66 ± 0.15, $P = 0.15$), uninvolved quadriceps strength (high: 2.5 ± 0.4, low:, 2.4 ± 0.4 $P = 0.20$), or uninvolved hop distance (high: 1.7 ± 0.3, low: 1.6 ± 0.3, $P = 0.13$) between the high and low-function groups. **Conclusions:** Involved and LSI hop distance were the strongest predictors of subjective knee function and were greater in high-function group. Both hopping variables predicted a similar magnitude variance in IKDC. Involved quadriceps strength was a significant predictor of subjective knee function and greater in the high-function group. Despite the popular clinical use of quadriceps limb symmetry for return to activity assessment, the variable did not predict knee function and was not different between groups.

### Long Term Consequences of Ankle Injury in the General Population

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**Context:** Long-term functional deficits and self-reported disability commonly develop and persist following ankle injury, leading to a high rate of re-injury. Recent investigations suggest these lingering impairments reduce physical function and increase ankle joint degeneration, which may worsen general health. However, the prevalence of comorbid health conditions, specifically cardiovascular and respiratory diseases, in patients with a history of ankle injury is not well established. **Objective:** Determine differences in physical activity, ankle joint health and general health among adults with and without a history of ankle injury. **Design:** Cross-sectional survey. **Setting:** Population-based, online survey. **Patients or Other Participants:** A total of 3,526 adults responded to an invitation on www.researchmatch.org to complete a survey about their injury history, present health status, and quality of life. Of these, 1843 sustained an ankle injury (ANK; age: 47.89 ± 20.99years; body mass index[BMI]: 29.15 ± 7.75kg/m2), and 1683 reported no ankle injuries (CTRL; age: 46.35 ± 21.98years; BMI: 27.62 ± 6.93kg/m2). **Interventions:** An online survey utilized general questions on demographics, ankle injury and surgery history, presence of comorbid health conditions, and overall pain and activity limitations (Short Form[SF]-12). **Main Outcome Measures:** Ankle injury history, BMI, overall pain and activity limitations (SF12), presence of at least 1 comorbid cardiovascular or respiratory condition, and ankle osteoarthritis diagnosis were determined from the survey. Independent samples t-tests were used to compare group differences in BMI. The prevalence of cardiorespiratory conditions and ankle osteoarthritis, and the level of overall body pain and daily activity restriction between groups were compared using separate Pearson's Chi-square analyses. Alpha level was set a priori at $P < 0.05$ for all analyses. **Results:** Respondents in ANK had a higher BMI ($P < 0.001$) than CTRL. More patients in ANK (38.2%) reported moderate to very severe body pain compared to 27.4% in CTRL ($P < 0.001$). More patients in ANK reported being "somewhat" to "completely" limited in daily activities (46.4%) compared to 36.0% in CTRL ($P < 0.001$) More patients in ANK (30.9%) reported having a cardiovascular or respiratory condition compared to 24.5% in CTRL ($P < 0.001$). A greater percentage of patients in ANK (9.4%) reported having ankle osteoarthritis compared to 1.8% in CTRL ($P < 0.001$). **Conclusions:** Our data suggest that respondents with a history of ankle injury have poorer overall health as indicated by higher BMI and greater prevalence of comorbid health conditions. Further, these data confirm that respondents with previous ankle injury have a greater prevalence of ankle osteoarthritis, and more bodily pain and activity restriction than those who have never sustained ankle injuries. Collectively, these data suggest the need for interventions to improve overall health following ankle injury.

### Osteoarthritis and Comorbidity Prevalence Among Patients With a History of Knee Surgery

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**Context:** Long-term strength deficits and osteoarthritis development following knee injuries and surgery are well known. It is likely that these lingering impairments reduce physical function and worsen general health. However, the prevalence of comorbid health conditions, specifically cardiovascular and respiratory diseases, in patients with a history of knee injury/surgery is not well established. **Objective:** Determine differences in physical function and general health among adults with and without a history of knee injury and surgery. **Design:** Cross-sectional survey. **Setting:** Population-based, online survey. **Patients or Other Participants:** A total of 3,523 adults responded to an invitation on www.researchmatch.org to complete a survey about their injury history, present health status, and physical activity status. Of these, 647 sustained a knee injury requiring surgery (SURG; age: 53.35 ± 14.19 years; body mass index [BMI]: 29.98 ± 7.70kg/m2), 1093 sustained a knee injury that did not require surgery (INJ; age: 47.08 ± 21.84 years; BMI:28.55 ± 7.78kg/m2), and 1783 reported no knee injuries (CTRL; age: 44.92 ± 22.98 years; BMI:27.77 ± 6.99 kg/m2). **Interventions:** An online survey utilized general questions on demographics, knee injury and surgery history, presence of comorbid health conditions, and overall physical activity level (UCLA Activity Score). **Main Outcome Measures:** Injury history, age, BMI, physical activity level (UCLA Activity Score), presence of at least 1 comorbid cardiovascular or respiratory condition, and knee osteoarthritis diagnosis were determined

from the survey. One-way ANOVA was used to determine group differences in age and BMI with independent samples t-tests used for post hoc testing. The prevalence of comorbidities and knee osteoarthritis between groups was compared using Pearson's Chi-square analyses. Alpha level was set a priori at <0.05. **Results:** Respondents in SURG were older and had a higher BMI than INJ (age: P<0.001; BMI: P<0.001) and CTRL (age: P<0.001; BMI: P<0.001). Similar differences were observed between INJ and CTRL groups for age (P=0.013) and BMI (P=0.005). More patients in SURG (15.6%) reported sedentary UCLA Activity Scores compared to 9.2% in INJ and 7.7% in CTRL (P<0.001). More patients in SURG (39.3%) reported having a comorbid cardiorespiratory condition compared to 28.2% in INJ and 23.5% in CTRL (P<0.001). A greater percentage of patients in SURG (54.4%) reported having knee osteoarthritis compared to 20.2% in INJ and 5.1% in CTRL (P<0.001). **Conclusions:** Our data suggest that respondents with a history of knee injury requiring surgery have poorer overall health as indicated by higher BMI and greater prevalence of comorbid health conditions. Further, these data confirm that respondents who undergo knee surgery have a greater prevalence of knee osteoarthritis than those with knee injury that did not require surgery or who have never sustained knee injuries. Collectively, these data suggest the need for future research and interventions to improve overall health following knee injury/surgery.

### Osteoarthritis and Comorbidity Prevalence Among Patients With a History of Knee and Ankle Injuries

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**Context:** Context: Long-term strength and functional deficits following knee and ankle injuries are well known. This impaired physical function likely encourages a sedentary lifestyle and decreases general health. However, it is unknown if the prevalence of comorbidities, specifically cardiorespiratory diseases, is higher in patients with a history of knee versus ankle injuries. **Objective:** Determine differences in physical function and general health among adults with a history of knee and ankle injury. **Design:** Design: Cross-sectional survey. **Setting:** Population-based, online survey. **Patients or Other Participants:** A total of 3,523 adults responded to an invitation on www.researchmatch.org to complete a survey about their injury history, present health status, and physical activity status. Of these, 701 sustained a knee injury (KNEE; age: 49.32 ± 15.85 years; body mass index [BMI]: 28.42 ± 7.43 kg/m2), 803 sustained an ankle injury (ANKLE; age: 45.79 ± 19.79 years; BMI: 28.61 ± 7.41kg/m2), and 1046 sustained both knee and ankle injuries (BOTH; age: 49.54 ± 21.69 years; BMI:29.55 ± 7.97kg/m2). **Interventions:** An online survey utilized general questions on demographics, knee injury, ankle injury, presence of comorbid health conditions, and overall physical activity level (UCLA Activity Score). **Main Outcome Measures:** Injury history, age, BMI, physical activity level (UCLA Activity Score), presence of at least 1 comorbid cardiorespiratory condition, and knee and/or ankle osteoarthritis (OA) diagnosis were determined from the survey. One-way ANOVAs compared group differences in age and BMI, with independent samples t-tests employed for post-hoc testing. Activity levels and cardiorespiratory disease and OA prevalence were compared between groups using Chi-square analysis. Alpha level was set a priori at < 0.05. **Results:** ANKLE respondents were significantly younger than those KNEE (P < 0.001) and BOTH (P < 0.001). There was no difference in age between KNEE and BOTH (P = 0.817). BOTH respondents reported a higher BMI than KNEE (P = 0.003) and ANKLE (P = 0.009). There were no differences in BMI between KNEE and ANKLE (P = 0.618). More respondents in the BOTH group (50.9%) reported sedentary UCLA Activity Scores compared to KNEE (24.2%) and ANKLE (24.9%; P < 0.001). More respondents in the BOTH group (45.9%) reported having a cardiorespiratory condition compared to KNEE (26.6%) and ANKLE (27.5%; P = 0.002). BOTH respondents reported more OA (knee OA: 58.5%; ankle OA: 67.9%) compared to KNEE (knee OA: 34.5%; ankle OA: 9.3%) and ANKLE (knee OA: 7.1%; ankle OA: 22.8%; P < 0.001). Conclusions: **Conclusions:** These data suggest that respondents with a history of both knee and ankle injuries have poorer overall health as indicated by higher BMI and greater prevalence of comorbid health conditions than those with isolated knee or ankle injuries. Further, our data confirm that respondents who have a history of both knee and ankle injuries have a greater prevalence of OA than those with isolated knee or ankle injuries. Collectively, these data suggest the need for interventions to improve overall health following lower extremity injury, particularly in those who sustain injuries to multiple joints.

## Collagen Turnover in Anterior Cruciate Ligament Reconstructed Individuals Differ Based on Knee Extension Moment Inter-limb Symmetry During Walking Gait

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**Context:** Radiographic osteoarthritis (OA) develops in within ten years one-third of patients following anterior cruciate ligament reconstruction (ACLR). There is evidence that knee cartilage breakdown begins soon after ACL injury and may be influenced by persistent inter-limb gait biomechanics alterations following ACLR. Monitoring serum biomarkers of collagen turnover following ACLR may provide insight into very early alterations in cartilage metabolism prior to irreversible joint damage. Quadriceps weakness is common following ACLR and has been implicated a risk factor in the development of OA. Individuals with weaker quadriceps demonstrate lesser internal knee extension moments (KEM) during gait, which corresponds to impaired eccentric quadriceps contraction needed for proper energy attenuation at the knee. Unfortunately, there is little evidence linking inter-limb KEM asymmetry to cartilage turnover following ACLR. **Objective:** To compare collagen turnover between ACLR participants separated into groups based on their KEM limb symmetry index (LSI). **Design:** Cross-sectional. **Setting:** Research Laboratory. **Patients or Other Participants:** Nineteen participants with unilateral ACLR (11 Females, age = 21.5 ± 2.8 yr, height = 171.0 ± 11.9 cm, weight = 72.3 ± 15.6 kg, 45.0 ± 36.5 months post ACLR) volunteered for the study. **Interventions:** Resting blood was collected and sera were stored at -80°C until later analysis. Three-dimensional kinetics and kinematics were during walking at a self-selected speed. **Main Outcome Measures:** Bilateral peak KEM during the first 50% of stance phase was used to calculate KEM LSI (ACLR Limb/Contralateral Limb), with LSI > 1 indicating greater KEM in the ACLR limb compared to contralateral limb. Participants were separated into two groups: LSI ≥ 1 and LSI < 1. Sera were assessed for collagen breakdown (i.e., collagen type-II cleavage product [C2C]) and synthesis (i.e., collagen type-II C-propeptide [CPII]) concentrations using a commercially available enzyme-linked immunosorbent assay. Collagen turnover was calculated as a ratio of breakdown to synthesis (C2C:CPII), with a higher ratio indicating more collagen breakdown relative to collagen synthesis. Independent samples t-tests were used to compare C2C:CPII between the ACLR participants with LSI ≥ 1 and LSI < 1 ($\alpha$ < 0.05). **Results:** Participants with an LSI < 1 displayed a greater collagen turnover ratio (n = 13, C2C: CPII = 0.37 ± 0.15, mean ± SD; t17 = 2.1, p = 0.05) compared to participants with an LSI ≥ 1 (n = 6, C2C: CPII = 0.24 ± 0.03). **Conclusions:** Participants with greater KEM on their injured limb during gait relative to their uninjured limb presented with a lower collagen turnover ratio than ACL participants with less KEM in their injured limb. Eccentric quadriceps contraction during gait may serve to protect the cartilage from early degeneration. Using treatments which maximize quadriceps function and restore inter-limb symmetry during gait may aid in preventing cartilage breakdown following ACLR.

## Evidence for Early Proteoglycan Loss in the Lateral Femoral Condyle at Twelve Month Follow-up Exams in Patients With Anterior Cruciate Ligament Reconstruction

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**Context:** One-third of individuals who undergo anterior cruciate ligament reconstruction (ACLR) develop post-traumatic osteoarthritis (PTOA) within the first decade following surgery. The ability to detect early changes in articular cartilage composition following ACL injury is critical for identifying which patients are at greatest risk of early PTOA development. Quantitative T1rho magnetic resonance imaging methods have shown promise as a biomarker of decreased proteoglycan content and early extracellular matrix degeneration that can be detected prior to development of radiographic osteoarthritis. The lateral femoral condyle (LFC) may be at highest risk for early extracellular matrix degeneration as bone marrow edema-like lesions are common in the LFC following ACL injury. **Objective:** Determine if T1rho relaxation times in the LFC differ between limbs in ACLR individuals and compared to healthy controls. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Twelve ACL injured patients were studied 12 months following ACLR (66% female, 21 ± 2 years, 174.5 ± 10.6cm, 72.4 ± 13.6kg). Ten healthy control participants reported no history of lower extremity injury (50% female, 21.8 ± 1.1 yrs, 173.8 ± 9.4cm, 66.8 ± 12.7kg). **Interventions:** All ACL reconstructions were performed with a bone-patella

tendon-bone autograft. **Main Outcome Measures:** T1rho relaxation times were collected with a Siemens Magnetom TIM Trio 3T scanner in both limbs of individuals with an ACLR at a 12-month clinic follow-up visit, as well as in a single limb of a group of control participants. T1rho was prepared with a 3D-FLASH sequence and five different spin lock durations (40, 30, 20,10, 0 ms). The articular cartilage of the LFC was manually segmented and divided within the sagittal plane into five subsections which included: posterior, posterior meniscus, central, anterior meniscus and anterior regions. Separate paired and independent t-tests were used to determine differences in LFC T1rho relaxation times between limbs in the ACLR group as well as between the ACLR limb and the healthy controls, respectively ($\alpha = 0.05$). **Results:** The ACLR limb demonstrated significantly higher T1rho relaxation times, indicating lesser proteoglycan density, in the posterior (61.1 ± 4.7ms vs 57.3 ± 5.5ms; P = 0.03), posterior meniscus (51.8 ± 5.5 ms vs 46 ± 5.1 ms; P = 0.001), central (54.9 ± 6.3ms vs 49.2 ± 4.0ms; P = 0.006), anterior meniscus (58.6 ± 9.8ms vs 53.4 ± 4.8 ms; P = 0.05) LFC regions, compared to the contralateral limb. T1rho relaxation times were also higher in all LFC regions of the ACLR limb compared to the healthy controls (posterior 45.9 ± 5.2 ms; P = 0.003, posterior meniscus 49.4 ± 4.7 ms; P = 0.01, central 46.8 ± 3.8 ms; P = 0.002, anterior meniscus 44.5 ± 3.5 ms; P = 0.001 and anterior subsections 61.1 ± 4.6 ms vs 57.3 ± 2.2 ms; P = 0.023). **Conclusions:** Greater T1rho relaxation times in the LFC of the ACLR limb compared to the contralateral and control limbs suggest early decreases in proteoglycan density following ACL injury and/or ACL reconstruction. These data suggest that early, pre-radiographic declines in cartilage health within 12 months following ACLR, which may indicate early signs of PTOA development. Research supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health under Award Number R03AR066840-01A1 & National Athletic Trainers' Association Research and Education Foundation New Investigator Grant.

### Factors Associated With Symptom Resolution Following Concussion in Cadets at the United States Military Academy

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**Context:** Despite significant advances in the assessment and management of concussion, it remains unclear what factors at the time of injury and during the initial days following injury are related to outcomes following injury. **Objective:** The purpose of this study was to determine if symptoms reported on the Sport Concussion Assessment Tool 3 (SCAT3) symptom evaluation and other factors at the time of injury and during the initial post injury period were associated with time to symptom resolution following concussion. **Design:** Retrospective cohort study. **Setting:** US Service Academy. **Patients or Other Participants:** Participants were cadets at a US Service Academy who sustained a concussion due to participation in either the Academy's Physical Education Program or a free-time activity. A total of 103 consecutive cases were included with an average subject age of 20.1 years, height of 68.5 inches, weight of 165.3 lbs. 67% of cases were males. **Interventions:** Participant's concussion symptoms and severity were documented at the time of initial injury and tracked daily via an in-person athletic trainer interview, utilizing the SCAT3 symptom evaluation. Data was also collected regarding amount of sleep, hours in class, hours using technology, caffeine, alcohol, nicotine intake, and concussion history. **Main Outcome Measures:** The primary outcome measure was days to symptom resolution following concussion. Univariate and multivariable regression models controlling for sex and history of concussion were used to determine if the baseline factors listed above were associated with time to symptom resolution following injury. All data were analyzed using Stata SE version 10.0 and an alpha level of $p < 0.05$. **Results:** In univariate analyses, SCAT3 symptom and severity scores at the time of injury were associated with time to symptom resolution during follow-up. On average, for every two points higher on the SCAT3 symptom score at the time of injury, participants required an extra day for their symptoms to fully resolve ($\beta = 0.51$, $p < 0.001$). Similarly, for every 5 points higher on the symptom severity score at the time of injury, participants required an extra day for their symptoms to resolve ($\beta = 0.17$, $p < 0.001$). In univariate analyses, SCAT3 symptom and severity scores accounted for 11.4% and 12.1% of the variability in time to symptom resolution, respectively. None of the other factors assessed at baseline were associated with time to symptom resolution. Results were similar in multivariable models controlling for the influence of sex and history of concussion; however, with these other factors included in the model, SCAT3 symptom and severity scores accounted for 17.6% and 17.5% of the variability in time to symptom resolution. **Conclusions:** SCAT3 symptom and severity scores at the time of injury appear to be associated with time to symptom resolution following concussion and may have prognostic value in estimating time to symptom resolution.

### Power 5 Conference Concussion Management Plans Adherence to NCAA Guidelines

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**Context:** The NCAA requires member institutions to develop institutional concussion management plans (CMPs). CMPs must comply with NCAA rules and should be consistent with NCAA best practice guidance. Recently the NCAA introduced a CMP review process for schools within the NCAA Division I Power 5 conferences and publically published the CMPs; however, independent review has not been performed. **Objective:** To evaluate institution's CMPs for compliance with NCAA rules and consistency with NCAA guidelines. **Design:** Cross-sectional study. **Setting:** N/A. **Patients or Other Participants:** 65 universities of NCAA Division I Power 5 conferences: Atlantic Coast, Southeastern, Big Ten, Big 12, and Pacific-12. **Interventions:** The 65 publicly-available CMPs were evaluated for compliance with the 47 NCAA rules and guidelines (combined N = 3,055). Each CMP was reviewed and graded "yes" or "no" for each recommended or required item and compliance was reported descriptively. Components assessed include: concussion education, pre-participation assessment, recognition/diagnosis of concussion, post-concussion management, return-to-play (RTP), return-to-learn (RTL), and reducing exposure to head trauma. **Main Outcome Measures:** Adherence to NCAA rules and guidelines. **Results:** Overall compliance with NCAA requirements was high (91% [2780/3055]). Areas of high compliance included baseline

assessment (99.1% [322/325]) and RTP (99% [450/455]), where all but one school had 100% compliance. Areas of lesser compliance included RTL (86.4% compliance [618/715]) and reducing exposure to head trauma (92.3% compliance [60/65]). Within RTL, the lowest compliance was with stating that "modification of schedule/academic accommodations for up to two weeks, as indicated, with help from the identified point person," where 21.5% (14/65) did not include this statement. The amount of detail and plan length varied significantly (range: 4 pages to 66 pages). **Conclusions:** Overall compliance with NCAA rules and guidelines was high across CMPs. Areas where CMPs could improve include more frequently specifying RTL considerations, such as when physicians will re-evaluate athletes, as well as specifying instructions following acute concussion, such as providing instructions to a responsible adult in addition to the injured athlete. Furthermore, the level of detail included in the CMPs varied considerably. For example, nearly all CMPs required athletes to participate in a baseline assessment (99.1%). Among these CMPs, many specified the domain assessments required during the baseline (e.g., balance), but fewer specified the specific test to be used (e.g., BESS). Variation in level of detail also took the form of explicitly denoting that a particular item would be left to a clinician's discretion. Having greater CMP specificity may improve the uniformity of care provided to athletes. However, too much detail (e.g., specifying "cut off" scores for a specific test) may inappropriately impede clinical judgement and prevent the individualization of concussion management across athletes. The balance between sufficient CMP specificity and appropriate clinical judgement is an important area for future research.

## Adolescents With Convergence Insufficiency Demonstrate Dual-Task Gait Stability Deficits Following Concussion

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**Context:** Dual-task gait assessments provide information about simultaneous motor and cognitive function, and can assist in monitoring recovery after sport-related concussion. Additionally, initial ocular deficits post-concussion are risk factors for developing persistent symptoms. Limited data exist, however, examining the association between dual-task gait and visual deficits post-concussion. **Objective:** We examined the post-concussion dual-task gait characteristics of adolescents who initially presented to a sport-concussion clinic with and without convergence insufficiency (CI), compared with a group of uninjured, healthy control participants. **Design:** Cross-sectional cohort study. **Setting:** Sports medicine clinic. **Patients or Other Participants:** Twenty-three patients who reported to the clinic were examined within 3 weeks of concussion (mean 9.3 ± 5.4 days post-injury). Of these, 15 patients presented with CI (mean age = 16.9 ± 3.1 years, BMI = 22.6 ± 3.6 kg/m2), 7 presented without CI (mean age = 14.2 ± 2.2 years, BMI = 20.1 ± 2.9 kg/m2). Thirty-eight healthy control subjects also completed the dual-task gait protocol (mean age = 15.4 ± 5.6 years, BMI = 23.1 ± 9.7 kg/m2). **Interventions:** NPC was assessed by measuring the distance from the tip of the nose to the point where the patient reported diplopia while moving a fixation target slowly toward their nose. CI was defined as a NPC distance > 5cm. **Main Outcome Measures:** Gait measures (gait speed, cadence, stride length, and double support time) were obtained using 3 inertial sensors (Opal, APDM Inc., Portland, OR, USA) while patients walked at a self-selected speed and simultaneously completed a mental task (spelling backwards, serial subtraction, and reverse month recitation). Patients also completed the post-concussion symptom scale (PCSS). Univariate ANOVAs were used to compare dual-task performance among those with CI, without CI, and uninjured controls. **Results:** Mean PCSS scores were not significantly different between concussion patients with CI and those without (mean = 24.5 ± 17.9 vs. 22.3 ± 14.1). Those with CI had slower mean gait speed (0.77 ± 0.19 m/s vs. 0.97 ± 0.17 m/s; p = .001), shorter mean stride lengths (0.99 ± 0.14 m vs. 1.15 ± 0.17 m; p = .005), and a lower mean cognitive task accuracy (80.3 ± 22.4% vs. 91.5 ± 7.0%; p = .02) than the uninjured participants. No differences between those without CI and the healthy participants were found for dual-task gait stability or cognitive accuracy. **Conclusions:** Adolescents with CI post-concussion exhibited significant deficits during dual-task walking compared with healthy controls, while those without CI did not display such deficits. Vergence deficits present after concussion may be related to motor system dysfunction. Gait and vergence measures may each contribute useful information to multifaceted post-concussion evaluations.

## A Helmet-Less Tackling Training Intervention to Decrease Head Impacts in American Football

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**Context:** A variety of efforts have been pursued in an attempt to mitigate acute and chronic brain injury risk in American football. For example, researchers have sought improvements in helmet technology, while governing agencies have reduced the number of full-contact practices and altered game rules. However, these do not directly address the fundamental cause of the injury; head impacts. Furthermore, the concept of risk compensation suggests that wearing a helmet contributes to the behavior of involving the head in tackling and blocking. **Objective:** To study the effectiveness of a novel helmetless-tackling intervention to reduce head impact exposure in collegiate football players. **Design:** Prospective, randomized controlled investigation. **Setting:** An NCAA FBS Division I collegiate football season. **Patients or Other Participants:** Fifty players with at least two years eligibility were stratified by position (offense, defense) and randomized equally (n = 25) to treatment or control groups after providing consent. Interventions: The treatment consisted of Helmetless Tackling Training (HuTT®) drills performed twice per week during the pre-season (3 weeks) and once per week throughout the competitive season (16 weeks). Drills involved executing tackling techniques against an upright pad or padded shield held by a teammate at 50-75% effort without helmets and shoulder pads. The control group underwent non-contact football skills at the same frequency and duration. Both treatment and control activities were supervised by the football coaching staff following standardized instruction. Subjects were assigned an xPatch™ impact sensor which was worn to record head impacts sustained during each practice and game. Subject attendance was recorded for all HuTT® interventions and team sessions (practices and games). **Main Outcome Measures:** Frequency of all impacts ≥10g threshold of linear acceleration were filtered and exported into spreadsheet format. Frequency of head impacts per athlete exposure (AE) were compared between groups at three timepoints (pre, mid, and end of season) using repeated measures analysis of variance (ANOVA). Significant interactions and main effects ($P < .05$) were followed with dependent and independent t-tests. **Results:** The HuTT® intervention resulted in a 28% reduction in head impact frequency/AE (13.84 ± 7.27 versus 9.99 ± 6.10) at the end of the season, while the control group frequency remained the same ($P = .009$). By the end of the season, the intervention group experienced an average of 30% fewer impacts/AE (9.99 ± 6.10 versus 14.32 ± 8.45) compared to the control group ($P = .045$). **Conclusions:** While a helmet is necessary during full contact practices and games, it also conveys a false sense of security that enables impacts to the head. These data suggest that practicing tackling and blocking without a helmet under a controlled, supervised environment improved tackling behavior by reducing head impact frequency in collegiate football players after one season. Future research is necessary to determine the effect with football participants on other levels of play (youth, high school).

## The Ability of an Aftermarket Helmet Add-On Device to Attenuate Impacts During Drop Tests

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**Context:** The Guardian Cap (Guardian, Apharetta, GA) provides a soft covering intended to mitigate energy transfer to the head during football contact. However, it remains unknown how well they attenuate impacts. **Objective:** To evaluate the changes in GSI and linear acceleration during drop tests on helmeted head forms with and without Guardian Caps. **Design:** Crossover study. **Setting:** Temperature controlled laboratory (72 ± 5 degrees F). **Patients or Other Participants:** Three Riddell Speed helmets that came directly from the manufacturer in new condition were used for the study. **Interventions:** We dropped the helmets at three velocities on six helmet locations (front, side, right front boss, top, rear right boss, and rear) as prescribed by the National Operating Committee on Standards for Athletic Equipment (NOCASE) for football helmets. Helmets were tested with facemasks in place but no Guardian Cap followed by retesting with the facemasks in place with the Guardian Cap affixed properly as per manufacturer guidelines. Main Outcome Measures: The Gadd Severity Index (GSI) scores and linear accelerations measured in g forces were used as our dependent variables. We used repeated measures ANOVAs with location as the repeated factor to determine the effect of Guardian cap presence on GSI scores. **Results:** All 18 trials passed the NOCSAE standard at all 3 velocities at each of the 6 drop locations regardless of whether a Guardian Cap was applied or not. For GSI, there were no statistically significant main effects for the presence of the Guardian Cap at low ($F1,14 = .57$, $P = .46$), medium ($F1,4 = 1.22$, $P = 29$), or high ($F1,4 =$

.97, P = .34) testing speeds. In addition, we found a non-significant interaction between drop location and guardian cap presence at the low (F1.90, 26.62 = .40, P = .66), medium (F1.51, 21.18 = 0.43, P = .60), and high (F1.36, 19.07 = .12, P = .81) velocities. Finally, there were no pairwise significant differences between Guardian Cap condition at any of the testing locations across the 3 velocities. Similarly for linear accelerations, there were no statistically significant main effects for the presence of the Guardian Cap at low (F1,14 = .90, P = .36), medium (F1,14 = 1.11, P = .31), or high (F1,14 = 1.36, P = .26) testing speeds. In addition, we found non-significant interactions between drop location and guardian cap condition at the low (F2.41, 33.79 = 0.68, P = .54, $\omega^2 <$ .001, 1-$\beta$ = .17), medium (F1.72, 24.04 = 0.72, P = .50, $\omega^2 <$ .001, 1-$\beta$ = .15), and high (F1.50, 20.95 = 0.56, P = .56, $\omega^2 <$ .001, 1-$\beta$ = .12) velocities. There were also no pairwise significant differences between Guardian Cap condition at any of the testing locations across the 3 velocities. **Conclusions:** The Guardian Cap failed to significantly improve the helmets' ability to mitigate impact forces. There is limited evidence to indicate how a reduction in GSI would provide clinically relevant benefits beyond reducing the risk of skull fracture or similar catastrophic event. However, our testing did not examine how the guardian cap might mitigate rotational accelerations which may contribute to concussive events.

### A Comparison of Cervical Spine Motion Following Immobilization With Traditional Spine Board and Full-Body Vacuum-Mattress Splint

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**Context:** Current recommendations for cervical spine immobilization include use of a rigid spine board with equipment removal if appropriately trained medical personnel are available. Recently, the use of a full-body vacuum-mattress splint has been described, and proposed to offer rigid cervical immobilization with improved comfort due to body conformity and reduced pressure points. No data exist regarding differences in cervical spine motion based on immobilization technique with and without equipment. **Objectives:** To compare cervical spine motion using a traditional rigid backboard and a full-body vacuum-mattress splint, both with and without equipment. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patient or Other Participants:** 12 healthy males (age = 27.9 ± 6.1 years; height = 185.6 ± 9.8 cm, mass = 104.1 ± 22.9 kg, BMI = 30.4 ± 7.9) volunteered. **Interventions:** Participants were fit with a football helmet and shoulder pads by experienced certified athletic trainers, and immobilized on a rigid backboard (R) and vacuum-mattress split (V). A six-person lift, 30-degree tilt, and table transfer were conducted with equipment (E) and no equipment (NE) using both immobilization techniques. The order of immobilization technique was counterbalanced. **Main Outcome Measures:** Electromagnetic motion capture was used to quantify peak sagittal, frontal, and transverse angular motion of the cervical spine during the lift, tilt, and transfer conditions for each immobilization technique, with and without equipment. Paired t-tests were used to compare peak angular motion between immobilization techniques, with and without equipment. Subjective ratings of perceived comfort and security were measured immediately following the procedures for each immobilization technique using a visual analog scale. **Results:** With football equipment, there were no significant differences in sagittal or transverse plane cervical spine motion between the rigid backboard and vacuum-mattress splint during the static hold, 30-degree tilt, or transfer conditions (all $P > 0.05$). Increased frontal plane motion was observed when using the vacuum-mattress splint during the tilt ($R = 1.86 \pm 0.84°$ vs. $V = 3.05 \pm 2.10°$; $P = 0.058$). With the equipment removed, no differences in sagittal or axial plane motion were detected between immobilization techniques during any condition (all $P>0.05$). Increased frontal plane motion was observed when using the rigid backboard without equipment ($E = 3.89 \pm 2.55°$ vs. $NE = 5.76 \pm 2.44°$; $P = 0.004$). No differences were observed for any condition using the vacuum mattress with or without equipment (all $P > 0.05$). Subjective ratings of comfort and security did not differ between immobilization techniques (all $P > 0.05$). **Conclusions:** The vacuum mattress splint is an acceptable device for immobilization and transfer following a cervical spine injury. Increased coronal plane motion was observed during the 30-degree tilt in participants with equipment on the vacuum splint and participants without equipment on a rigid backboard. Caution should be taken with regard to frontal plane motion under these circumstances.

### Efficacy of Spinal Immobilization and Spinal Motion Restriction in Minimizing Cervical Spine Motion During Patient Transfer

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**Context:** Traditional spinal immobilization (SI) standards have changed in some emergency medical services (EMS) systems to exclude routine spineboard use. Rather, patients are managed by employing spinal motion restriction (SMR); whereby only a cervical collar is applied and a scoop stretcher or sheet are used during ground-to-stretcher and stretcher-to-bed transfers. Data comparing spine motion between SI and SMR are lacking. **Objective:** To compare the effectiveness of SI and SMR in limiting spine motion during two transfer scenarios. **Design:** Counterbalanced crossover. **Setting:** Controlled laboratory. **Patients or Other Participants:** Twenty males without previous history of destabilizing cervical spine injury (age = 20.9 ± 2.2 yrs, mass = 83.4 ± 12.6kg, height = 178.6 ± 7.6cm). **Interventions:** Each participant was fitted with a rigid cervical collar and had inertial measurement unit sensors (MyoMotion IMS system, Noraxon USA, Inc, Scottsdale, Arizona) placed on the center of the forehead and on the sternum 2.54cm inferior to the base of the cervical collar. Participants were transferred using two distinct transfers: from the ground to an EMS stretcher (ground-to-stretcher) then from the stretcher to a simulated hospital bed (stretcher-to-bed). In SI trials, an athletic trainer 1) provided manual stabilization while the participant was secured to a rigid spineboard, 2) coordinated a six-plus-person lift onto the EMS stretcher, and 3) transferred participants onto the hospital bed and

coordinated a log-roll, off the spineboard. In SMR trials, an athletic trainer 1) provided manual stabilization while 4 other rescuers used a scoop stretcher to transfer participants from the ground to the stretcher using a four-corner lift, 2) removed the scoop stretcher leaving the participant resting directly on the stretcher, and 3) coordinated a sheet transfer technique to transfer the participant to the simulated hospital bed. A two-factor repeated measures analysis of variance compared CIM and ROM in each plane ($P \leq 0.05$). **Main Outcome Measures:** Sagittal, frontal, and transverse plane spine motion was measured in SI and SMR conditions for each transfer (ground-to-stretcher, stretcher-to-bed). Dependent variables included cumulative integrated motion (CIM) and peak range of motion (ROM). **Results:** For CIM, a significant condition effect was observed in all planes (sagittal: $F_{1,19} = 28.91$, $P < 0.001$; frontal: $F_{1,19} = 34.52$, $P < 0.001$; transverse: $F_{1,19} = 61.45$, $P < 0.001$). Regardless of transfer technique, SI resulted in greater sagittal (2508.7 ± 1801.2°/s), frontal (1075.5 ± 610.1°/s) and transverse (1128.9 ± 650.6°/s) CIM compared to SMR (sagittal: 1530.2 ± 956.9°/s; frontal: 554.5 ± 236.9°/s; transverse: 482.0 ± 253.8°/s). Additionally, transverse ROM was greater ($F_{1,19} = 25.15$; $P < 0.001$) during SI (11.2 ± 3.7°) compared to SMR (7.3 ± 3.5°). Lastly, frontal ROM was greater ($F_{1,19} = 5.96$; $P = 0.025$) with SI (10.3 ± 2.6°) compared to SMR (7.4 ± 1.9°) during the stretcher-to-bed transfer. **Conclusions:** In our study, SMR resulted in less spine motion when transferring patients on and off an EMS stretcher compared with SI. Although the spine motion required for injury exacerbation is unknown, the concept that less spine motion is better supports using SMR.

## Cervical Spine Motion During Removal of Football Equipment

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**Context:** The National Athletic Trainers' Association had previously recommended deferring equipment removal until the athlete is transferred to an emergency medical facility, however a recent recommendation advocates for the removal of equipment prior to transfer to an emergency medical facility. **Objective:** To assess cervical spine motion during removal of football helmet and shoulder pads using a traditional rigid spine board and full-body vacuum splint. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 12 healthy males (age = 27.9 ± 6.1 years; height = 185.6 ± 9.8cm; mass = 104.1 ± 22.9kg [77.1–139.7kg]) volunteered. **Interventions:** Three electromagnetic sensors were fixed to the lumbar spine, sternum, and custom mouthpiece to 3-dimensionally reconstruct the spine using an electromagnetic motion capture system. Participants were fitted with a football helmet and shoulder pads by certified athletic trainers (ATs), and immobilized on a rigid backboard (R) and vacuum-mattress splint (V). A team of ATs with more than 10 years of collegiate football experience and fellowship-trained sports medicine orthopaedic surgeons maintained in-line cervical stabilization, and removed the helmet and shoulder pads according to standard practice. **Main Outcome Measures:** Peak sagittal, frontal, and transverse cervical spine kinematics were recorded during equipment removal for each immobilization technique. Peak angular motion (degrees) and time-normalized peak angular motion (degrees/second) were compared to assess the influence of duration of equipment removal on cervical spine motion. Paired t-tests were used to compare angular motion during equipment removal between immobilization techniques. Cohen's d effect sizes were calculated to determine the magnitude of differences using each technique. Separate 1x3 ANOVAs were used to detect differences between planes of motion for each technique. **Results:** No differences in sagittal (R = 15.6 ± 9.2 vs. V = 11.7 ± 6.7°; $p = 0.119$), frontal (R = 13.4 ± 5.3 vs. V = 10.6 ± 4.7°; $p = 0.165$), or transverse (R = 15.4 ± 3.8 vs. V = 17.3 ± 6.4°; $p = 0.384$) plane cervical spine motion were detected between immobilization techniques during the process of equipment removal. Small to medium effect sizes were calculated between techniques in the sagittal (d = -0.6 [95% CI -1.3,0.1]), frontal (d = -0.6 [95% CI -1.3,0.1]), and transverse (d = 0.3 [95% CI -0.4,1.0]) planes. Time-normalized peak angular motion was not different between immobilization techniques in the sagittal (R = 0.3 ± 0.1 vs. V = 0.29 ± 0.16°/sec; $p = 0.150$) or frontal (R = 0.5 ± 0.5 vs. V = 0.3 ± 0.1°/sec; $p = 0.659$) planes. Significantly greater transverse plane motion occurred using the vacuum splint (R = 0.3 ± 0.1 vs. V = 0.5 ± 0.2°/sec; $p = 0.021$). Motion did not differ between planes using a rigid board ($p = .663$), however, increased transverse motion occurred compared to sagittal ($p = 0.028$) or coronal ($p = 0.009$) using a vacuum splint ($p = 0.021$). **Conclusions:** The cervical spine moved uniformly in each plane of motion while removing the helmet and shoulder pads of an immobilized individual on a rigid backboard, whereas greater transverse plane motion occurred using the vacuum-mattress splint. Cervical spine motion did not differ between immobilization techniques; however, when normalized to the duration of time taken for equipment removal, increased transverse plane motion occurred using the vacuum-mattress splint.

## Is There Any Advantage to the X-collar Compared to a Traditional Cervical Collar: A Biomechanical Cadaveric Study

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**Context:** Cervical immobilization collars are used in prehospital management of trauma patients with or under suspicion of having a cervical spine injury. The intent is to prevent secondary injury and it has been proposed that the X-collar may have some advantage over traditional collars. **Objective:** We sought to determine the amount of motion generated between C5 and C6 for the X-collar versus a traditional collar during application and subsequent log-roll maneuver. **Design:** Prospective, block randomized, repeated measures. **Setting:** Anatomy and biomechanics surgical skills laboratory. **Patients or Other Participants:** Five fresh-frozen whole human cadavers with surgically prepared C5-C6 ligamentous injuries to simulate a worst case scenario injury. Cervical collars were applied by one EMS paramedic (15 years of experience). The log roll was completed by the EMS physician, two athletic trainers, and two spine surgeons. **Interventions:** The intervention was collar type (X-collar and Ambu Perfit). Order of collar application was randomized. Electromagnetic sensors were placed on the lamina of C5 and C6 for data acquisition. **Main Outcome Measures:** The dependent measures were maximum angular (flexion/extension; lateral bending; axial rotation) and linear (anterior/posterior, medial/lateral and axial translations) motion between C5 and C6 as measured by a Liberty, three-dimensional, electromagnetic motion analysis device (Polhemus Inc., Colchester, VT). These measurements were recorded during application of the collars and during a log-roll maneuver. For each of the six motions analysis was completed using a generalized mixed linear model, which takes into account the non-independent relationship between the three repetitions in each cadaver. **Results:** During X-collar application there was more movement in all planes of motion. When examining angular motion this reached statistical significance in flexion-extension (X-collar 7.4 ± 3.8; Ambu 5.1 ± 2.7 $p = 0.002$) and lateral bending (X-collar 4.1 ± 2.6; Ambu 3.1 ± 1.9 $p = 0.025$). There was also significantly more axial distraction (X-collar 6.1 ± 3.4; Ambu 4.9 ± 2.7 $p = 0.009$) and anteroposterior translation (X-collar 5.5 ± 0.6; Ambu 3.6 ± 0.28 $p = 0.013$). There were no significant differences in motion during log-rolling in any of the 6 motions when comparing between the X-collar and Ambu Perfit (all $p > 0.05$). **Conclusions:** Our data indicates no apparent advantages to using the X-collar over the Ambu Perfit cervical collar during the management of a patient with an unstable cervical spine injury. We did show more motion during the application process of the X-collar as compared to the Ambu Perfit. Given the increased complexity of the X-collar we do not feel it should be used in place of a traditional, commonly used cervical collar such as the Ambu Perfit.

## The Effect of Lacrosse Protective Equipment and Different Airway Management Devices on the Ability to Provide CPR on a Manikin

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**Context:** During acute cardiac emergencies, it is imperative to have expedient access to the patient's airway and chest for performing CPR. Protective equipment worn by lacrosse athletes may present challenges for providing care. **Objective:** To determine if equipment condition (no equipment [NE]; equipment - shoulder pads and helmet with facemask removed [EQ]) would inhibit CPR performance (chest compressions and ventilations). Additionally, we wanted to determine the effects of four different airway management devices (bag valve mask [BVM], oral pharyngeal [OPA], nasal pharyngeal [NPA], King Airway [KA]) on rescue breath performance. **Design:** Cross-sectional. **Setting:** Simulation lab. **Patients or Other Participants:** Five (3 male, 2 female) certified athletic trainers (Age = 33.80 ± 6.76 years; AT experience = 10.80 ± 9.01 years). **Interventions:** The SimMan 3G manikin (Laerdal Medical Corporation, Wappingers Falls, NY) was used for all trials. The manikin was fitted with Core (Brine Inc, Milford, MA) lacrosse shoulder pads and a Warrior Renegade (Warrior Sports, Holingsworth, MI) helmet with the facemask removed for all EQ trials. Participants completed a total of 10 trials (8 in the role of ventilating the patient [two equipment conditions x four airway management devices], 2 in the role of performing chest compressions [NE vs EQ]). Three cycles of CPR were performed during each trial. **Main Outcome Measures:** The dependent variables were ventilation volume (mL), rate (#/min) of ventilations, depth (mm) of compressions, and rate (#/min) of compressions. Separate 2 x 4 ANOVAs were used to evaluate

the main and interactive effects of the equipment condition and the airway management device on ventilation rate and ventilation volume with Bonferroni post hoc tests for pairwise comparisons. T-test was used to evaluate differences in chest compression rate and compression depth between equipment conditions. Alpha levels were set at $p \leq 0.05$ a priori. **Results:** We found a significant main effect for equipment condition ($p = 0.01$) and a significant main effect for airway management device ($p = 0.001$) for the ventilation volume, but no interaction, and no significant effects for ventilation rate. All airway devices except KA (720.00 ± 44.72 mL) failed to meet the 400 mL threshold recommended by American Heart Association in EQ conditions. All airway devices reached the 400mL threshold in NE conditions, with KA being greatest (740.00 ± 22.36 mL). There was no significant difference for compression rate ($p = 0.79$, NE [115.60 ± 10.95/min] vs E [116.40 ± 14.57/min]) or compression depth ($p = 0.23$, NE [42.80 ± 8.29 mm] vs E [41.80 ± 9.04 mm]). **Conclusions:** Lacrosse shoulder pads did not affect chest compression depth and may not need to be removed for CPR compressions. The KA produced the highest ventilation volume in both the NE and EQ conditions, and may be the suggested airway management device for an athlete with a helmet in place and facemask removed, since it does not require the seal of the pocket mask.

### Cardiopulmonary Resuscitation and Automated External Defibrillator Certification of Club Coaches in Alaska, Idaho, Oregon, Montana, and Washington

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**Context:** Annually, 7.8 million student-athletes participate in interscholastic sports, many of which also practice their sport with an outside club. It is unknown as to the cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) qualifications of coaches for these teams. **Objective:** (a) To identify the prevalence of CPR and AED training/certification for club sport coaches in five states, and (b) To assess the availability of AEDs at practices and games. **Design:** Cross sectional. **Setting:** On-line survey. **Patients or Other Participants:** 86 club coaches (Volleyball n = 62, 72%; Softball n = 6, 6%; Baseball n = 13, 15%; Other n = 5, 5%) responded to an email and social media request for participants. Of those who responded, 61 (70.9%) were head coaches and 25 (29.1%) fulfilled another role (administration, volunteer, assistant). Responses were stratified by state (Alaska n = 12, Washington n = 39, Oregon n = 15, Idaho n = 11, Montana n = 6). **Interventions:** Participants completed an online survey via SurveyMonkey that consisted of demographic information (e.g. sport coached, age group, gender, state, position held) and sections regarding: 1) certifications they possess, 2) how far away an AED is from practice, and 3) how far away an AED is from game events. Content validity was established by a panel of experts. **Main Outcome Measures:** Descriptive statistics (frequencies and percentages) described prevalence of CPR and AED training. Additionally, availability of AEDs were calculated. Pearson's correlations determined relationships between CPR and AED training by state and sport, as well as AED availability at practice and games. Alpha was set at $P < 0.05$. **Results:** Not all coaches identified having CPR (Volleyball n = 64, 73.8%; Softball n = 6, 50%; Baseball n = 13, 72.7%; Other n = 5, 100%) and/or AED training (Volleyball n = 60, 58.3%; Softball n = 6, 50%; Baseball n = 12, 41.7%; Other n = 5, 60%). By state, those coaches with both certifications were Alaska (n = 13, 69.2%), Washington (n = 40, 75%), Oregon (n = 16, 81.3%), Idaho (n = 12, 41.7%), and Montana (n = 7, 28.6%). The majority of coaches reported having an AED at practice (n = 43, 54.4%). 12.7% (n = 10) reported no AED at practice, while 32.9% (n = 26) did not know the availability of an AED at practice. For games, there were fewer coaches identifying the availability of an AED (n = 36, 43.4%), with 6% (n = 5) reporting no AED at games, and 50.6% (n = 42) not knowing of the availability at games. **Conclusions:** While the majority of coaches report CPR and AED training there are conflicting responses in that several coaches did not select both CPR and AED training although AED is a part of all CPR training courses. There was no consistency as to the availability of an AED at practices or games. Though this is a small sample of coaches, it demonstrates a need for all coaches to have CPR and AED training, as well as access to AEDs at both practices and games. .

## Head/Spine Evidence-Based Forum: Inter-Professional Practice of EMS & Athletic Trainers in the Pre-Hospital Management of the Injured Athlete: Bridging the Gap

Friday, June 24, 2016, 8:45AM-9:45AM, Room 314; Moderator: Darryl Conway, MA, ATC
Discussants: Edward Strapp, ATC, WEMT-P; Ellen Payne, PhD, LAT, ATC; Andrew Pollock, MD

### The Effectiveness of Rehabilitation for Improving Patient-Reported Outcomes Associated With Chronic Ankle Instability: A Systematic Review With Meta-Analysis

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**Context:** Health-related quality of life (HRQL) assessment has become an essential aspect of evaluation and rehabilitation delivery for people with chronic ankle instability (CAI). Although multiple studies have examined HRQL following rehabilitation, it is unclear whether current rehabilitation strategies improve HRQL for those with CAI. **Objective:** To conduct a systematic review with meta-analysis assessing the effectiveness of rehabilitation programs for improving HRQL in individuals with CAI. Data Sources: Electronic databases (Pubmed, MEDLINE, CINAHL, and SPORTDiscus) were searched from inception to September 2015. Search limits were set to full-text publications written in English. A hand search of references was also conducted. **Study Selection:** The inclusion criteria required that studies examined the effects of a conservative rehabilitation protocol in those with CAI, utilized validated patient-reported outcomes (PRO) to quantify participant perceived HRQL, and provided adequate data for the calculation of effect size (ES) and 95% confidence intervals (CI). Studies were excluded if they evaluated surgical interventions, prophylactic taping or bracing applications, or if only immediate effects of a single treatment session were examined. **Data Extraction:** Two investigators independently assessed methodological quality with the Physiotherapy Evidence Database (PEDro) scale. Studies were considered low quality if <60% of the criteria were not met. The level of evidence was assessed using the Oxford Center of Evidence-Based Medicine Levels of Evidence. Pre-intervention and post-intervention sample sizes, means, and standard deviations of PROs were extracted from included studies. **Data Synthesis:** Fourteen studies provided 21 participant groups that were included in the analysis. Six high quality studies were identified with a median PEDro score of 50% (range = 10-80%). The median level of evidence was 2b with a range from 4 to 1b. Fourteen groups utilized the Foot and Ankle Ability Measure (FAAM) Activities of Daily Living and Sport subscales which were pooled for analysis. Three groups utilized only the FAAM-Sport subscale and four groups used the Cumberland Ankle Instability Tool. The magnitude of pre-intervention to post-intervention PRO differences were determined with bias-corrected Hedge's g ES. A random-effects meta-analysis was performed to synthesize HRQL changes across all participant groups. Positive ES values indicated improvements in PRO scores at post-intervention compared to pre-intervention. Significance was set at $p < 0.05$. Meta-analysis revealed a strong ES with a non-overlapping 95% CI (ES = 1.20, CI = 0.80-1.60, $p < 0.001$) indicating HRQL significantly improved following conservative rehabilitation. Based on the quality of the evidence and the results of the meta-analysis, there is grade B evidence that conservative rehabilitation produces large magnitude HRQL improvements in people with CAI. Conclusions: This meta-analysis indicates that people with CAI report meaningful improvements in region-specific HRQL following conservative rehabilitation strategies. Thus, the current evidence-based interventions for those with CAI should be employed within clinical practice to enhance HRQL in this patient population.

### The Effect of Static Stretching and Joint Mobilization on Self-Reported Function in Individuals With Chronic Ankle Instability

Pathoomvanh MM, Powden CP, Feldbrugge CM, Welsch LA, Hoch MC: Old Dominion University, Norfolk, VA

**Context:** Individuals with chronic ankle instability (CAI) have reported decreased health-related quality of life (HRQL). To address these deficits, clinicians have utilized manual therapy techniques including talocrural joint mobilizations (JM). However, the effect of talocrural JM used in amalgamation with gastroc-soleus stretching on a broad spectrum of patient-reported outcome (PRO) instruments encompassing global well-being, region-specific function, and dimension-specific fear of re-injury, has not been examined in individuals with CAI. **Objective:** Determine the effect of a 4-week JM and static stretching intervention on self-reported function in individuals with CAI. **Design:** Single-blind, pretest-posttest design. **Setting:** Laboratory. **Patients or Other Participants:** Ten adults (5 males; age = 24.20 ± 4.32years; height = 171.56 ± 10.14cm; weight = 80.01 ± 24.15kg) 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, <24 on the Cumberland Ankle Instability Tool, and >24 on the Godin Leisure-Time Exercise Questionnaire. **Interventions:** Participants completed a 4-week static stretching and JM intervention. The static stretching intervention was completed at home daily for four weeks and included two stretches targeting the gastroc-soleus complex. Stretches were held for 30 seconds and repeated three times each. The JM intervention included six treatment sessions of Maitland Grade III talocrural joint traction followed by

four, two minute sets of Maitland Grade III anterior-to-posterior talocrural JM. Self-reported function was measured using the Disablement in the Physically Active Scale (DPA), the ADL and Sport subscales of the Foot and Ankle Ability Measure (FAAM-ADL, FAAM-Sport), a reduced-item FAAM (Quick-FAAM), and the Physical Activity (PA) and Work subscales of the Fear Avoidance Behavior Questionnaire (FABQ). Each PRO instrument was completed immediately before the first treatment and 24 hours following the end of the 4-week intervention. **Main Outcome Measures:** The independent variable was time (pre-intervention and post-intervention). The dependent variables were scores on the DPA, FAAM-ADL, FAAM-Sport, Quick-FAAM, FABQ-PA, and FABQ-Work. Descriptive statistics were calculated using median and interquartile range. For each dependent variable separate Wilcoxon tests examined the differences in pre-intervention and post-intervention scores. Alpha was set a priori at $p<0.05$. **Results:** Significant improvements in HRQL were identified between pre-intervention and post-intervention using the FAAM-ADL (Pre = 88.69 [9.24], Post = 94.64 [8.93], p = 0.038), Quick-FAAM (Pre = 81.25[7.81], Post = 85.42[12.5], p = 0.021) and FABQ-PA (Pre = 11.50 [6.5], Post = 8.00 [6.5], p = 0.023). No significant differences were identified for the DPA, FAAM-Sport, FABQ-W ($p > 0.066$). **Conclusions:** A combined intervention of JM and gastroc-soleus complex stretching improved self-reported function in individuals with CAI. Specifically, participants reported improved ankle function as well as less injury-related fear during physical activity. No differences were discovered using PRO measures of global function following the intervention. Future research should examine the effect of JM and static stretching on self-reported function when used in combination with other interventions.

## Effects of Rehabilitation With and Without Destabilization Devices on Lower Extremity Joint Coupling Variability in Chronic Ankle Instability Patients

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**Context:** Chronic ankle instability (CAI) has been associated with kinematic changes in the lower extremity. Alterations in joint-coupling variability have been identified during walking and jogging gait in CAI patients compared to healthy patients. Conservative rehabilitation remains the gold standard for treatment in CAI patients but little is known about the effects of rehabilitation on lower extremity joint-coupling. Previously, wearable destabilization devices have shown an increase in muscle activity during functional tasks potentially increasing the effects of rehabilitation on musculature around the ankle joint. **Objective:** To assess the lower extremity joint-coupling during walking gait prior to and following a 4-week comprehensive rehabilitation program performed with and without wearable destabilization devices. **Design:** Randomized control trial. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** Twenty-six young active individuals with CAI participated (Device Group: n = 13, Sex:4 males, 9 females, Age = 21.3 ± 3.4 years, height = 168.8 ± 6.9cm, mass = 66.1 ± 12.9kg, Pre-rehabilitation FAAM Sport = 67.1 ± 13.4%, Post-rehabilitation FAAM Sport = 85.8 ± 8.3%; No Device Group: n = 13, Sex: 3 males, 10 females, Age = 21.5 ± 2.8 years, height = 169.1 ± 10.6cm, mass = 75.3 ± 13.7kg, Pre-rehabilitation FAAM Sport = 65.9 ± 18.2%, Post-rehabilitation FAAM Sport = 86.8 ± 11.4%). **Interventions:** Patients were randomly assigned to 4 weeks of comprehensive supervised ankle rehabilitation with or without ankle destabilization devices. All rehabilitation included range of motion, strength, static and dynamic balance, functional lower extremity exercises and treadmill walking. An electromagnetic 3D motion capture system was used to collect lower extremity kinematics during 15 trials of walking across a 10m long walkway at self-selected pace. A vector coding analysis was used to assess lower extremity joint coupling variability (VCV) of the knee and hip motion relative to the ankle. **Main Outcome Measures:** Joint coupling variability (0 = no variability, 1 = maximal variability) for knee sagittal-ankle sagittal (KSAS), knee sagittal-ankle frontal (KSAF), hip frontal-ankle sagittal (HFAS) and hip frontal-ankle frontal (HFAF) joint couples were compared across the walking gait cycle between pre- and post-rehabilitation for each group. Groups means and 90% confidence intervals were compared for intervals where the confidence intervals did not overlap for at 3 consecutive percentage points. Such differences were considered statistically significant and pre-post mean differences were then calculated across these intervals. **Results:** The Device Group had significant decreases in VCV following rehabilitation in HFAS (44-47%, mean difference = 0.11 ± 0.02, 67-70%, mean difference = 0.12 ± 0.05) and KSAS (0-5%, mean difference = 0.19 ± 0.05, 63-66%, mean difference = 0.09 ± 0.03) joint couples during walking gait. There were no significant pre-post rehabilitation differences identified in the No Device Group. **Conclusions:** The decrease in joint coupling variability may represent a change in the sensorimotor organization that may provide a protective role in CAI patients following rehabilitation using destabilization devices. The addition of destabilization devices may present unique task and environmental constraints during rehabilitation which challenges CAI patients to develop adaptations in control of the lower extremity. The use of destabilization devices may be used in rehabilitation to maximally challenge CAI patients.

## A Clinical Prediction Rule for Patients With Chronic Ankle Instability Who Respond to Plantar Massage Treatments

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**Context:** Plantar massage has been shown to improve patient-reported disability group means in chronic ankle instability (CAI) patients. However, it is likely that some patients fail to improve following the massage intervention while others have profound improvements. Currently there are no data available to help identify which CAI patients are more likely to have improvements in patient-reported disability following plantar massage interventions. **Objective:** To develop a preliminary clinical prediction rule (CPR) that identifies which CAI patients are most likely to show meaningful improvement in patient-reported disability following 2-weeks of plantar massage. **Design:** Prospective cohort study. **Setting:** Research Laboratory. **Patients or Other Participants:** 19 patients with self-reported CAI (age: 22.26 ± 2.81years; height: 172.34 ± 7.97cm; mass: 75.44 ± 14.15kg) volunteered to participate. CAI was defined as ≥2 episodes of "giving way" within the past 6 months (mean: 5.36 ± 4.74); scoring <90% on the Foot and Ankle Ability Measure (FAAM) (mean: 76.75 ± 12.85%, and scoring <80% on the FAAM-Sport (mean: 62.66 ± 13.59%). **Interventions:** Patients received 6, 5-minute plantar massage treatments consisting of petrissage and effleurage over a 2-week period. **Main Outcome Measures:** Treatment success, defined as either a change in Foot and Ankle Ability Measure (FAAM) activities of daily living subscale or a change in FAAM-Sport (FAAM-S) scores that exceeded the minimal detectable change (FAAM: 4.8%, FAAM-S: 7.6%) for each outcome after the 2-week intervention. Potential predictor variables such as patient and injury demographics as well as baseline FAAM, FAAM-S, dorsiflexion range-of-motion (weight-bearing lunge test [WBLT]), single limb balance scores and associated asymmetry indices of the baseline assessments were entered into a stepwise logistic regression model to determine the most accurate set of variables for predicting FAAM and FAAM-S treatment success. **Results:** The treatment was considered successful for 10 out of 19 patients (52.63%) based on the FAAM and 8 out of 19 (42.11%) based on the FAAM-S. Patients with a successful treatment averaged 10.62 ± 5.69% and 19.10 ± 6.60% improvements in their FAAM and FAAM-S scores, respectively, while patients without a successful treatment averaged a 2.51 ± 3.54% and -0.57 ± 6.52% improvement in their FAAM and FAAM-S, respectively. If a patient was <23 years old and had a baseline FAAM score ≤83.33%, they had a 99% chance of having a meaningful improvement in their FAAM scores. Similarly, if a patient was <22 years old and ≤9.9cm on the WBLT, they had a 99% chance of having a meaningful improvement in their FAAM-S scores. **Conclusions:** Our preliminary CPR suggests that younger CAI patients with more severe impairment during activities of daily living are highly likely (99%) to have meaningful FAAM score improvements following a 2-week plantar massage intervention. Additionally, younger CAI patients with greater dorsiflexion deficits are highly likely (99%) to have meaningful FAAM-S score improvements following a 2-week plantar massage treatment.

# Free Communications, Oral Presentations: Seasonal Effects on Concussion Assessment Performance

Friday, June 24, 2016, 5:00PM-6:00PM, Room 314; Moderator: David Howell, PhD, ATC

### Resultant Effects of Head Impacts on Vestibular Function Among NCAA Division I Male Lacrosse Players

Vander Vegt CB, Gobert DV, Miyashita TL, Vela LI, Harter RA: Texas State University, San Marcos, TX, and Sacred Heart University, Fairfield, CT

**Context:** Few studies have evaluated the cumulative effects of the number and magnitude of head impacts on vestibular function among collegiate men's lacrosse players. **Objective:** To determine the influence of the total number of head impacts (THI), peak linear acceleration, and Head Injury Criteria (HIC) score on vestibular ocular reflex (VOR) function after one competitive collegiate lacrosse season. **Design:** Prospective cohort. **Setting:** Combined field-based and laboratory study. **Patients or Other Participants:** 41 male NCAA Division I lacrosse players (age = 20.6 ± 1.4 yrs, height = 181.9 ± 6.6 cm). **Interventions:** Head impact measures were collected with the GForce Tracker™ system, and included total number of head impacts greater than 20 g (THI), magnitude of head impacts as assessed by peak linear acceleration, and Head Injury Criteria (HIC) score. Paired samples t-tests were used to compare the pretest and posttest VOR results. A multiple regression approach was used to explore the contributions of accelerometer variables, participant-reported number of previous concussions, and symptom severity during VOR testing to the post-season VOR measurements ($\alpha = 0.05$). **Main Outcome Measures:** VOR parameters, as assessed by the inVision™ system included: maximum gaze velocity of the gaze stabilization test (GST) yaw, visual acuity difference of the dynamic visual acuity test (DVA) for pitch and yaw head movements, and absolute change in directional bias for each test. **Results:** A total of 8,648 impacts were recorded during the 2015 NCAA lacrosse season among the 32 athletes who participated in the post-season VOR assessments. Multiple regression analyses indicated that the total number (mean, 270.3 + 158.2), peak linear acceleration (mean, 50.9 + 158.2 g), HIC score (mean, 33.9 + 38.3), and symptom severity (mean, 2.35 + 2.97) were not significantly related to the changes observed in vestibular function ($R = 0.201$ to $0.535$, $P > 0.05$). However, participant-reported number of previous concussions was significantly related to the absolute change in directional bias during the GST ($P = .036$). The absolute change in directional bias of participants' vestibular system was 6.64 + 19.57 for GST, 2.25 + 10.73 for DVA pitch, and 2.90 + 8.03 for DVA yaw ($P > 0.05$). **Conclusions:** Participant-reported concussion history had the greatest influence on changes in VOR directional bias measures and vestibular asymmetry in collegiate male lacrosse players over the course of one competitive season. These findings support the inclusion of vestibular assessment and treatment in concussion management protocols to improve patient care and health related quality of life among lacrosse participants with previous medical histories of concussion. Supported by a Southwest Athletic Trainers' Association Graduate Student Research Grant.

### The Impact of a Competitive Lacrosse Season on BESS Scores in Athletes Who Did Not Reportedly Sustain a Concussion

Miyashita TL, Diakogeorgiou E, Marrie K: Sacred Heart University, Fairfield, CT

**Context:** Concussions can disrupt the integrity of the vestibular system, and dysfunction within the vestibular system is the proposed etiology for balance deficits associated with a concussion injury. Balance disturbances are self-reported in approximately 30% of concussion cases, and balance deficiencies can last for up to 30 days after initial injury. Evaluation of sub-concussive impacts on neurological function is currently in its infancy, but it is theorized that cumulative sub-concussive impacts will result in neurological deficits including balance. **Objective:** To determine the effect of a competitive men's lacrosse season on BESS scores, and to determine if a change in scores correlated to head impact data received from accelerometers placed within the players' helmets. **Design:** Prospective Longitudinal Study **Setting:** Athletic Training Room **Patients or Other Participants:** 34 Division I Men's Lacrosse players (age = 19.59 ± 1.42 years) **Interventions:** Competitive men's lacrosse season **Main Outcome Measures:** Subjects performed pre and post-season BESS tests, and score differentials were correlated to their head impact data (average linear acceleration, HIC, GSI scores, and total number of head impacts for the season) received from the accelerometers. **Results:** There was not a significant correlation found between BESS scores and head impact data. The number of errors from pre to post season increased during the double leg stance on foam ($p < .001$), tandem stance on foam ($p = .009$), total number of errors on a firm surface ($p = .042$), and total number of errors on a foam

surface (p = .007). Errors committed during the double leg stance on foam: pre = .029, SD = ± .171; post = .559, SD = ± .86. Errors committed during the tandem stance on foam: pre = 3.56, SD = ± 1.69; post = 4.79, SD ± 1.97. Total number of errors committed on a firm surface: pre = 3.6, SD = ± 2.5; post = 4.69, SD = ± 2.5. Total number of errors committed on the foam surface: pre = 9.4, SD = 2.68; post = 11.46, SD = ± 3.99. **Conclusions:** There does not appear to be a correlation between head impact data collected over the course of 1 season (total number of head impacts, average linear acceleration/impact, average HIC score/impact, and average GSI score/impact) and the change in BESS scores observed from pre to post-season. The BESS test may not be sensitive enough to detect balance deficits associated with cumulative sub-concussive impacts. However, the significant increase in the number of errors committed from pre to post season gives support to the recommendation for frequent assessment of baseline levels.

## Cumulative Change in Ocular Near Point of Convergence in Response to Football Subconcussive Head Impact

Kawata K, Lee JH, Sim T, Takahagi M, Assari S, Szwanki V, Bellamy Al, Darvish K, Tierney RT, Langford D: Temple University, Philadelphia, PA

**Context:** Given subconcussive impacts occur far more frequently than concussive blows, understanding the cumulative subconcussive effect is needed. In a laboratory study using controlled mild soccer heading impacts we recently identified statistically significant increase in ocular near point of convergence (NPC). **Objective:** To investigate our hypothesis that cumulative on field subconcussive head impacts would cause an increase in NPC. **Design:** Longitudinal observational study **Setting:** Clinical/field **Patients or Other Participants:** Thirty-four Division I collegiate football players (mean age, 20.63 +/- 1.4 years old) volunteered to participate and signed an IRB approved consent form. **Interventions:** The independent variables were group (low impact versus high impact) and time (six NPC collection sessions). During pre-season physical screening, participants were fit with the Vector mouth guard (10 g threshold) that recorded head impact kinematics during five practices, with 3-4 day interval between each data collection. Based on the kinematic data, players were categorized into low (n = 7) and high (n = 23) impact groups (number of impacts, 6.3 +/- 5.6 vs. 43.1 +/- 18.3; average per player total practice linear acceleration, 177.8 +/- 181.6 g vs. 1297.8 +/- 558.1 g; average per player total practice angular acceleration, 9532 +/- 9112 rad/s2 vs. 65753 +/- 29696 rad/s2, respectively). The NPC scores were obtained before preseason for baseline and before each practice (6 total times). Data were analyzed with a 2x6 repeated measures ANOVA and appropriate follow-up tests using IBM SPSS Statistics Version 21 ($p < 0.05$). **Main Outcome Measures:** During the NPC assessment participants were seated and a visual target was moved towards the eyes at 1cm/sec using an accommodative ruler. The participant signaled when they experienced diplopia or deviation of the eye was observed, and the distance was recorded in centimeters. One tester assessed NPC for all data collection sessions (intra-rater reliability: $r = 0.93$; $p < 0.01$) **Results:** There was a statistically significant Group x Time interaction for NPC, $F(5,125) = 3.354$, $p = 0.007$. Follow-up one-way ANOVAs within each group over time indicated a significant main effect for the high impact group only, $F(5,110) = 6.552$, $p < 0.001$. Conversely, the low impact group showed no difference in NPC scores over time, $F(5,30) = 1.04$, $p = 0.415$, baseline (5.32 +/- 1.7cm), Practice-1 (5.69 +/- 1.7cm), Practice-2 (5.44 +/- 2.3cm), Practice-3 (4.66 +/- 2.0cm), Practice-4 (5.03 +/- 1.7cm), and Practice-5 (4.93 +/- 2.2cm). Post-hoc paired t-test indicated high impact group NPC scores from Practice-3 (8.14 +/- 2.9cm; $p < 0.05$), Practice-4 (7.96 +/- 2.3cm; $p < 0.05$), and Practice-5 (7.97 +/- 2.7cm; $p < 0.05$) were significantly higher (worse) than baseline (6.33 +/- 2.7cm) and Practice-1 (6.46 +/- 1.9cm). **Conclusions:** Repetitive subconcussive head impacts during pre season practices affect NPC. The change could be due to the number and magnitude of subconcussive head impacts sustained. The clinical meaningfulness of this change is unknown and needs further study.

## A Comparison of Neurocognitive Changes Over One Competitive Season in Adolescent Contact and Non-Contact Athletes

Long AS, Price DE, Niemeier JP, McWilliams AM, Patterson CM, Templin M: Carolinas HealthCare System, Charlotte, NC

**Context:** Concern exists over the possibility of short term neurocognitive dysfunction related to participating in contact sport. Much is still not understood regarding differences in sport participation on neurocognitive function in adolescent males. **Objective:** Investigate neurocognitive function in healthy contact (C) and non-contact (NC) male, high school athletes before, during, and after the season. **Design:** Prospective Cohort **Setting:** Computer Laboratory **Patients or Other Participants:** Fifty-three male athletes participated as part of a voluntary sample. Twenty six football players (mean age = 15.77 ± 1.14 years) and 26 cross country runners (mean age = 15.23 ± 1.14) completed the study. **Interventions:** We administered the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) to each participant at pre-, mid-, and post season. Additionally, subjects in the C cohort were subdivided into groups according to age of first participation in contact, tackle football: five to nine years old (n = 12) and 10-14 years old (n = 14). **Main Outcome Measures:** Demographic variables and symptom and composite scores (verbal memory, visual memory, processing speed, and reaction time) were compared between the two groups of athletes at three points in time. Chi-square tests were performed to compare the frequency of history-related items that are known to affect outcomes of neurocognitive testing in each group. Student's t-test was used for data measured on an interval scale and the Wilcoxon rank sum test was employed for non-normally distributed variables. **Results:** Although there was no significant interaction effect in any composite score between C and NC subjects over one season, C players' mean Verbal Memory composite score decreased significantly (p = .006) over preseason (81.31 ± 11.34), midseason (80.85 ± 10.14), and post-season (74.15 ± 15.15). Contact players' visual motor speed composite score also significantly increased (p = .023) over preseason (34.55 ± 7.21), midseason (36.30 ± 8.14) and post season (37.96 ± 8.91).Contact athletes who began playing football between the ages of 5-9 scored lower in verbal (p = .042) and visual memory (p = .010) and visual acuity (p = .021) than participants who began playing football between the ages of 10-14. The younger group also showed a decline in visual memory over time, while visual memory remained constant for those who began playing football in the older age group (p = .002). **Conclusions:** C athletes experience significant changes over one season, but not compared to NC athletes. Athletes commencing participation in contact football at younger ages displayed decreased performance, overall, than those who began after age 9. Further research with larger samples is needed to examine a comparison between sport types over time on neurocognitive measures and the additional potential modifier of age at first play.

### Lower Extremity Muscle Volume Symmetry in College Basketball Players


Leitch L, Slater LV, Hertel J, Hart JM: University of Virginia, Charlottesville, VA



**Context:** Limb symmetry is often used as an indicator of recovery when making return to activity decisions following major athletic injury or surgery, however this assumes all healthy athletes are symmetrical. **Objective:** To compare lower extremity muscle volume between limbs in elite and club men's basketball players. **Design:** Descriptive, case series. **Setting:** Laboratory. **Patients or Other Participants:** 6 Division I varsity basketball players (21.3 ± 0.5 years, 100.1 ± 9.2 kg, 199.0 ± 5.9 cm) and 6 age-matched club basketball players (21.9 ± 1.5 years, 83.9 ± 10.9 kg, 188.4 ± 8.1 cm). **Interventions:** Muscle volumes were collected via magnetic resonance imaging scans from T12 to malleoli and calculated using custom Matlab software. **Main Outcome Measures:** Height-mass normalized muscle volumes were calculated for 35 individual muscles. Left leg muscle volumes were compared to the right leg and converted to z-scores with 95% confidence intervals. Absolute values of z-scores were interpreted as symmetric ($1 > z > 0$ SD) or asymmetric ($z \geq 1$ SD). Confidence intervals (CI) that did not overlap were considered statistically significant between varsity and club players. **Results:** Varsity players demonstrated asymmetry in the adductor longus (z = 1.08 [CI: 0.22,1.94]), adductor magnus (z = 1.21 [CI: 0.24,2.18]), external rotators (z = 8.36 [CI: 1.67,15.05]), obturator externus (z = 2.97 [CI: 0.59,5.35]), pectineus (z = 1.38 [CI: 0.28,2.48]), piriformis (z = 2.45 [CI: 0.49,4.41]), and semimebranosus (z = 1.45 [CI: 0.29,2.61]). No asymmetry was noted in any lower extremity muscles in club players. Confidence intervals did not overlap between the varsity and club players for the adductor longus, adductor magnus, external rotators, obturator externus, pectineus, or semimembranosus. **Conclusions:** Non-uniform distribution of muscle was noted in elite athletes while recreational club players were symmetrical. These differences between elite and club players indicate that symmetry may not always be an appropriate measure of readiness to return to activity dependent on level of performance.


### Relationships of Ultrasound-Based Knee Cartilage Thickness Measures to a MRI-Based Gold Standard


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**Context:** Establishing clinically accessible measures associated with maintenance of cartilage health are critical for assessing the effectiveness of protocols to reduce risk of osteoarthritis (OA) development and progression. Cartilage thickness is one important measure in describing both OA development and progression. Magnetic resonance imaging (MRI) is a gold standard for assessing knee cartilage thickness, but this measure is clinically limited with regard to access and cost. Ultrasound measures of knee cartilage may offer a more clinically available and less expensive alternative. However, little is understood about the association of ultrasound and MRI measures of knee femoral cartilage. **Objective:** To determine the relationship between ultrasound and MRI measures of the femoral cartilage in the medial knee. **Design:** Cross-sectional. **Setting:** Controlled laboratory. **Patients or Other Participants:** Five healthy females (1.67 ± .05m, 55.9 ± 7.3kg, 21.6 ± 1.5yrs) and five healthy males (1.81 ± .07m, 77.7 ± 3.7kg, 22.0 ± 0.7yrs) were recruited. **Interventions:** Knee medial femoral condyle articular cartilage was obtained via T1 weighted MRI scans (3T, voxel size 0.5x0.5x0.5mm) and with a 15 MHz linear ultrasound transducer. **Main Outcome Measures:** Mean medial femoral condylar cartilage thicknesses of the left limb were measured via MRI and ultrasound imaging from anterior, middle, and posterior medial femoral sub-regions. Additionally, the clinically dominant

transverse ultrasound measure was performed. Pearson correlations examined relationships between MRI and ultrasound measures. **Results:** Mean MRI-based cartilage region thicknesses: anterior = 3.9 ± 0.6 mm; middle = 4.0 ± 0.7 mm; and posterior = 4.3 ± 0.8 mm. Mean ultrasound-based region thicknesses: anterior = 2.0 ± 0.6 mm; middle = 1.9 ± 0.5 mm; posterior = 1.6 ± 0.4 mm; and transverse = 2.0 ± 0.4 mm. MRI measures of medial femoral condyle cartilage were strongly positively correlated with ultrasound measures in the longitudinal middle (r = .79, P = .007) and posterior (r = .75, P = .012) portions, but not in the anterior region (r = -.041, P = .910). With respect to transverse ultrasound measures, there was a significant relationship to the MRI-based middle region (r = .75, P = .012), but not anterior (r = .40, P = .257) and posterior (r = .55, P = .098) regions. **Conclusions:** Given the strong correlation between MRI and ultrasound measures of cartilage thickness in the medial femoral condyle of the knee, these results suggest that ultrasound is a viable clinical tool to assess cartilage thickness changes in the middle and posterior medial femoral regions. The inability to predict anterior thickness is likely a function of the location of ultrasound transducer. However, the validity of the ultrasound measure is called into question due to the larger MRI-based thickness measures. Future work is needed to establish improved ultrasound methods to assess anterior sub-region measures as well as improve absolute agreement between ultrasound and MRI-based measures.

## Reliability of Ultrasound Measurement of the Vastus Lateralis Fascicle Length During Contraction in Various Angles

Choi JY, Oh JH, Lee SY: Yonsei University, Seoul, South Korea, and University of Miami, Coral Gables, FL

**Context:** Muscle fascicle length (MFL), pennation angle (MPA) and thickness (MT) are commonly associated with force generation during contraction, and ultrasonography is widely used for measuring them in human skeletal muscles in vivo. There are many studies regarding test-retest reliability for resting muscles, but few for contracting muscles. **Objective:** This study was to determine the test-retest reliability of MFL, MPA and MT in the vastus lateralis (VL) during both relaxation and contraction in various angles using ultrasonography. If both measurements have a good reliability, the testing reliability in resting solely would enable to estimate muscle architecture during contraction. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Eleven healthy subjects, who have no history of lower extremity injuries participated in this study (7M, 4F; 24.5 ± 1.5 yrs; 170.5 ± 15.5cm; 70.1 ± 24.2kg). **Interventions:** An isokinetic dynamometer was used for determining the participant's knee flexion angle while they were asked to perform a maximal voluntary isometric contraction. Ultrasound images were taken during both relaxation and isometric contraction at 40°, 60°, 80° and 100° knee flexion respectively. The Ultrasound probe was placed on the belly of VL and was marked by a permanent marker to ensure the identical location of the probe for the next measurement. The same measurement session was taken in at least a 24 hour interval in order to confirm the reliability of MFL. In order to gain a strong reliability, three weeks of intensive practice with only the muscle relaxation condition has been performed before recruiting subjects. **Main Outcome Measures:** Real time ultrasound image and Image J software were used for measuring MPA and MT. MFL, which does not appear in images, was estimated by using the trigonometric function with the measured MPA and MT. Interclass correlation coefficients (ICC) were calculated for examining the test-retest reliability. **Results:** The ICC values for test-retest reliability were good for both conditions. The ICC (SEM)s for rest condition were as the following: .95 (0.50) in 40°; .96 (0.41) in 60°; .96 (0.46) in 80°, and .96 (0.50) in 100° knee flexion. The ICC (SEM)s for isometric contraction were .93 (0.39) in 40°; .99 (0.35) in 60°; .98 (0.44) in 80°; and .98 (0.45) in 100° knee flexion. **Conclusions:** The results of this study indicated that the reliabilities of test-retest measurements for both resting and contracting muscles in various angles were excellent. Since both measurements showed clinically acceptable reliabilities with practice of only the resting muscle, it is suggested that retaining reliability of resting muscle alone would allow attaining reliable fascicle length measurement during muscle contraction as well.

## Reliability of Image Based Measures of the Vastus Medialis Oblique Muscle Structure and Function

Koen S, Sutherlin MA, Saliba SA, Hart JM: University of Virginia, Charlottesville, VA

**Context:** Dysfunction and atrophy of the vastus medialis oblique (VMO) has been associated with individuals who suffer from patellofemoral pain (PFP) during physical activity. Understanding the role of individual quadriceps muscles may provide additional insight into the muscular contributions to PFP. Ultrasound imaging is a noninvasive way to measure both muscle function and structure during voluntary quadriceps contractions. Before using ultrasound imaging for outcome measures of VMO muscle function and structure in pathological populations, the reliability of these measures must first be established in healthy individuals. **Objective:** To assess the reliability of muscle thickness and pennation angle of the VMO across multiple knee joint flexion angles. **Design:** Descriptive Laboratory. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen healthy participants (3 males and 12 females, age: 20 ± 1 years, height: 166.9 ± 6.9 cm, mass: 67.3 ± 11.9 kg). **Interventions:** Ultrasound imaging measures of the VMO were recorded by a single examiner at rest and during a maximal voluntary isometric contraction while seated in an isokinetic dynamometer with the knee flexed at 90°, 60°, 30°, and 0° knee flexion, standing at rest and during a quadriceps contraction, and during a mini wall squat with the knee in 30° flexion on two separate days. **Main Outcome Measures:** Intraclass correlation coefficients (ICC) with 95% confidence intervals (95% CI) and standard errors of measurement (SEM) between sessions for resting and contracted muscle thickness and pennation angle thickness averaged across both limbs. Additionally, activation ratios were calculated as the ratio between contracted over resting values for both muscle thickness and pennation angle. ICC's values above .750 indicated good reliability and measures below .750 resulted in low reliability. **Results:** Resting and contracted muscle thicknesses ICCs were good for all measures, (ICC range = .802-.884, 95% CI range = .409-.961, SEM range = 0.126-0.173 cm) except for contracted standing thickness (ICC = .707, 95% CI = .127-.902, SEM = 0.227 cm). Only resting pennation angle at 30° flexion (ICC = .796, 95% CI = .394-.932, SEM = 2.212°) and contracted thickness at 0° (ICC = .853, 95% CI = .563-.951, SEM = 2.162°), 30° (ICC = .789, 95% CI = .373-.929, SEM = 2.913) and 90° knee flexion (ICC = .803, 95% CI = .414-.934, SEM = 1.737°) were reliable measures across days. Reliability for muscle thickness activation ratios across knee positions were low (ICC's <.720). Only the standing pennation activation ratio had good reliability (ICC = .794, 95% CI = .385-.931, SEM = 0.094°) between days. **Conclusions:** Assessing muscle thickness and pennation angle using ultrasound imaging is a reliable measure of the VMO at rest and during isometric contraction in healthy individuals. However, knee flexion angle influences VMO muscle thickness and pennation angle reliability across testing sessions. Good reliability was observed for the standing pennation angle activation ratio. Activation ratios for muscle thickness were not reliable in any of the testing positions. Future research should focus on differences in VMO muscle architecture parameters between healthy and PFP individuals.

## MRI-Based Assessment of Lower Extremity Muscle Volumes in Patients Before and After ACL Reconstruction

Norte GE, Knaus KR, Kuenze CM, Handsfield GG, Meyer CH, Blemker SS, Hart JM: University of Virginia, Charlottesville, VA

**Context:** Magnetic Resonance Imaging (MRI) is a novel approach used to quantify muscle volume. MRI-based assessment of muscle volumes have been performed in patients after ACL injury and reconstruction (ACL-R), yet are largely limited to cross-sectional study of the thigh musculature, which may inadequately describe complete post-traumatic lower extremity skeletal muscle function. **Objective:** To assess MRI derived lower extremity muscle volumes in patients prior to and following ACL reconstruction, and secondly quantify quadriceps function using traditional force-based assessment. **Design:** Prospective, case series. **Setting:** University laboratory and research MRI facility. **Patients or Other Participants:** Four patients with a history of ACL rupture (2 females, 2 males; age = 27.4 ± 7.4 years; height = 169.2 ± 8.1cm; mass = 74.3 ± 18.5kg; time from injury to pre-surgery scan = 8.1months [range, 2.1-24.3]; time from surgery to post-surgery scan = 7.4months [range, 5.5-9.6]) volunteered prior to surgical reconstruction. **Interventions:** Participants were assessed within 7 days of reconstruction and again following reconstruction once physician clearance for unrestricted activity was obtained. A bilateral MRI (3.0T) was obtained from ankle mortise to thoracic vertebrae, and thirty-five lower extremity muscles were manually segmented using custom image-processing Matlab software. Bilateral quadriceps function was quantified by knee extensor maximal voluntary isometric contraction (MVIC) torque at 90 degrees of knee flexion, and quadriceps activation measured via burst superimposition. **Main Outcome Measures:** Normalized muscle volumes ($cm^3/kgm$) were analyzed

as (1) compared to a normative database of healthy muscle volumes previously collected pre- and post-surgery, (2) limb symmetry pre- and post-surgery, and (3) percent change pre- to post-surgery. Normalized knee extension MVIC torque (Nm/kg) and quadriceps central activation ratio (CAR) were secondary measures of interest. Muscle volumes were quantified using Z-scores and compared to a normative database of 24 healthy individuals. Descriptive statistics were calculated for muscle volumes and quadriceps function pre- and post-surgery. **Results:** Compared to healthy individuals, 42.9% (95% CI 20.1,65.6%) of the total involved limb musculature was smaller pre-operatively, and 51.4% (95% CI 27.0,75.8%) post-operatively. The involved vastus lateralis (Z = -1.5 [95% CI -2.0,-1.0]) and tibialis anterior (Z = -1.7 [95% CI -2.3,-1.6]) were each consistently smaller pre and post-surgery. The involved rectus femoris and vastus lateralis were more than 15% smaller compared to contralateral limb pre-operatively, whereas asymmetries of the involved rectus femoris, gracilis, vastus medialis, vastus intermedius, and vastus lateralis volumes exceeded 20% post-operatively. The involved gracilis and semitendinosus atrophied more than 30% from pre-to-post surgery. Involved limb quadriceps strength and activation increased by 12.7% and 12.5% respectively, yet strength remained more than 30% asymmetric post-operatively. **Conclusions:** Adaptations in lower extremity muscle volumes and quadriceps function are present following ACL injury and reconstruction. Persistent impairments in muscle volume and quadriceps strength were observed beyond the time of physician clearance. MRI-based volumetric measurements may supplement traditional force-based estimates following ACL injury and reconstruction.

## Dominant to Non-Dominant Limb Measures of ACL Volume and Anterior Knee Laxity

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**Context:** Limb dominance has been suggested to play a role in the ACL injury incidence; however, the reasons for this are unknown. As anterior knee laxity (AKL) asymmetry has been an identified as a prospective risk factor of ACL injury, ligamentous characteristics may offer some explanation. Further, smaller ACL volume is predictive of ACL injury. While there are previous reports of right-to-left AKL and ACL volume symmetry, little is known about the precision of dominant to non-dominant differences in measures of ligamentous characteristics. **Objective:** To examine dominant to non-dominant differences in ACL volume and AKL. **Design:** Cross-sectional. **Setting:** Controlled laboratory. **Patients or Other Participants:** Eleven recreationally-active females (1.63 ± .07m, 62.0 ± 8.8kg, 22.6 ± 2.9yrs) and ten recreationally-active males (1.80 ± .08m, 82.3 ± 12.0kg, 23.2 ± 3.4yrs) were recruited. **Interventions:** ACL volume measure was obtained with T2 weighted magnetic resonance scans (3T) of the both knees. AKL was obtained via a commercial knee joint arthrometer. **Main Outcome Measures:** Limb dominance was defined as the leg used to kick a ball for maximum distance. The ACL was manually segmented from each sagittal image to calculate ACL volume. AKL was measured as the anterior displacement of the tibia relative to the femur (mm) at 130N of force. Paired samples t-tests examined dominant to non-dominant differences in ACL volume and AKL. Dominant to non-dominant differences were further examined by using 95% limits of agreement. **Results:** There were no differences in ACL volume (1593.2 ± 431.2 $mm^3$ Vs 1565.9 ± 393.1 $mm^3$, p = .501) or AKL (7.1 ± 2.2 mm Vs 7.6 ± 2.2 mm, p = .239) from dominant to non-dominant limb, respectively. Mean inter-limb differences exceeded the absolute measurement error in 32% of cases on both ACL volume (27.2 ± 182.0 $mm^3$ > -3.2 ± 99.4 $mm^3$) and AKL (-0.5 ± 1.8 mm > -0.5 ± 1.2mm). **Conclusions:** No mean differences in ACL volume and AKL existed between dominant and non-dominant limbs in a healthy active population. However, dominant to non-dominant differences in ACL volume and AKL exceed the measurement error in at least 32% of cases. This work suggests that the absolute measurement error should be considered when attempting to detect the differences between limbs. Future work should continue to investigate other structural measures associated with dominant to non-dominant differences in ACL injury risk.

### Iterative Examination of Algorithms for EMG Onset Assessed With M-Mode Ultrasound: A Pilot Study

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**Context:** EMG onset of specific muscles is commonly examined in relation to an external event such as heel-strike in gait or in relation to the onset of other muscles (e.g. vastus lateralis/vastus medialis oblique). However, different researchers quantify EMG onset differently and this may substantially impact resulting conclusions. **Objective:** Systematically examine multiple iterations of the linear envelope and Teager-Kaiser energy operator (TKEO) methods for EMG onset and evaluate them against muscle movement detection with M-mode ultrasound. **Design:** Cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** Five males are presently enrolled (age: 31.6±10.8 years). **Interventions:** Participants were instrumented with surface EMG and diagnostic ultrasound on the short head of the biceps brachii and the vastus lateralis. Participants performed three isolated elbow flexions and knee extensions with 2.3 kg of resistance. **Main Outcome Measures:** The EMG detection of muscle onset was examined with standard linear envelope algorithms of different low-pass filter types (2 Hz – 50 Hz) and varying thresholds (1 – 3 standard deviations in signal amplitude). The same iterative algorithms were also used after the application of the TKEO transform which has previously been suggested to increase EMG onset detection accuracy. The EMG onset was correlated and evaluated in context with the M-mode ultrasound detection of muscle movement. Theory dictates that EMG onset should always precede muscle movement with a consistent electromechanical delay. **Results:** There was high variability in Pearson correlation coefficient range for both standard (0.64 – 0.05) and TKEO algorithms (0.55 – 0.03). All algorithms inconsistent with theory (i.e. detecting EMG onset after muscle movement) were removed from analysis, improving the correlation range for both the standard (0.56 – 0.47) and TKEO algorithms (0.54 – 0.43). In the case of both classes of algorithms, the same detection threshold (3 standard deviations) and low-pass filter types (4 Hz – 50 Hz) were found to produce theoretically sound results that were statistically significant (all algorithms $p < 0.05$). The algorithms producing the highest correlation coefficients use substantially higher low pass filters than typically reported in the literature (standard: low-pass 50 Hz, 3 standard deviation threshold; TKEO: low-pass 18 Hz, 3 standard deviation threshold). **Conclusions:** Preliminary evidence suggests there is a large variability in detected EMG onset depending on the detection methodology employed. Three standard deviations of signal amplitude should always be employed while the selection of low-pass filter frequency is dependent upon signal preconditioning. It is important for the field to adopt a standard processing technique to facilitate reproducibility of results.

### Single Leg Squat Performance Errors & Core Muscle Activation via Ultrasound Imaging

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**Context:** The single leg squat (SLS) has been utilized to assess movement patterns and potential injury risk in the lower extremity in both clinical and research laboratory settings. Previous literature has assessed relationships between lower extremity kinematics and SLS performance. However, there is a lack of evidence showing the relationship between core stability and performance of a SLS. The transverse abdominis (TrA) is a local spinal stabilizer of the core and can be measured via ultrasound imaging (USI). TrA thickness during a SLS on both right and left legs may be able to provide more information of the contribution of core musculature in this lower extremity movement screening tool. **Objective:** To determine the relationship between TrA activation in a single limb stance, during a SLS and frontal and sagittal plane movement errors during a SLS, representing overall performance on right and left legs. **Design:** Descriptive laboratory study. **Setting:** University research laboratory. **Patients or Other Participants:** 35 healthy participants (Age = 21.3 ± 2.7 yrs, Mass = 61.3kg, Height = 1.68m, 12M, 23F) volunteered for the study. **Interventions:** USI was captured during single leg stance and at peak knee flexion during the SLS. **Main Outcome Measures:** TrA activation ratio (AR) was determined by dividing contracted thickness of TrA (cm) by resting thickness (cm). Frontal and sagittal plane SLS errors (10 total errors possible) were identified post testing from 2D video. Sagittal errors included, but were not limited to: knee displacement anterior to great toe and AC joint displaced anterior to greater trochanter. Two of the five possible frontal errors involved knee displacement outside of foot and tibial shaft not perpendicular to

floor during motion. Correlation coefficients were determined between right and left TrA AR and SLS errors utilizing non-parametric Spearman's rho. **Results:** On the right side, there were significant negative correlations between SLS TrA AR and frontal errors ($\rho = -0.36$). The left side single limb standing TrA activation ratio and SLS AR had a significant positive correlation ($\rho = 0.38$). There were no other significant correlations present between sagittal errors on either side or single limb standing on the right leg. **Conclusions:** Few significant correlations were present between TrA AR in single leg stance, SLS and errors in the frontal or sagittal plane in these healthy participants. The negative correlation between TrA AR during a SLS with frontal errors indicates greater activation of the core is related to fewer frontal errors. Healthy individuals would not be expected to have many significant relationships between one of these variables over another. Thus, future researchers should investigate these relationships in individuals with low back pain or lower extremity pathologies to determine the role of core stability as it relates to movement during a SLS.

## Diagnostic Ultrasound of the Ulnar Collateral Ligament in Collegiate Division I Pitchers

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**Context:** Pitching causes large valgus torque to the elbow. Incidence of injury to the ulnar collateral ligament (UCL) throwing arms of pitchers is high, and require UCL reconstructive surgery to return to play. This study compared the laxity of the UCL in the throwing arm to the non-throwing arm in an unloaded condition and a loaded condition to simulate valgus forces during pitching. **Objective:** to determine if the throwing arm will have greater UCL laxity (as indicated by increased ulnohumeral joint space width) than the non-throwing arm in a loaded and unloaded condition. Secondarily, to determine relationship between UCL laxity and pitch count and throwing **Design:** cross-sectional study. **Setting:** Athletic training room. **Patients or Other Participants:** 18 Division 1 baseball pitchers (Age = 19.39 ± 0.98 yrs; Height = 1.86 ± 0.08m; Weight = 90.86 ± 13.45kg; Hand dominance = 13 Right, 5 Left). **Interventions:** A physician with 8 years of experience performed diagnostic imaging using a 8-12 Hz linear probe transducer (LOGIQ e Ultrasound, General Electric Co, Fairfield, CT) with standard acoustic coupling gel on all pitchers during pre-participation physicals. The LOGIQ e software was used to mark the edge of the coronoid process and trochlea to calculate joint space width. During evaluation, patients were placed supine on a plinth with 90° shoulder abduction and maximal external rotation with 45° elbow flexion. Image was first collected in unloaded followed by loaded (2.27kg dumbbell) on the right arm followed by the left arm. The pitching coach provided average pitch velocity and number of pitches thrown throughout collegiate career. T-tests were used to evaluate mean differences in joint space width between throwing and non-throwing arm, and between the loaded and unloaded condition. Pearson's r was used to evaluate relationship between total pitches and pitch velocity and joint space width of throwing arm when loaded. **Main Outcome Measures:** The dependent variables were ulnohumeral joint space width (mm), average pitch velocity (m/s) and total pitches (#) across college career. **Results:** There was significant difference in joint space width between the dominant arm in the loaded and unloaded condition ($p = 0.002$) and between the throwing arm and non-throwing arm in the loaded condition ($p = 0.04$). The joint space width of the throwing arm was (loaded = 71.0 ± 26.0mm; unloaded = 54.0 ± 13.0mm). The joint space width in the loaded condition was (throwing arm = 71.0 ± 26.0mm; non-throwing arm = 60.0 ± 20.0mm). There was no significant relationship between joint space width and average pitch velocity ($p = 0.11$, $r = 0.41$) or between joint space width and total career pitches thrown ($p = 0.45$, $r = 0.29$). **Conclusions:** The dominant elbow of collegiate pitchers has greater joint laxity (as indicated by ulnohumeral joint space width) compared to the non-dominant elbow under unloaded and loaded conditions. Increased joint laxity doesn't seem to be a result of higher pitch velocity or higher pitch count.

## Differences in Bicipital Groove Orientation, Not Shape, in Professional Baseball Pitchers

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**Context:** It has been suggested that the development of overuse shoulder injuries can be related to structural adaptations that occur in the throwing arm. Biceps tendon pathology is common in baseball pitchers without a clear understanding of the underlying mechanism. Although several shoulder adaptations have been identified in baseball pitchers, the morphology of the bicipital groove has yet to be examined. **Objective:** The primary objective of this study was to determine if bilateral bicipital groove morphology (depth, width, area, radius of curvature, and transepicondylar axis rotation) differences existed in professional baseball pitchers. A secondary objective was to determine if the amount of humeral retroversion (HR) correlated with bicipital groove morphology. **Design:** Cross-sectional design. **Setting:** Clinical setting. **Patients or Other Participants:** Fifty professional pitchers with no current injury or surgery in the past six months were asked to participate (age = 24.2 ± 4.1 years, mass = 89.0 ± 9.0 kg, height = 188.2 ± 5.4 cm). **Interventions:** Arm (dominant and non-dominant) was the independent variable. Bicipital groove bony morphology and HR were assessed by diagnostic ultrasound (Sonosite Titan, Sonosite Inc., Bothell, WA). Bicipital groove morphology (depth, width, area, and radius of curvature) was calculated from the combined series of 2-D ultrasound images. Transepicondylar axis rotation was calculated from HR values using the following equation: Transepicondylar axis rotation = (HR + 25.8)/0.72. This equation was determined to be highly predictive in a previous study. Paired sample t-tests were performed for bicipital groove morphology. Pearson correlation coefficients assessed relationships between HR and bicipital groove morphology. **Main Outcome Measures:** Bicipital groove morphology and HR were measured supine with the arm abducted to 90° and elbow flexed to 90°. For groove morphology a plastic cuff was placed over the athletes' anterior shoulder and arm. This cuff was used to accurately position and move the ultrasound probe during testing. A stack of 12 two dimensional images were taken from the most inferior portion of the bicipital groove to the most proximal. **Results:** The dominant arm had significantly less transepicondylar axis rotation compared to the non-dominant arm (21.1°, p = 0.0001), respectively. There were no bilateral differences for depth, width, area, or radius of curvature (-0.3mm, p = 0.2; -0.7mm, p = 0.4; -0.5mm2, p = 0.3; 0.2mm, p = 0.4), respectively. Humeral retroversion was not significantly correlated with depth, width, area, or radius of curvature (0.14, p = 0.4; -0.2, p = 0.2; -0.06, p = 0.7; -0.8, p = 0.6), respectively. **Conclusions:** Although bicipital groove dimensions did not differ between dominant and non-dominant sides, transepicondylar axis rotation was found to differ between sides. The dominant arm demonstrated less rotation or a more vertical groove as it goes from distal to proximal into the glenohumeral joint. This adaptation may have implications on mechanical stresses to the biceps; however, that was not assessed in this study.

### The Influence of Foam Rolling and Local Muscle Vibration on Overhead Squat Kinematics


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**Context:** Range of motion (ROM) restrictions contribute to aberrant lower extremity (LE) kinematics that may elevate injury risk. Interventions that improve ROM may be important components of injury prevention programs. Foam rolling combined with vibration therapy is more efficacious than foam rolling alone for improving ROM. However, it is unknown if foam rolling with vibration therapy also alters LE kinematics. **Objective:** To compare changes in LE kinematics during a double-leg squat following foam rolling with and without combined vibration therapy. **Design:** Crossover. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty healthy, physically active adults (male = 6, female = 14; 21.3 ± 2.2 yrs; 167.6 ± 7.6cm; 64.5 ± 11.2kg) were recruited to participate. All participants demonstrated restricted ankle dorsiflexion ROM (weight-bearing lunge dorsiflexion ROM <40º) and at least one myofascial trigger point in the triceps surae. **Interventions:** Participants completed two different foam rolling interventions one week apart. During each session the participants performed foam rolling of their triceps surae musculature (30 seconds rolling the length of the muscle and 3 45-second holds on myofascial trigger points) using either a foam roller with 32Hz vibration (FR-V) or a foam roller with no vibration (FR). The order of the foam rolling interventions was counter-balanced. Immediately following the foam rolling intervention, static calf stretching (3 sets of 30 seconds) with the knee-straight and knee-bent was performed. **Main Outcome Measures:** A three-dimensional motion analysis system collected kinematic data of 5 consecutive double-leg squats before and after the foam rolling and stretching interventions. Change scores were calculated for knee and ankle displacement values (knee flexion, knee valgus, ankle dorsiflexion, ankle eversion) during the descent phase of the squat. Change scores for FR-V and FR conditions were compared for each dependent variable using paired t-tests ($\alpha = 0.05$). **Results:** The change in knee flexion displacement was greater ($t_{18} = 2.83$; $p = 0.01$; $d = 0.54$) following FR-V (2.59° ± 3.72°, 95% CI: (0.80, 4.38)) compared to FR (-0.54° ± 5.14°, 95% CI: (-3.01, 1.94)). No other significant differences were observed for the other change score variables ($p > 0.05$). **Conclusions:** Foam rolling interventions alter LE biomechanics in individuals with triceps surae myofascial trigger points. Specifically, knee flexion displacement increased following the FR-V intervention, while no other differences between interventions were observed. Increased knee flexion displacement is associated with reduced joint loading during functional tasks; however, it is unclear if our observed changes will reduce injury risk. Acute foam rolling interventions with and without vibration therapy improve LE passive ROMs, but the gains in ROM may not be sufficient to result in meaningful improvements in kinematics. Additional research is required to determine if long-term foam rolling interventions are capable of improving LE kinematics. Clinicians should continue to use foam rolling to aid in acutely improving passive ROM but should also utilize movement retraining programs to improve LE kinematics and reduce injury risks.

### A Comparison of Four Foam Roller Treatment Protocols on Hamstring Flexibility


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**Context:** The hamstring muscle group is commonly tight in the general population for a multitude of reasons including prolonged sitting, overuse and injury. Self-myofascial release (SMR) utilizing a foam roller is a technique used to restore and gain flexibility in soft tissues. However, limited research has been done indicating what treatment duration or type of foam roller is most effective in acutely gaining flexibility. **Objective:** The purpose of this study was to compare two foam roller types (Smooth or Bumpy) and two treatment durations (30 or 90-seconds) on acute measurements of hamstring flexibility. **Design:** Single-blind repeated measures experimental. **Setting:** Athletic training clinic. **Patients or Other Participants:** Twelve (10M, 2F, 22.7 ± 1.44 years, 1.81 ± .01 m, 76.7 ± 9.07 kg) volunteers who met inclusion criteria of >20° knee extension angle (KEA) participated in the study. KEA >20° has been established as the measurement to indicate hamstring tightness. Volunteers were also free from any musculoskeletal injury of the hamstring muscles. **Interventions:** Five randomly assigned treatment protocols each separated by at least 72 hours. Protocols included: 1)30-second smooth foam roller; 2)90-second smooth; 3)30-second bumpy; 4)90-second bumpy; and 5) Control (no treatment). **Main Outcome Measures:** Hamstring flexibility was assessed by a blinded second investigator with established reliability (ICC(3,k) = 0.926, SEM = 3.26°) immediately before and after each condition utilizing a digital inclinometer. Pain experienced during each protocol was assessed post-protocol using a 0-10 visual analog

scale (VAS). Descriptive statistics were calculated including mean, standard deviation and range. A 1-way repeated measures ANOVA ($P \leq .05$) was utilized to compare total change in degrees from pre to post treatment. Post-hoc analyses were performed using a Tukey procedure when the ANOVA was significant. **Results:** Significant differences in flexibility were found among the five protocols ($F(4,55) = 2.54$, $P = .05$). Both the 90-second smooth ($P = .008$, 5.76° ± 3.64°) and 90-second bumpy($P = .01$, 5.64° ± 2.57°) protocols were significantly greater than the control condition (2.19° ± 3.4), but neither the 30-second smooth (3.79° ± 3.58°) nor the 30-second bumpy (3.99° ± 2.53°) protocols were significantly different than control. The minimal detectable difference (MDD) was calculated to be 7.4°. All four protocols were more painful than the control condition ($P < .001$) and the 90-second bumpy protocol elicited a significantly higher pain rating (3.5 ± 1.62) than both the 30-second smooth (2.21 ± 1.62) and 90-second smooth (2.38 ± 1.67) protocols as revealed by Tukey post-hoc ($P=.04$). **Conclusions:** A 90-second smooth or bumpy foam roller protocol produces greater gains in flexibility than either 30-second protocol or a control condition. The 90-second bumpy protocol elicits a higher pain rating when compared to either of the smooth protocols. Therefore, it is recommended the 90-second smooth protocol be used to gain flexibility. These results may aid allied health professionals in the selection and prescription of modalities to acutely increase hamstring flexibility, which may prevent injuries and enhance athletic performance.

### Self-Myofascial Release Effects on Dermal Temperature and Hamstring Flexibility

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**Context:** Myofascial release is a type of massage that releases bonds between the fascia and muscle, elongating the tissue. The premise of myofascial release is to increase blood-flow, increase tissue flexibility, and decrease pain. Self-myofascial release (SMR) is a myofascial release technique where the patient performs the treatment on themselves. Currently there are many types of foam rollers available for SMR, but no study has examined the effects of different types of foam rollers on dermal temperature and hamstring flexibility. **Objective:** To compare the effects of three types of SMR on dermal temperature and hamstring flexibility (hip flexion ROM). **Design:** Randomized, repeated measures design. **Setting:** University research laboratory. **Patients or Other Participants:** Participants included 28 healthy, college-aged volunteers (14 male, 14 female; age = 23.0 ± 2.0 y; weight = 78.87 ± 17.16kg; height = 174.17 ± 11.26cm). **Interventions:** Participants experienced three types of foam rollers: semi-ridged foam roller (SRFR), rigid foam roller (RFR), and high intensity vibrating foam roller (HIVFR). During each session the participant rolled over the respective foam roller 4 times (from ischial tuberosity to popliteal fossa) aided with a metronome. They completed the foam rolling protocol 3 times. **Main Outcome Measures:** We measured dermal temperature (mid belly of the hamstring) and hamstring flexibility before and after (up to 30-min) the foam rolling protocol. We measured dermal temperature using VitalSense® dermal temperature sensing system. Dermal temperature has been accepted as a valid measure of indirect blood flow. We measured hamstring flexibility using a digital inclinometer at the mid-femur and mid-tibia. The hips and opposite thigh were strapped to the table to minimize hip rotation or the opposite leg coming off the table and influencing our results. We performed separate 3x3 (condition x time) and 2x3x6 (limb x condition x time) repeated measures ANOVA statistical analyses with p value set at $< 0.05$. **Results:** All foam rollers significantly increased ($F2,54 = 48.236$, $p < 0.001$, $\eta2 = 0.641$, $1\text{-}\beta = 1.00$) hamstring flexibility (61.26 ± 1.68°) following the treatment (mean difference = 5.86°, $p < 0.001$) immediately following and 30-min post-treatment (mean difference = 3.98°, $p < 0.001$). Although not statistically significant, HIVFR resulted in greater ROM (70.01 ± 1.96°) immediately following the treatment that the SRFR (65.14 ± 2.19°) and the RFR (66.20 ± 1.93°). We identified an interaction effect for condition and time ($F3.27,88.4 = 23.415$, $p < 0.001$, $\eta2 = 0.464$, $1\text{-}\beta = 1.00$).The foam rollers significantly increased ($F1.65,44.54 = 112.90$, $p < 0.001$, $\eta2 = 0.806$, $1\text{-}\beta = 1.00$) dermal temperature from pre-treatment (30.81 ± 0.15°C) to 10-min ($p < 0.001$), 15 min ($p < 0.001$), 20-min ($p < 0.001$), 25-min ($p < 0.001$), and 30-min ($p < 0.001$). The HIVFR increased (32.86 ± 0.22°C) dermal temperature significantly ($F1.77, 47.72 = 26.484$, $p < 0.001$, $\eta2 = 0.495$, $1\text{-}\beta = 1.00$) more than the SRFR (31.62 ± 0.16°C) and RFR (31.39 ± 0.16°C). **Conclusions:** After an acute bout of SMR, hamstring flexibility and dermal temperature significantly increased across all conditions. Dermal temperature significantly increased with the HIVFR over the other SRFR and RFR. Foam rolling can be used as an effective way at increasing hamstring flexibility and dermal temperature.

### A Single Session of Compressive Myofascial Release is More Effective Than a Graston® Treatment for Improving Ankle Dorsiflexion Range of Motion

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**Context:** Restricted dorsiflexion (DF) at the ankle joint can cause acute and chronic injuries at both the ankle and knee, such as tendinopathy, plantar fasciitis, ankle sprains, patellar femoral pain symptoms, and anterior cruciate ligament injuries. Potential causes for DF restrictions include soft tissue adhesions, muscle tightness, and muscle spasm. Myofascial release and instrument assisted soft-tissue mobilization (IASTM) techniques have been utilized to increase range of motion, however, there is limited evidence comparing their effectiveness. **Objective:** To compare the effects of a single-session of compressive myofascial release (CMR) or IASTM using the Graston® Technique (GT) on closed chain ankle DF range of motion (ROM). **Design:** Randomized control trial. **Setting:** Patient clinic. **Patients or Other Participants:** Forty-seven physically active participants (60 limbs), age: 20 ± 1.6 years old, weight: 69.9 ± 11.4kg, height: 168.4 ± 10.3cm, with less than 30 (27.3 ± 2.3) degrees of dorsiflexion were recruited to participate. **Interventions:** Participants' closed chain DF ROM was measured in both a standing position with the test leg straight, and half kneeling with the test leg bent to start at 90°. An average of three trials was recorded. Legs with less than 30° of DF and positive Silfverskiold test indicating a soft tissue restriction were enrolled in the study. Qualifying participants' limb(s) were randomly assigned to one of three groups: CMR, GT, or control. Both treatment groups received one five minute treatment that included scanning the area and treating specific restrictions. Participants in the CMR received broad strokes to the triceps surae with the clinician's knuckles followed by direct pressure with the thumbs to specific restrictions. Participants in the GT group received scanning strokes with GT5 using a sweeping motion. Specific restrictions were treated using strum strokes with GT3. The control group sat for five minutes before measurements were retaken. **Main Outcome Measures:** Standing and kneeling ankle DF were measured before and immediately post-intervention. Change scores were calculated and a one-way ANOVA was used for analysis. Alpha was set a priori at $p \leq 0.05$. **Results:** A significant difference between groups was found in both the standing ($F_{2,57} = 11.85$, $p = 0.001$) and kneeling position ($F_{2,57} = 3.88$, $p = 0.03$). Post-hoc testing showed significant improvements in DF in the standing position following the CMR compared to the GT ($p = 0.003$, effect size = 1.01) and control groups ($p = 0.001$, effect size=0.74). In the half-kneeling position, DF improved significantly following the CMR compared to the control group ($p = 0.03$, effect size = 0.63). **Conclusions:** Compressive myofascial release significantly increases ankle DF following a single treatment in participants with DF range of motion deficits. These results suggest that a single treatment of CMR is more beneficial for improving ankle DF than a single GT treatment. Clinicians should consider adding CMR as a treatment intervention for patients with DF deficits.

### Utilizing Mulligan Concept Thoracic Sustained Natural Apophyseal Glides (SNAGs) for the Treatment of Mechanical Neck Pain in the Athletic Population: A Clinical Case Series

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**Background:** Six subjects (3 male, 3 female) with a primary complaint of non-traumatic mechanical neck pain (MNP) involving static posture, traumatic, or self-induced events participated in the clinical case series. The mean age was 18.8 (±2.0) years and a mean duration of symptoms of 8.2 (±12.4) days. The inclusion criteria for the patients were: (1) neck pain lasting less than 1 month; (2) absence of upper extremity symptoms distal to the shoulder; (3) looking up does not aggravate symptoms; (4) Fear Avoidance Beliefs Questionnaire-Physically Active (FABQPA) score of <12; (5) diminished upper thoracic spine kyphosis; (6) cervical extension ROM < 30°; (7) Neck Disability Index (NDI) score of >10%. **Treatment:** The current range of cervical motion (CROM) was measured and direction of cervical restriction established by asking the patient to demonstrate which movement (flexion, extension or rotation) was most painful. The application of Mulligan Concept Sustained Natural Apophyseal Glides (SNAGs) was performed. The athletic trainer placed the end of one thumb on the spinous process of the involved segment (i.e. the vertebra above the suspected site of the problem) and the other thumb placed on the spinous process below the treatment level. The athletic trainer pushed their thumbs towards one another in a transverse direction to provide a SNAG. While sustaining this pain-free accessory glide, the patient was instructed to actively perform the painful or restricted movement. Application of overpressure by the patient at the end of the range of movement enhanced the effect. The patient returned to the starting position actively while the clinician maintained the glide with the treatment repeated for 3 sets of 10. Three treatments of

thoracic SNAGs were performed over a 7 day period. **Results:** The patients' mean change for CROM in degrees from pre to post after 3 SNAG treatments was 10° for flexion, 10° for extension, 5° for left rotation, and 10° for right rotation. Minimal Detectable Change (MDC) was achieved for flexion (9.6° improvement), and left rotation (7.6° improvement). The mean change of Numeric Pain Rating Scale (NPRS) score from initial evaluation to discharge was 4.74 (±1.75), statistically significant (p = .01) and met the Minimal Clinically Important Difference (MCID) of 2. Additionally, NDI mean change (±SD) score from initial evaluation to discharge was 9.20 (±7.0). Although NDI was statistically significant (p =.01) it did not meet the Minimal Clinically Important Difference (MCID) of 9.5% improvement. A Pearson's correlation was performed to examine the pre-post outcomes measures for NPRS, NDI and CROM. Cervical flexion (r = .882, p = .048) as well as cervical rotation to the left (r = .895, p = .040) demonstrated statistical significance for all patients and this effect was maintained during follow up. **Uniqueness:** Brian Mulligan's concept of Mobilization with Movement (MWM) specifically thoracic SNAGs, are clinically indicated to increase CROM and decrease pain in patients with MNP through the theorized correction of a "positional fault". At this time, no attempts have been made to examine the effect of thoracic SNAGs on pain and disability in patients classified with MNP utilizing a regional interdependent (RI) model. **Conclusions:** Identifying interventions for patients within the athletic population with MNP has been challenging as the majority of research efforts have focused on traumatic cervical spine injuries rather than the recalcitrant clinical problem of MNP. This case series highlights the utilization of the RI model and SNAGs to provide an increase in function and decrease in pain for the athletic population not suffering from traumatic cervical spine injury as SNAGs have been shown to be considerably safer and within the scope of the athletic trainer's clinical practice for the treatment of MNP.

## Sequential Pulse Compression's Effect on Muscle Strength and Blood Flow in the Lower Extremity

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**Context:** Exercise-induced muscle damage or delayed onset muscle soreness (DOMS) affects physically active individuals at all levels and can last for multiple days. These conditions may leave the individual with symptoms of soreness, inflammation, and decreased strength, which can affect his or her performance. One popular approach to reduce the intensity and duration of the symptoms associated with DOMS centers around the use of extremity compression. Common methods by which this is accomplished include massage, compression garments, intermittent pneumatic compression, and most recently, Sequential Pulse Compression (SPC). These treatments aim to increase blood flow to alleviate symptoms. However, to date, no research has examined if SPC alters total blood flow of the treatment area in physically active individuals. **Objective:** To examine the acute effects of a single treatment of SPC on blood flow compared to a control condition. **Design:** Single cohort, crossover design. **Setting:** University research laboratory **Patients or Other Participants:** Twenty-three participants (male = 15, female = 7; age = 21.78 ± 3.38 years; height = 179.76 ± 11.97 cm; mass = 81.33 ± 19.9 kg) who reported exercising a minimum of 200 minutes per week volunteered for this study. Participants reported no current or history (past 12 months) of surgery, lower extremity injury, or cardiovascular, neurologic, or metabolic disease. **Interventions:** Participants reported to the University research laboratory on two separate occasions. Participants were randomly assigned to receive either the experimental condition or control condition during the first session. The experimental condition included the application of SPC boots (NormaTec MVP Pro Leg Recovery System, MA, USA) for 30 minutes in a resting, supine position at a compression level of 80 mmHg in each cell. The control condition included 30 minutes of quiet lying in a resting, supine position. Baseline measures of total blood flow were collected following a 10-minute rest period and at the conclusion of the 30-minute experimental or control condition. No less than 24 hours after the conclusion of session one, participants returned to the research laboratory to complete the second session. **Main Outcome Measures:** Relative change in total blood flow between pre- and post-condition measurements as measured by near-infrared spectroscopy at the medial gastrocnemius muscle. **Results:** We found a significant difference between the change scores of the experimental condition compared to the control condition ($t_{22} = 3.12$, $P = 0.005$, $d = 0.63$). SPC resulted in a total relative blood flow increase of 4.45 ± 6.85 units greater than the control condition. **Conclusions:** These data suggest that a 30-minute treatment of SPC increases blood flow in the lower extremity, which may have implications for the treatment of exercise-induced muscle damage or DOMS. Therefore making a viable option in the management of DOMS.

## Isometric Quadriceps Strength and Response to Prolonged Patellar Tendon Vibration: A Reliability Study

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**Context:** Quadriceps muscle weakness is a common consequence following anterior cruciate ligament reconstruction (ACL-R) surgery. Underlying neural adaptations in the proprioceptive input from muscle receptors have been implicated as a potential mediator for quadriceps weakness after ACL-R. Previous studies have utilized the change in quadriceps strength following prolonged tendon vibration to studying potential proprioceptive consequences after ACL-R. These techniques may be a valuable tool for scientific study or clinical assessments, however reliability of these techniques have yet to be examined. **Objective:** To determine the reliability of measures of isometric quadriceps strength and the percent-change in quadriceps strength following prolonged vibration in individuals with ACL-R knees and healthy controls. **Design:** Controlled Laboratory Study **Setting:** Laboratory **Patients or Other Participants:** Fourteen participants had a history of primary, unilateral ACL-R (4 males, 10 females, age: 22.4 ± 5.2 years, mass: 71.7 ± 14.2 kg, height: 1.71 ± .13 m, months post-op). Thirteen healthy controls (6 males, 7 females, age = 22.8 ± 3.6 years, mass: 67.6 ± 11.9 kg, height: 1.71 ± .11 m) with no history of lower-extremity injury. **Interventions:** Participants completed study procedures at 2 time-points, 1-week apart. At time-point 1, three baseline knee extension maximal voluntary isometric contractions (MVIC) at 90-degrees flexion were performed using a Biodex dynamometer, followed by a 20-minute vibration protocol, and repeated post-vibration MVIC measures. Participants were instructed to hold a steady, 3-second, maximal contraction for each MVIC trial. Vibration was applied to the mid-substance of the patellar tendon at a frequency of 50 Hz, amplitude of 4 mm, and pressure of approximayely 30 N. Participants were instructed to relax legs and limit movement. At time-point 2, participants completed the same procedures as time-point 1. **Main Outcome Measures:** Mass normalized average knee extension MVIC torque (Nm/kg) at baseline was calculated for both time-points. The percent-change in MVIC torque (%) from baseline to post-vibration was calculated both time-points. Intraclass correlation coefficients (ICC1,k) were calculated between time-point 1 and 2 for baseline MVIC measures and %-change in MVIC in the ACL-R and healthy controls participants separately. **Results:** Reliability for baseline knee extension MVIC were excellent in ACL-R (0.94 [.80-.98]) and healthy control (0.96 [.86-.99], P < .001) participants. Reliability for the percent-change in MVIC after vibration was low and not statistically significant for the ACL-R participants (.57 [-.29-.86], P = .06) and healthy control (.40 [-.89-.82], P = .19) participants. **Conclusions:** Isometric quadriceps strength measures at 90-degrees of flexion are reliable in participants with a history of ACL-R and healthy controls over 1-week. The percent-change in MVIC in response to prolonged patellar tendon vibration could not be reliably assessed in participants with a history of ACL-R or healthy controls over 1-week. Future research needs to develop more reliable techniques of vibration application and assessment before these techniques can used scientifically or clinically.

### Vestibular and Oculomotor Assessments May Increase Accuracy of Subacute Concussion Assessment

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**Context:** Dizziness is frequently reported in concussion, and is associated with an increased risk for prolonged recovery. Common testimonial of dizziness, visual motion sensitivity, and postural instability suggests that concussion causes dysfunction in visual/vestibular processing. This has led researchers to examine the diagnostic value of vestibular and oculomotor assessments in concussion management. However, further understanding of what tests are most accurate is necessary. **Objective:** To analyze preliminary data for the internal consistency and discriminant validity of a condensed model to assess vestibular and oculomotor impairments following a concussion. **Design:** Cross sectional research design. **Setting:** Laboratory setting. **Patients or Other Participants:** Seventy-two college students participating in either Division I NCAA sport or college intramural team were recruited to participate in this study (42 males; 30 females). There were 60 healthy participants (21.7 ± 3.6 years; 68.3 ± 3.7 in; 71.4 ± 12.2 kg) and 12 concussed (20.5 ± 1.8 years; 69.4 ± 4.2 in; 72.8 ± 8.4 kg). The concussed athletes had experienced symptoms for 4 to 90 days before evaluation. **Interventions:** Each participant was tested with a standardized concussion assessment protocol that consisted of the NeuroCom's Sensory Organization Test (SOT), Balance Error Scoring System (BESS) exam, and eight vestibular and oculomotor assessments (i.e., near point convergence, horizontal eye saccades, smooth pursuits, optokinetic stimulation, horizontal gaze stabilization, head thrust, dynamic visual acuity, and King-Devick). Participants rated their signs and symptoms (s/s; i.e., nausea, dizziness, and headache) before and after vestibular and oculomotor assessments. **Main Outcome Measures:** Pearson's correlations between balance, vestibular, and oculomotor assessments were examined to determine concurrent validity. Logistic regression for binary outcomes was performed to examine predictive validity of the balance, vestibular, and oculomotor assessments. Regression model was tested using receiver operating characteristic (ROC) curves. Areas under the curve (AUC) for these ROC curves were calculated and cutoff scores were determined. **Results:** Of these assessments, SOT (somatosensory ratio r =- 0.26, p = 0.028; visual ratio r = -0.26, p = 0.032), near point convergence (r = 0.34, p = 0.004), and the s/s scores collected following optokinetic stimulation (r = 0.55, p = 0.001), horizontal eye saccades (r = 0.34, p = 0.001), and gaze stabilization tests (r = 0.51, p = 0.001) significantly correlated with health status. The best model consisted of four SOT sensory ratios, near point convergence, and the optokinetic stimulation s/s score (accuracy = 98.6%, AUC = 0.983); however, if the SOT ratios were excluded, this more economical model was also very sensitive (accuracy = 94.4%, AUC = 0.951). **Conclusions:** The results of this preliminary study may provide health professionals with a sensitive and specific battery of simple vestibular and oculomotor assessments for concussion management.

### Are There Sex Difference on Baseline Sport Concussion Assessment Tool 3 Among High School Athletes?

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**Context:** Consensus statements suggest baseline testing athletes at high-risk for a sport-related concussion as variables such as sex may influence baseline scores. The Sport Concussion Assessment Tool 3 (SCAT3) is a popular sport-related concussion assessment that is best used with a baseline. However, there is a lack of research examining baseline differences between male and female high school athletes on the SCAT3. **Objective:** To determine if there are baseline sex differences on the SCAT3 in a sample of high school athletes. **Design:** Cross-Sectional study. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** A total of 217 female (age = 15.6 + 1.8 years, height = 144.78 + 10.9 cm, mass = 59.5 + 10.3 kg) and 258 male (age = 15.9 + 1.5 years, height = 152.49 + 15.0 cm, mass = 73.3 + 17.3 kg) high school athletes volunteered to participate in the study. **Interventions:** The independent variable was sex (female, male). Participants completed the SCAT3 at baseline in a quiet room. The SCAT3 consists of the Standardized Assessment of Concussion (SAC) (e.g., orientation, immediate memory, concentration, delayed memory), the modified balance error scoring system (mBESS), tandem gait, and 22 symptoms. The SCAT3 takes approximately 15 minutes to complete. None of the participants sustained a sport-related concussion during the study period. The data were analyzed using descriptive and

inferential statistics. **Main Outcome Measures:** Dependent variables included the SAC, mBESS, tandem gait, total symptoms. A series of ANOVAs were performed for each of the subscales of the SCAT3. The alpha level was set aprior at .05. **Results:** There was a significant difference for the SAC total score ([Female: Male] M = 26.7 + 2.3: M = 25.0 + 2.7 p = .00). Female high school athletes score higher at baseline on the SAC than male high school athletes. Significant differences were also noted on tandem gait with males reporting faster times compared to females (M = 15.21 + 4.1: M = 13.0 + 3.4 p = .00). However, there were no significant differences at baseline on the mBESS (M = 4.2 + 3.0: M = 4.6 + 3.2 p = .29) and total symptoms between females and males (M = 4.45 + 7.3: M = .3.69 + 6.2 p = .51). **Conclusions:** Overall this study suggests that there are sex differences on the SCAT3 between male and female high school athletes. Therefore, it is recommended that if clinicians use the SCAT3 they administer a baseline test for post-concussion comparisons.

## The Influence of Mood on the Sensory Organization Test

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**Context:** The Sensory Organization Test (SOT) has gained wide acceptance as a method of measuring postural stability prior to and following the diagnosis of a sports concussion (SC). The SOT has been demonstrated to possess variable reliability and sensitivity. A potential extraneous variable which may influence SOT performance is mood. Mood has been shown to alter balance performance in related studies and may serve as rationale for the varying reliability and sensitivity evidence of the SOT. **Objective:** To examine the influence of mood state on SOT performance in healthy college students. **Design:** Cross-Sectional **Setting:** Research laboratory **Patients or Other Participants:** Participants consisted of 34 healthy college participants (male = 16, female = 18) who were 21.3 + 2.11 years of age and 170.7 + 9.58 cm tall. **Interventions:** Participants completed the SOT on Days 1, 2, 45, and 50. At Day 1, participants provided consent and were familiarized with the SOT. At Days 2, 45, and 50 participants completed a health questionnaire, the Profile of Mood States (POMS-B) and the revised Head Injury Scale (HIS-r) followed by administration of the SOT trials in serial order. **Main Outcome Measures:** Pearson correlation coefficients were calculated for each of the seven POMS-B factors fatigue-inertia (F-I), vigor-activity (V-A), tension-anxiety (T-A), depression-dejection (D-D), confusion-bewilderment (C-B), anger-hostility (A-H), total mood disturbance (TMD) and the SOT Composite Score and Somatosensory, Visual, and Vestibular Sensory ratios. Analyses were performed with $\alpha = .05$. **Results:** Significant correlations were observed between the several SOT and POMS-B composite scores at Day 2. Significant correlations were observed between F-I and the SOT composite score (r =-.55, r2 = .30, p = .001), Visual ratio (r = -.44, r2 = .19, p = .009), and Vestibular ratio (r = -.38, r2 = .14, p = .03). The SOT Somatosensory ratio was significantly correlated to D-D (r = -.35, r2 = .12, p = .04) and TMD (r = -.41, r2 = .17, p = .02). The Visual Conflict ratio was significantly correlated to D-D (r = -.44, r2 = .19, p = .01), A-H (r = -.47, r2 = .22, p = .04), F-I (r = -.60, r2 = .36, p < .001) and TMD (r = -.41, r2 = .17, p = .02). **Conclusions:** Our results suggest that F-I, T-A, D-D, and A-H may decrease SOT performance in healthy college aged participants. These mood states are commonly experienced by incoming freshman athletes and may influence baseline balance performance. Clinicians using the SOT to assess athletes prior to and following SC must be aware of extraneous sources of error such as mood which may limit clinical utility. Future research with a larger sample size is needed to substantiate our findings.

## Comparison of Item Response Theory Models for Analyzing Standard Assessment of Concussion Data

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**Context:** Item Response Theory (IRT) is a popular analysis method for assessing the quality of items on a test. There are three IRT models, which include the one-parameter (1-PL), the two-parameter (2-PL), and the three-parameter (3-PL) models. The 1-PL estimates item difficulty and assumes that all items discriminate equally with no chance of guessing an item correctly. The 2-PL allows items to discriminate differently, while the 3-PL includes the additional guessing parameter. Previous evaluation of the Standard Assessment of Concussion (SAC) has occurred using the 1-PL model. However, there are currently no studies comparing the efficiency of the three models to determine which is most appropriate for analyzing SAC data. **Objective:** To compare the 1-PL, 2-PL, and 3-PL IRT models to determine which model is most appropriate for analyzing SAC data. **Design:** Cross sectional **Setting:** High School Athletic Training Room **Patients or Other Participants:** One hundred forty-two high school student-athletes volunteered for this study (mean age 16.1 years ± 1.2). **Interventions:** Student-athletes were administered each of the three alternate SAC forms. To determine test order, athletes were randomly assigned to one of three groups. Possible order of test administration included "A, B, C", "B, C, A", and "C, A, B". The test administration order was randomized to limit measurement errors associated with practice effects. 1-PL, 2-PL, and 3-PL IRT models were calculated from the SAC data using XCalibre v4.0. Bayesian information criterion (BIC) and $X^2$ Δ assessed the fit of each model. BIC is the criterion method for model selection among a finite set of models; the model with the lowest BIC is preferred. $X^2$ Δ is another method for comparing the efficiency of nested models. A non-significant $X^2$ Δ indicates that increasing the complexity of the model (i.e., increasing the number of parameters estimated) does not significantly improve model fit. Thus, the more parsimonious model is preferred with non-significant findings. **Main Outcome Measures:** BIC and $X^2$ Δ **Results:** BIC values were 6,885.102, 7021.204, and 7,814.306 for the 1-PL, 2-PL, and 3-PL models, respectively. $X^2$ Δ indicated that the 2-PL (X278 = -39.43, p = .999) and the 3-PL (X2156 = 22.792, p = .989) models were not significantly better than the 1-PL. **Conclusions:** The results of this study suggest that the use of additional item parameters (e.g., item discrimination and guessing) does not significantly improve model-data fit of SAC data. Therefore, the 1-PL model is the most appropriate model when analyzing SAC data.

## Establishing Normative Concussion Baseline Values for Groups Within the Dancer Population

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**Context:** A baseline assessment may be helpful in identifying abnormal findings after concussive injury, but many dancers do not have access to baseline testing. Normative values may be helpful in recognizing concussion but can be influenced by numerous factors so it is important to establish normative values for specific, target groups. **Objective:** Establish normative values for various subgroups within the dancer population. **Design:** Cohort study. **Setting:** Onsite pre-season screenings during summers 2013-2015. Baseline scores were conducted one-on-one with a trained investigator in an isolated area. **Patients or Other Participants:** 236 dancers (65 male; 171 female; 153 university; 83 professional) were recruited from dance companies that we provide ongoing, onsite care. 4.2% had a self-reported history of concussion. Mean age was 21.09 years (±4.837). **Interventions:** Groups were analyzed by sex, age, professional status, history of depression, concussion, and orthopedic injury, general alcohol intake, hours of sleep the night before baseline testing, and general amount of sleep each night. **Main Outcome Measures:** Symptom severity score, Standardized Assessment of Concussion (SAC) score, King Devick (KD) score, and mean modified Balance Error Scoring System (mBESS) score were analyzed. Mann Whitney U, t-test, Pearson & Spearman's Rho correlations were used to determine significance. **Results:** Mean symptom score was 16.48 (±12.798); Mean SAC score was 27.49 (±1.780); mean KD was 41.565 seconds (±8.19 sec); mean mBESS was 3.21 errors (±3.123). Females had superior KD scores (p = .026). Hours of sleep before testing showed a moderate, negative correlation to symptom scores (p < .001); increased weekly alcohol

consumption showed a low positive relationship with symptom scores (p = .048). History of depression was related to increased symptom scores (p = .029) Females had less errors than males on mBESS (p = .013). There were no significant findings in those with history of concussion, no differences between university and professional dancers, or findings in those with a history of repeated orthopedic injury. **Conclusions:** Similar to athletes, it cannot be assumed that a dancer's baseline symptom score is zero. Dancers may have higher baseline symptom severity scores than athletes. KD scores and mBESS scores are different between sexes, with females performing better on both tests. Baseline symptom severity scores are influenced by lifestyle habits and mental health history. Normative values should always be used with caution.

### The Test-Retest Reliability and Minimal Detectable Change of the Stability Evaluation Test

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**Context:** Balance testing is an integral component of the evaluation of concussed athletes as balance deficits are often recorded following a concussion and are believed to be a result of sensory-integration problems. Furthermore, balance assessments have been recommended to be part of standardized baseline testing for all athletes. The difficulty with balance assessments comes from a lack of portable objective testing measurements. The Stability Evaluation Test (SET) provides an objective analysis of the athlete's functional balance control based on the individual's postural sway velocity. The SET test includes double limb, single limb, and tandem stances on both a foam and a firm testing surface. The equipment associated with the SET can be easily moved from location to location, allowing for side-line testing. The reliability of the SET has not been previously established. **Objective:** To examine the test-retest reliability and minimal detectable change (MDC) of the Stability Evaluation Test. **Design:** A prospective, time series, case-control design. **Setting:** University research laboratory. **Patients or Other Participants:** 25 healthy volunteers (12 males, 13 females; age 21.80 ± 1.87 years; mass 77.24 ± 20.42 kg; height 172.31 ± 10.46 cm). **Interventions:** All participants completed the all six conditions of the SET on 2 days: baseline, and day 10. Subjects had no prior experience with the SET and were not given practice trials. Order of trials was randomized to minimize fatigue as a confounding factor **Main Outcome Measures:** Descriptive statistics were calculated for all dependent variables, which included; Composite Score, and all SET Sway Velocity scores for each stance and each surface. Intraclass correlation coefficients (ICC version 2,1) were calculated on all dependent variables to determine the test-retest reliability, and MDC values were computed as a measurement of change in scores over time. Bland-Altman plots were computed to determine level of agreement between the two days of testing. **Results:** Test-retest reliability for the SET composite score was excellent (Intraclass Correlation Coefficient = 0.772). ICC values for individual testing conditions were poor. Minimal detectable change was 0.69 deg/sec for SET composite score. Bland-Altman plots revealed narrow limits of agreement between days of testing. **Conclusions:** The overall composite score for the SET is reliable in healthy college aged students. Individual sway velocities were found to not be reliable; therefore clinicians should use caution during clinical use. The MDC values will help clinicians determine if documented changes in outcome measures are clinically meaningful or as a result of change in the measurement tool. Narrow limits of agreement suggest that a increase the number of participants may reveal a higher level of reliability between testing days.

## Prediction of King-Devick Scores Utilizing Baseline Concussion Assessments in Collegiate Athletes

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**Context:** The King-Devick (KD) test assesses oculomotor speed and visual processing disturbances, which are common in concussed individuals. Clinicians may have limited resources available for conducting baseline concussion assessments. However, it is currently unknown whether the KD test provides unique information compared to symptomatology, postural control, and neurocognitive assessments collectively used as the currently recommended multi-dimensional approach to baseline evaluations. **Objective:** To determine whether symptomatology, balance performance, and neurocognitive function predict KD scores at baseline. **Design:** Cross-sectional. **Setting:** Clinical Research Laboratory. **Patients or Other Participants:** One hundred Division I collegiate athletes (63 males, 37 females, age = 19.2 ± 1.2 years, height = 179.8 ± 13.4 cm, mass = 83.4 ± 21.3 kg) were analyzed from eight sports (baseball, men's basketball, women's basketball, equestrian, football, gymnastics, women's soccer, and softball). Participants (n = 31) were excluded from the study if they self-reported any of the following: learning disability, attention deficit-hyperactivity disorder, psychiatric disorder, migraine disorder, 3+ concussions, balance disorder, vision problems (other than vision correction), or insufficient English language skills. **Interventions:** All participants completed a SCAT3 symptom evaluation, a balance assessment (Balance Error Scoring System - BESS), a computerized neurocognitive test (CNS Vital Signs), and an iPad®-administered KD test as part of a concussion baseline assessment. **Main Outcome Measures:** We analyzed the SCAT3 total symptom severity score, the BESS total error score (number of errors), and the following CNS Vital Signs standard scores (unitless): verbal memory, visual memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, and executive function. A forward stepwise linear regression was used to determine whether the SCAT3 total symptom severity score, BESS total errors, and the eight CNS Vital Signs domains predict KD scores (sec) ($\alpha = .05$). **Results:** Executive function and reaction time domains explained 20% of the variance of KD scores ($p < .001$, $R^2 = 0.20$). When reaction time is excluded from the model, 5% of the variance is lost. King Devick scores worsened by 0.15 seconds for each error in executive function ($\beta = -0.15$, $p = .003$) and worsened by 0.10 seconds for each reaction time delay ($\beta = -0.10$, $p = .022$). No other concussion assessment scores explained a significant amount of variance in KD performance. **Conclusions:** Oculomotor speed and visual processing is influenced by executive function and reaction time performance; however, as a collective assessment, SCAT3 symptom severity scores, BESS, and CNS Vital Signs, cannot be used to determine KD scores. These results indicate that the KD test provides unique information regarding oculomotor speed and visual processing during a baseline concussion assessment. Clinicians not currently assessing oculomotor speed and visual processing should consider these assessments. Further investigation is needed to determine whether the KD test is useful for further evaluating potential executive function and reaction time deficits following concussion.

## A Multimodal Assessment to Detect Concussion

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**Context:** A multifaceted concussion assessment yields greater than 90% sensitivity post injury, however many assessments are performed, and interpreted, independently or days following injury. Therefore, the development of a single comprehensive tool that encompasses multiple assessments, and can be implemented on the sideline is warranted. **Objective:** To assess a novel and immersive testing modality that includes reaction time, a balance task, oculomotor task and neuropsychological testing in a concussed population. **Design:** Cross-sectional, cohort study **Setting:** Concussion clinic **Patients or Other Participants:** 26 patients (age: 17.6 ± 4.8 years; n = 13 female, 13 male) presenting with dizziness or imbalance after concussion (32.9 ± 37.2 days post injury, range: 1-156 days) and 100 controls (age: 17.03 ± 3.8 years; n = 45 female, 55 male) were included. **Interventions:** Patients completed 1) a simple reaction time (RT) assessment, 2) a novel seated balance task which required patients to tilt their heads back and forth to keep a ball in equilibrium under five different degrees of difficulty, 3) a novel oculomotor task that required patients to visually track a target moving towards a goal and stop the target once it reached the goal, 4) previously validated neuropsychological modules. All of these were completed on the DETECT device. **Main Outcome Measures:** 1) Mean RT from the simple RT task 2) Path length, ingate time, and dominant frequency from the balance task 3) angle error between the stopped target and goal from

the oculomotor task 4) Response time from the neuropsychological assessments. Independent same T-tests were completed for each outcome measure to identify differences between groups. **Results:** 1) Mean RT was significantly greater in concussed individuals (478.2 ± 93.4 ms) compared to controls (448.5 ± 108.9 ms; $p = 0.02$). 2) Concussed displayed greater path length ($p = 0.015$), decreased in-gate time ($p = 0.032$), and decreased dominant frequency ($p = 0.011$) during the most difficult balance condition. 3) Concussed patients demonstrated increased angle error during the visible fast (5.9 ± 3.9° v. 4.5 ± 3.7°; $p = 0.005$) and invisible fast (16.6 ± 9.8° v. 14.3 ± 10.3°; $p = 0.034$) conditions compared to controls. 4) Concussed patients showed a significant reduction in response time for neuropsychological tasks in processing speed ($p = 0.038$) and working memory ($p = 0.016$). **Conclusions:** The individual assessments of DETECT were able to differentiate between concussed and controls post concussion, on average 30 days from injury. Our results also support the inclusion of vestibular and oculomotor testing, which are more novel concussion assessments. Combining these test modules into a single immersive platform may reduce the test burden and enhance clinical feasibility. Future goals are to use the results from all the modules into an integrated statistical model to increase sensitivity and specificity for clinical assessment.

## Clinically Feasible Biomarker to Identify Deficits in Neuronal Function Related to Acute Concussion

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**Context:** The World Health Organization (WHO) has projected that by the year 2020, Traumatic Brain Injury (TBI) will rank third as a leading cause in the global burden of disease and injury. Current methods for objective assessment of concussion injury and prognosis are limited to imaging approaches (CT, MR and DTI) that are often limited in clinical accessibility. Conversely, subjective clinical assessments of patient reported symptoms may be suboptimal to prognosticate severity and recovery pathway. Development of an objective, clinically feasible, diagnostic tool for TBI is imperative. **Objective:** The purpose of this study was to measure neurophysiological changes after acute concussion to identify a clinically feasible biomarker of brain network deficits using electroencephalography (EEG). **Design:** Prospective cohort. **Setting:** High School hockey and football athletes. **Patients or Other Participants:** A total of 52 males (15 Hockey, 37 Football) participated in this study. Interventions: Event related potentials (ERPs) were captured utilizing EEG in subjects performing a neurocognitive task (Auditory Oddball) prior to the start of head impact exposure during practices or competitions. Athletes were evaluated weekly for any sports related injury by an athletic trainer (AT). Athlete exposures were recorded by the AT. Any athlete with an identified concussion performed a follow-up exam at 2.9 ± 1.4 days following injury. **Main Outcome Measures:** A novel approach using algorithmic analysis was applied to multichannel EEG-ERP data that provides a measure of similarity to a normative brain network activation (BNA) during sensory processing, working memory and attention orientation. The difference in BNA scores between baseline and post-concussion/post- season was assessed for concussed and non-concussed athletes respectively, and compared using a Wilcoxon rank-sum test. **Results:** Concussed athletes ($n = 8$) exhibited larger changes in their combined BNA scores of sensory processing and attention orientation (-11.00 ± 14.81) from pre- to post concussion follow-up, compared to non-concussed athletes ($n = 44$, 7.63 ± 15.88; $p < 0.01$). **Conclusions:** The results suggest that the BNA system quantitatively assesses the network dynamics associated with concussive injury and may be a useful clinical tool for neurological health. This objective measure may more accurately depict brain injury and eliminate reliance on subjective self-reported symptoms. This biomarker has the potential for use in tracking progress and for predicting timeline for full recovery which may optimize clinical management of concussion and potentially reduce the health care burden associated with this injury.

### Examining Postural Control and Ankle Laxity in High School Football Players While Wearing Different Cleat Heights and Prophylactic Ankle Tape


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**Context:** Lateral ankle sprains are the most common injuries in high school sports. While ankle taping is a preferred method of external prophylactic support, its mechanical efficiency significantly declines during exercise. The Under Armour® Highlight cleat is marketed on the premise that it is lightweight and wraps your foot and ankle in a "second skin" for added support without the need for additional ankle taping. **Objective:** To determine if differences in ankle joint laxity and postural control exist between football players wearing the Under Armour® Highlight cleat (Under Armour Inc., Baltimore, MD) as compared to a low or mid-top cleat with ankle tape **Design:** Crossover trial **Setting:** Athletic training room and football practice field sideline. **Patients or Other Participants:** Thirty-two interscholastic football players (age = 15.8 ± 1.0 yrs.; height = 179.0 ± 7.2 cm; mass = 86.5 ± 19.8 kg). All participants were free from any lower extremity injuries at the time of the study. Consent documents were collected on all subjects prior to participation **Interventions:** Ankle laxity was assessed using an instrumented ankle arthrometer (Blue Bay Research Inc., Milton, FL), while balance testing was performed on the Tekscan MobileMat™ BESS (Tekscan, South Boston, MA). Balance was assessed with cleats on, eyes-closed, and trials lasting 20 seconds in length. The two treatments included Under Armour® Highlight cleats (session 1); while in the other session (session 2) participants wore a low/mid-cut cleat with ankle tape applied to the non-dominant ankle only. The non-dominant ankle was determined by asking each participant which foot they would use to kick a soccer ball with, and assigning the opposite as the non-dominant. Session order for this study was counterbalanced, and measurements were taken before and immediately after practice. **Main Outcome Measures:** The independent variable was cleat type (Highlight vs low/mid with ankle tape). Dependent variables included ankle arthrometry measures of anterior displacement (mm), inversion/eversion rotation (deg); and the Tekscan MobileMat™ BESS single-leg and tandem stance error scores. Double-leg firm and foam surface stances were not analyzed. A linear mixed-effects regression model was used for analysis. **Results:** The mid/low-cut cleat with tape condition (pre-exercise = 17.6 ± 6.2 deg; post-exercise = 27.5 ± 12.6 deg) had significantly higher inversion/eversion rotation post-exercise when compared to the Highlight cleat (pre-exercise = 21.2 ± 6.5 deg; post-exercise = 25.0 ± 5.9 deg) ($b = 5.89$, $df = 35.51$, $t = 3.102$, $p = 0.004$). No other significant differences were derived with the other dependent variables. **Conclusions:** The results of this study provide some evidence that the Under Armour® Highlight cleat restricts inversion/eversion rotation following a training session better than the taped low/mid-cut cleat. Further study is warranted to determine if this high-top style of football cleat can reduce the incidence of ankle sprains and how it might compare to spat taping. (Funding support provided by Under Armour®).

### Comparing Adhesion Over Five Days Between Three Brands of Elastic Therapeutic Tape


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**Context:** The application of elastic therapeutic tape (ETT) has emerged as a method for treating a variety of musculoskeletal conditions. A critical prerequisite to the efficacy of any brand of ETT is that it remain adhered to the skin during the prescribed treatment. Clinicians who administer ETT typically target a single application for 3-5 days at 25% elongation. No studies have compared the rate of adhesion over five days of different brands of ETT. **Objective:** To compare the adhesion of TheraBand™ Kinesiology Tape(TKT) with KT Tape®(KT) and Kinesio® Tex Gold™(KTEX) under 25% elongation over five days in healthy adults. **Design:** Descriptive cohort **Setting:** Outpatient physical therapy/chiropractic rehabilitation clinics **Patients or Other Participants:** Convenience sample of 20 healthy volunteers, ages 18-65, without low back pain. **Interventions:** Two independent cohorts of 20 volunteers each were randomized to receive simultaneous applications of two brands of de-identified ETT on either side of their lower back. Cohort1 received TKT and KTEX while Cohort2 received TKT and KT. Two 6 inch strips of assigned ETT were applied at 25% elongation, one on each side of the low back, from L5 superiorly over the erector spinae while in a flexed position. Data were collected at 1 hour (D1), 3 days (D3) and 5 days (D5) following the initial application of the ETT. **Main Outcome Measures:** Data collected included three digital photographs (left

side, right side and straight on) of the subject's lower back where the ETTs were applied. These photographs were assessed independently by three evaluators who were blinded to the brand of the tape and the time during the protocol when the pictures were obtained. After observing the photographs the evaluators rated the percent of the tape that remained adhered (0-100). **Results:** There was a high degree of inter-rater reliability among the three evaluator's rating of the percentage of tape adhered at D3 and D5 ($\alpha$ = 0.97-0.99). The evaluators' ratings were averaged to arrive at a percentage of tape adhesion (%Adh) for each brand of tape at each data collection point. Descriptive statistics indicated no differences in age, gender, or racial distribution between the two cohorts. Repeated measures ANOVA of Cohort1 indicated no %Adh differences between TKT and KTEX at any time. However, post hoc analysis of the significant time effect indicated KTEX%Adh significantly declined from D1(97%) to D3(74%) and to D5(59%), while TKT%Adh did not change over time (97%, 86%, 70%). In Cohort2, KT significantly declined over time (99%, 67%, 35%) and exhibited lower %Adh than TKT (99%, 83%, 76%) at D3 and D5. Adhesion of the TKT tape did not decline significantly in the second cohort. **Conclusions:** Compared to other ETT, the TKT provides significantly better adhesion over five days.

## The Impact of Kinesio© Tape on Balance for Individuals With Chronic Ankle Instability

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**Context:** There is limited research on the effectiveness of Kinesio© Tape in regards to balance. There has yet to be research comparing Kinesio© Tape with non-elastic tape, and no tape relative to balance. **Objective:** The purpose of this study was to compare ankle stability using the Biodex Balance System (BBS) with the application of Kinesio© Tape, the application of non-elastic athletic tape, and without tape in subjects with chronic ankle instability (CAI). **Design:** True experimental design using repeated measures. **Setting:** Florida Gulf Coast University Physical Therapy Lab. **Patients or Other Participants:** Participants were recruited from Florida Gulf Coast University and consisted of students in the College of Health Professions and Social Work. Participants were asked to volunteer through class dialogue and email. Descriptives: 10 males and 7 females with an average age of 24 years. **Interventions:** Each individual received KT, elastic white, and no tape. Participants were randomly selected by choosing a number from random to have either Kinesio© Tape, non-elastic tape, or no tape applied. The Kinesio© application used was for ligament/proprioception deficits consisting of a "y" cut anchored to the calcaneus and an "I" cut anchored to the medial malleolus. The non-elastic white tape procedure performed was the closed basket weave. Each participant was tested on the BBS with each condition on three separate days. Participants performed one practice trial before beginning each session. The Athletic Single Leg Stance protocol as preset by the BBS was utilized to determine the effectiveness of each independent variable. Data analysis consisted of a General Linear Model (GLM) Repeated Measures Procedure, using Wilks lambda ($p = 0.05$). **Main Outcome Measures:** The dependent variable in this study was balance on the BBS, indicated by the anterior posterior stability index (APSI), medial-lateral stability index (MLSI), and overall stability index (OSI). **Results:** No statistically significant difference in outcomes was noted for the three conditions: KT, non-elastic tape, or no tape based on a comparison of APSI ($p = 0.34$), MLSI ($p = 0.61$) and OSI ($p = 0.59$ ) as measured by the BBS. **Conclusions:** Kinesio© Tape has no significant difference in balance for individuals with CAI as measured by APSI, MLSI, and OSI on the BBS when compared to the application on non-elastic tape and no tape. When applying Kinesio© Tape to individuals with CAI, there is no added benefit when compared to non-elastic tape and no tape relative to balance when performing dynamic activities. Further research is needed on this topic.

## A Comparison of Ankle Strapping and Spatting on Range of Motion and Performance

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**Context:** Ankle injuries are common in sport and tend to reoccur. To reduce the risk of reinjury, ankle strappings are commonly applied to limit ROM, specifically plantarflexion (PF) and inversion (INV). The loosening characteristics of taping over the skin have prompted clinicians to use other restrictive techniques such as spatting. However, the efficacy of spatting and comparisons to traditional strapping have not been extensively researched. **Objective:** To compare the effects of traditional ankle strapping and spatting and their combination on ankle ROM and performance. **Design:** A randomized cross-over design. **Setting:** Athletic training facility. **Patients or Other Participants:** Ten healthy varsity athlete and recreationally active males (age = 20.5 ± .97 y, height = 181.02 ± 6.45 cm, mass = 87.05 ± 10.02 kg). **Interventions:** Participants reported on one occasion and completed four conditions; no tape (C), ankle strapping (T), spatting (S), and combined strapping and spatting (TS) in a randomly assigned order. For each taping condition, 3.81-cm Jaybird® white tape was applied by a Certified Athletic Trainer. The T condition consisted of a Gibney closed-basket-weave with heel-lock and figure-eight strips directly applied to pre-wrapped skin. The same Gibney technique was used over the sock and shoe for the S condition. The TS condition consisted of a combination of both techniques, while no tape was used during the C condition. **Main Outcome Measures:** PF and INV ROM were assessed immediately prior to and following application of each condition using Saunders® digital inclinometers and were assessed passively and actively using standard methods. Passive ROM was also assessed with overpressure as the clinician applied a force equivalent to 10% of the participant's body mass using a hand-held dynamometer (Hoggan Scientific, Salt Lake City, Utah). Immediately following ROM assessment, participants were assessed for maximum vertical jump height (Vertmax) and agility using a three cone drill. The tape was then removed and identical procedures were followed under the remaining conditions. **Results:** All three taping conditions significantly decreased passive ($F_{3,27}$ = 17.03, p = .001), active ($F_{3,27}$ = 8.29, p = .001) and overpressure ($F_{3,27}$ = 16.28, p = .001) PF with the TS condition providing the greatest restriction. The taping conditions also decreased passive ($F_{3,27}$ = 4.35, p = .013), active ($F_{3,27}$ = 6.48, p = .002) and overpressure ($F_{3,27}$ = 4.73, p = .009) INV, however no differences between techniques were observed. Vertmax during the C condition (60.1 ± 11.4 cm) was significantly greater ($F_{3,27}$ = 5.90, p = .003) than the taping conditions (T = 58.3 ± 11.3, S = 58.2 ± 10.2, TS = 57.7 ± 10.8 cm) while no differences were noted when comparing taping conditions. Time to complete the three cone drill was significantly greater ($F_{3,27}$ = 3.61, p = .026) during the TS condition (7.98 ± .48 s) as compared to the C condition (7.80 ± .45 s), while no other differences were noted (T = 7.96 ± .58, S = 7.94 ± .54 s). **Conclusions:** The results suggest that both taping and spatting are effective for limiting ROM, however their combination provides the greatest restriction. While the taping conditions impaired performance, neither was found to impair performance more than the others.

## Ground Reaction Forces and Stretch-Shortening Cycle Muscle Function Associated With Standing and Depth Vertical Jumping and Prophylactic Ankle Bracing

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**Context:** Ankle bracing is a widespread method for protecting the ankle ligaments during participation in athletic activities despite limited research findings on the effects of bracing on jump performance and jump landing force dissipation. The stretch-shortening cycle (SSC) is an effective measurement of jump performance and is measured using the reactive strength index (RSI) and the eccentric utilization ratio (EUR). Altered coupling between the SSC components and the brace and restricted sagittal plane motion could result in decreased efficiency to utilize the muscle's stored elastic energy. The resulting deteriorated eccentric muscle function could lead to reduced tolerance to impact, loss of elastic energy potential, and less force produced during the push-off phase of the jump. An increase in vertical ground reaction forces (GRFv) during landing could lead to increased risk of lower extremity injury. No comprehensive analysis of SSC function associated with various brace types has been reported. **Objective:** To examine the effect of ankle bracing on SSC function using countermovement (CMJ) and depth vertical jumping (DVJ) and biomechanical measures of performance obtained from GRFv. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four uninjured female athletes (20.3 ± 1.6 years, 68.2 ± 12.4 kg, 170.6 ± 9.0 cm). **Interventions:** Participants performed CMJ and DVJ on a force plate with double-leg landings across three ankle support conditions (soft-shell brace (Zoom™), lace-up brace (ASO™), and no-brace) while wearing a low-top athletic shoe. **Main Outcome**

**Measures:** The dependent variables of RSI (jump height/ground contact time), EUR (DVJ height/CMJ jump height), maximal GRFv (normalized to bodyweight; N/kg), time to maximal GRFv (s), and loading rate to maximal GRFv (N/kg/s)] were examined using separate 1-way repeated-measures analysis of variance (ANOVA), with the within subjects factor being ankle support. The a priori α level was set at .05. **Results:** The RSI of the no-brace condition (0.413 ± 0.12) was significantly greater than the RSI of the soft-shell brace (0.394 ± 0.11; P = .047). The RSI of the lace-up brace (0.420 ± 0.12; P = .008) was significantly greater than the RSI of the soft-shell brace, but not for the RSI of the no-brace (P = .523). Wearing the soft-shell brace (0.083 ± 0.01 s) resulted in a significantly slower time to maximal GRFv than the no-brace (0.074 ± 0.02 s; P = .03) and lace-up (0.73 ± 0.02; P = .009) conditions. No significant differences were found for jump height, EUR, maximal GRFv, and loading rate to maximal GRFv among the support conditions. **Conclusions:** Overall findings support the use of ankle bracing for ankle injury prevention. Wearing the soft-shell brace inhibited reactive strength during performance of the depth jump and resulted in a longer time for the jump landing GRFv to dissipate which could lead to lowered injury risk. Objective information on the effects of different types of bracing on jump performance may assist sports medicine professionals when recommending ankle bracing.

## The Effect of Ankle Braces on Sagittal and Frontal Plane Ankle Kinematics

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**Context:** Ankle braces are commonly used to prevent an ankle sprain. It is theorized that ankle braces stabilize the joint by restricting ankle range of motion(ROM). However, it is unclear if this ROM restriction occurs during actual functional performance. **Objective:** To evaluate if ankle joint kinematics are altered in different ankle brace condition during functional performance testing. **Design:** Cross-sectional study. **Setting:** Athletic Gymnasium. **Patients or Other Participants:** Twenty physically active individuals (11 females, 9 males, 20.6 ± 1.62 years, 177.1 ± 9.4cm, 74.75 ± 14.44kg) that regularly participate in basketball, volleyball, soccer or tennis. All individuals participated in at least 1 hour of physical activity 5 days a week. Exclusion criteria were the presence of any acute injury which prohibited them from completing the functional performance testing. **Interventions:** Participants attended one session and wore a standardized shoe (Adidas Barricade shoe) during all testing. Three functional performance tests were used: standing long jump, vertical jump, and t-test. Each participant performed three trials of each test in each condition (no brace, traditional lace-up brace(TL) (ASO EVO), modified lace-up brace(ML) (ASO Quatro). Both ankles were braced during the testing while the subject's dominant leg was used for kinematic data collection. Two-dimensional video(Innovision Systems, Inc., MI) was collected at 120 Hz to capture ROM data of the ankle. MaxTRAQ software(Innovision Systems, Inc., MI) was used to digitize and track the markers. For the vertical jump and standing long jump tests, three reflective markers were placed on the tibial plateau, lateral malleolus, and the base of the 5th metatarsal. Maximal dorsiflexion to plantarflexion ROM was captured during the takeoff period of each trial. For the t-test, two reflective markers bisected the calcaneus and two markers bisecting the lower third of the posterior leg. Maximal eversion to inversion ROM was captured when the subject changed direction during the t-test. The average of the trails was used for statistical analysis. A multivariate ANOVA with repeated measures(no brace, TL, ML) was used to determine differences in maximal ROM angles. Follow-up univariate analyses of variance and pairwise comparisons were conducted on any significant findings. **Main Outcome Measures:** Ankle eversion to inversion range(°) during the t-test, dorsiflexion to plantarflexion range(°) during the standing long and vertical jumps. **Results:** During the vertical jump, both brace conditions(TL = 50.03 ± 4.84°, ML = 49.92 ± 7.88°) significantly reduced ROM compared to the no brace condition(57.78 ± 6.51°, p = 0.01). During the standing long jump both brace conditions(TL = 49.30 ± 6.11°, ML brace = 48.52 ± 6.41°) significantly reduced ROM compared to the no brace condition(55.98 ± 6.58°, p = 0.01). No significant differences were identified between the conditions during the t-test(p > 0.05). **Conclusions:** Wearing an ankle brace significantly restricted dorsiflexion to plantarflexion ROM but did not restrict eversion to inversion ROM. Ankle braces may limit the performance of athletes who are primarily required to move in the sagittal plane.

## The Effectiveness of Modified Low-Dye Taping Technique on the Subtalar Joint Neutral Position Before and After a Period of Moderate Exercise

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**Context:** Low-dye taping is a technique commonly used to provide support for the medial longitudinal arch and reduce symptoms associated with over-pronation. However, conflicting results in the literature exist regarding its effectiveness after activity. Research is also lacking on the effect of the modified low-dye taping technique as well as its effectiveness after moderate exercise. **Objective:** To determine the effectiveness of modified low-Dye taping on navicular height and comfort levels after moderate exercise. **Design:** Randomized repeated-measures crossover design. **Setting:** University Laboratory. **Patients Or Other Participants:** Twelve (Male: 5, Female: 7) healthy, recreationally trained participants (Age: 21.25 ± 1.76 years; Height: 168.1 ± 8.3 cm; Weight: 71.9 ± 12.3 kg) who were pronators, determined by the navicular height drop test, completed the study. **Interventions:** Navicular drop and comfort level were assessed in each subject's right foot before and after a 10 minute treadmill jog during a no tape condition and a modified low-Dye tape condition. Participants were randomized to either condition on two different testing sessions separated by 3-7 days. **Main Outcome Measures:** Navicular drop was determined from the height (mm) of the navicular bone in subtalar joint neutral (STJN) position and in a relaxed position. Comfort levels were objectively measured with an adapted comfort questionnaire. Repeated measures analysis of variance assessed pre and post jog outcome measures independently between the tape and no tape conditions. **Results:** Statistically significant differences ($P < 0.001$) were found between the means of the pre-jog, STJN position (13.75 ± 5.14mm) and the pre-jog, post-tape positions (6.42 ± 2.94mm). Statistically significant differences ($P < 0.001$) were found between the means of the pre-jog, STJN (13.75 ± 5.14mm) and the post-jog positions (7.83 ± 2.66mm) in the taping condition. No variability was observed between the navicular height means for the pre-jog, STJN position (13.75mm) and the post-jog positions in the no tape condition. There was no significant difference found ($P = 0.55$) between the comfort values of the tape (19 ± 12.25) and no tape (16 ± 9.34) conditions. **Conclusions:** The modified low-Dye taping technique is an effective method for controlling arch support and maintaining it after a 10 minute jog and potentially other forms of moderate exercise. The tape was found to be slightly less comfortable than no tape, but the difference was not significant. More research is needed on the modified low-Dye method following longer, more vigorous bouts of exercise in symptomatic participants.

## Ankle Braces Have a Negative Impact on Power Related Functional Performance Testing

Mann LB, Murphy SP, Gruber AH, Docherty CL: Indiana University, Bloomington, IN

**Context:** Many athletes wear ankle braces to prevent ankle sprains from occurring. However, some athletes and healthcare providers are concerned about how these braces impact functional performance. **Objective:** To evaluate if wearing an ankle brace has an impact on functional performance. **Design:** Cross-sectional study. **Setting:** Athletic Gymnasium. **Patients or Other Participants:** Twenty subjects (11 females, 9 males, 20.6 ± 1.62 years, 177.1 ± 9.4 cm, 74.75 ± 14.44 kg) who were involved in at least 1 hour of physical activity (e.g. sport activity, cardiovascular exercise, weight training) 5 days a week participated in the study. Subjects were excluded if they had a current injury that precluded them from participating in practice or competition with no restriction. All subjects were either former or current high school or Division 1 college athletes. They participated in the following sports: tennis (n = 7), volleyball (n = 3), basketball (n = 8) and soccer (n = 2). **Interventions:** Participants attended one testing session and wore a standardized shoe designed for court sports (Adidas Barricade shoe). All participants completed four functional performance tests: standing long jump, vertical jump, 40 yd. sprint, and t-test. The vertical jump test was performed using the Vertec (Sports Imports, Ohio). The standing long jump test was completed using a standard measuring tape. For both the t-test and the 40 yd. sprint an electronic gate timing system (Brower Timing Systems Draper, Utah) was used to measure time. All participants performed three trials of each test in each condition and the average was used for statistical analysis. The conditions included: no ankle brace, traditional lace-up brace (TL) (ASO EVO), modified lace-up brace (ML) (ASO

Quatro). Two Multivariate Analyses of Variance (MANOVA) with repeated measures (TL, ML, no brace) were calculated. One MANOVA evaluated the power functional performance tests (vertical jump and long jump) and one MANOVA evaluated the speed/agility functional performance tests (t-test and sprint). Follow-up univariate analyses of variance and pairwise comparisons were conducted on any significant findings ($p < 0,05$). **Main Outcome Measures:** Vertical jump (cm), standing long jump (cm), t-test (sec), 40 yd. sprint (sec). **Results:** The analysis of the power tests yielded a significant difference between the brace conditions (Wilks' $\lambda = .46$, $F4,15 = 4.75$, $p = 0.01$). Subjects had decreased performance in the braced conditions compared to no brace for both the vertical jump (TL = 47.1 ± 10.0cm, ML = 47.1 ± 10.6cm, no brace = 48.3 ± 10.6cm) and standing long jump (TL = 169.9 ± 36.8cm, ML = 170.4 ± 36.7cm, no brace = 179.2 ± 33.2cm). The analysis of the speed/agility functional performance test yielded no significant differences between the brace conditions (Wilks' $\lambda = .83$, $F4,15 = .85$, $p = 0.51$). **Conclusions:** Ankle braces appear to have a negative effect on power functional performance measures but not speed and agility tests.

### Kidney Laceration in a Soccer Player

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**Background:** A 15 year old male soccer player collided with opponent during game while going up for a header. During the collision the opponent's knee contacted the lower abdomen and caused the player to fall backwards onto the soccer ball. The athlete immediately began hyperventilating and gagging while lying fully supine. The athletic trainer immediately responded to the athlete on the field at which point he was moved to a side-lying position and began to vomit. While on the field the athlete complained of severe abdominal pain but reported that the pain subsided once he walked off the field. Once on the sideline he experienced shallow, rapid breathing and complained of mild abdominal discomfort. Upon palpation, no specific point tenderness was noted. After approximately 15 minutes the athlete reported additional pain in his lower back on the right side. During the course of the game the athlete went to the locker room to urinate, after which reported to the athletic trainer that blood was noticed in his urine. Parents were notified and athlete was referred to the emergency room. **Differential Diagnosis:** kidney contusion, abdominal contusion, ruptured appendix. **Treatment:** Parents took the athlete to the local emergency department where he was then transferred to the Children's Hospital and admitted. He was diagnosed with a right kidney laceration. Surgery was performed the next day to insert a nephrostomy tube. At the hospital doctors were able to determine that his right kidney was enlarged due to an infection caused by a blocked ureter, which resulted in a kidney being more susceptible to injury and laceration. The athlete was hospitalized for 4 days. Upon his release, the nephrostomy tube remained in place for 1 month. The possibility of future surgery within 4-6 months of injury was discussed to insert a stent in his ureter, which was 100% blocked. **Uniqueness:** Internal injuries in sport are relatively uncommon, especially in soccer. However, with any contact sport there are risks for such injury. The underlying circumstances of this injury were unique as there were no prior complaints regarding any symptoms related to a blocked ureter or enlarged kidney. Without knowing the athlete had an enlarged kidney, the outcome of the injury seemed inconsistent with the mechanism in which it happened. **Conclusions:** The athlete was able to return to sport without complications. Although organ injuries are rare in sport they do occur and it is imperative to have athletic trainers present at athletic events. Being able to recognize symptoms associated with internal injuries, even in the apparent absence of a typical mechanism, can help prevent a catastrophic event from being improperly treated. Furthermore, it is also important for athletic trainers to be aware of means to protect against internal injuries if predisposing factors are noticed.

### Neurocardiogenic Syncope in a Female Collegiate Basketball Athlete

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**Background:** A 19 year old female basketball player (170.68cm; 65.77kg) reported suffering from episodes of feeling faint, dizzy, nauseous, clammy, experiencing tunnel vision, and loss of hearing, usually after standing up too quickly. She had experienced these episodes for as long as she can remember, but claims recently additional symptoms, such as complete loss of sight, syncope and feeling fatigued, began to accompany the episodes without explanation. The symptoms usually lasted for approximately 30 seconds after standing up rapidly. Specifically, the patient recalled 4 of these episodes within the previous year before consulting with her general medical physician. The first episode occurred in March 2013 while shopping, when she was experiencing severe menstrual cramps. The second episode happened 2 weeks after shoulder labral repair in June of 2013 during a physical therapy session. The patient reports the third episode from November 2013 during basketball practice while she was experiencing pain due to Achilles tendinitis. The fourth episode occurred in April 2014 after she had been outside in the sun all day and reports being dehydrated. No relevant contributing family history was concluded from conversations with the patient. The patient did complain of a heavy feeling in her lower extremities and feeling exhausted after these episodes. She was not on any medication at the time. **Differential Diagnosis:** Orthostaic hypotension, vertigo, dehydration, brain tumor, neurocardiogenic syncope. **Treatment:** The patient was referred to her general medical

physician in May 2014 and completed a series of diagnostic tests including electrocardiogram, echocardiogram, stress test, and tilt table test. The EKG, echocardiogram and stress tests were inconclusive, but the table tilt test was positive for reproduction of symptoms. The patient was diagnosed with neurocardiogenic syncope. The physician did not explore any possibility of brain involvement due to athlete's lack of history of seizures. The patient was placed on fludrocortisone, once daily, to maintain blood pressure homeostatic levels. Before medication, the patient's resting blood pressure was 115/50, but has since improved to 130/75.The patient has experienced less frequent episodes (one episode since May 2014) and feels her symptoms have decreased. **Uniqueness:** Neurocardiogenic syncope has a 22% prevalence in the general population. It is also referred to as situational syncope, because it is thought to be triggered by abnormal or exaggerated response to a stimuli. Things such as various emotions, experiencing pain, and rapid standing can cause an episode of syncope. Physiologically, it is caused by an abnormal response of the autonomic nervous system that results in vasodilation, increased vagal tone, decreased cardiac filling and decreased heart rate. **Conclusions:** It is important for clinicians to be aware of neurocardiogenic syncope in their patient population because it is possible that it can be passed off as something more minor, such as dehydration. In some cases, syncope can be a precursor for underlying heart disease. It is important for the patient to get proper medical care and to have more serious conditions ruled out.

## Morel-Lavallée Lesion to the Elbow in a Male Collegiate Soccer Player: A Case Report

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**Background:** The patient is a relatively healthy 21-year-old male goalkeeper on a collegiate soccer team. During an offseason indoor practice on hardwood floors, the patient dove and landed on his right elbow. He had no issues until two-weeks post injury. He presented with swelling at the posterior elbow and point tenderness on the olecranon process. He had no history of elbow injury bilaterally and has no predisposing conditions. **Differential Diagnosis:** Olecranon bursitis, olecranon contusion, olecranon fracture. **Treatment:** The physician's initial exam revealed edema and mild pain localized to the olecranon process with full ROM, strength, and normal neurovascular exam. The patient was diagnosed with olecranon bursitis and was prescribed prednisone followed by Naprosyn. He responded well to the anti-inflammatories and was able to play with padding. Over the next few months he experienced fluctuating edema consistent with persistent olecranon bursitis. Treatment included warm whirlpool, effleurage massage, diathermy, NSAIDs, and elbow padding for activity. Due to the reoccurring symptoms, an MRI was performed that revealed a lobulated fluid collection in the subcutaneous soft tissues of the posteromedial elbow joint. The physician attempted to aspirate the fluid under diagnostic ultrasound, but the fluid proved too viscous. Diathermy use was increased to help resolve the fluid collection. Eleven weeks post injury, the edema increased again with no new mechanism. This time the physician was able to aspirate fluid from the space and inject Depo-Medrol. The patient subsequently took three weeks off with no activity or treatment and experienced complete relief from the aspiration, injection, and rest. One month after return to activity, the patient experienced another increase in edema. A second MRI performed revealed the same fluid collection, but an overall decrease in size. The patient was instructed to continue the same treatment as before with no restriction from activity. Twenty-four weeks post injury the patient presented with new symptoms. With no new mechanism, the edema had increased again, but had moved anteromedial and slightly distal from the previous location. Hyperemia and erythema were also present. The physician again aspirated fluid from the space, applied a compression wrap, and ordered an MRI. The MRI performed suggested a possible infection, but the fluid aspirated was more seroma-type than purulent. Lab work done at this time further confirmed that there was no infection. This exam led to the diagnosis of a Morel-Lavallée lesion. A Morel-Lavallée lesion is a closed degloving injury in which the skin shears away from the underlying fascia to create a space that fills with blood and lymph. The patient underwent four surgeries: the first to irrigate and debride the lesion and insert a wound VAC, the next two to change the wound VAC, and the final to remove the wound VAC. The patient then began a gradual increase in activity until full clearance thirty-one days post-op. Treatment during the progression consisted of moist heat pack, ultrasound, and effleurage massage. **Uniqueness:** There is limited research available on Morel-Lavallée lesions to the elbow. Morel-Lavallée lesions are most commonly seen in the trochanteric region or in the knee. These types of lesions typically occur secondary to specific high velocity trauma so it is rare to occur in a low velocity trauma. **Conclusions:** The patient presented with olecranon bursitis for six months. The Morel-Lavallée lesion then formed in addition to the bursitis. The patient underwent a successful surgery and rehabilitation. He is currently playing professionally with no foreseeable future complications. It is not uncommon for Morel-Lavallée lesions to go unnoticed for a period of time. It is always important to continue to reevaluate when injuries are not progressing as expected.

## Morel Lavallée Lesion in a Division 1 Lacrosse Player

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**Background:** A twenty-one year old male, Division I Lacrosse defenseman presented with the chief complaint of posteriolateral lower leg pain and fatigue. History revealed the athlete sustained injury during play of March 2015 when a shot grazed his lower leg. Initially, he self-treated with ice and continued to play. Five days later, he presented to the athletic training staff displaying lower leg edema ranging from the proximal to distal lower extremity. Further presentation included a soft fluctuant mass, ecchymosis, and tenderness with palpation over the site of impact. The patient had full ROM and was full weight bearing, although did report slight pain during toe-off. Pain increased with MMT of gastrocnemius, soleus, anterior tibialis and peroneals, and he complained of lower leg fatigue. The athlete began treatment for a contusion with high volt stimulation, ice, elevation and a compression dressing. A pad was created for protection during play. One-week post-injury, he began complaining of calf cramping during game play. The athlete was stretched and given electrolytes, but unable to continue. He was evaluated the following day, presenting with increased ecchymosis, erythematous skin and was significantly warm to touch. The affected area also increased in range. During ROM re-evaluation the patient reported cramping sensation. **Differential Diagnosis:** Contusion/hematoma, cellulitis, hemorrhagic bursitis, acute compartment syndrome. **Treatment:** The athlete was referred to the team physician who performed diagnostic ultrasound, which identified a Morel Lavallée Lesion (MLL). The athlete took two days off and was treated with Kinesiotape, padding, electrical stimulation, and ice. After two days, the edema and warmth decreased, and play was permitted as tolerated, assuming symptoms did not increase. It was believed tissue edema created the urge to cramp. Two weeks after the MD visit, the athlete presented with no signs or symptoms and returned to play. A MLL is a rare cause of subcutaneous swelling created by traumatic shearing of the hypodermis from the underlying fascia. This creates space that fills with a combination of hemorrhage, fat and lymphatic fluid. If untreated, an inflammatory reaction creates a peripheral capsule, preventing reabsorption of the contents and self-perpetuation. The lack of self-perpetuation leads to the potential for open debridement. Treatment of such lesions is not well established due to limited occurrences. In this case, conservative treatment was successful. **Uniqueness:** The case is unique due to mechanism, incidence rate, duration and evaluation findings. A MLL would typically be seen following a car accident, or a low-velocity crushing injury, often in combination with an underlying fracture. In our case, a lacrosse ball produced enough shearing force to cause the lesion. Research has found that only 1.5% of all MLL incidences occur within the calf, and the more common sport-related cause of MLLs are within football from knee-turf contact. The lesion our patient suffered only presented with symptoms for two weeks rather than the average of thirteen months. **Conclusions:** This case has been presented involving an atypical site, mechanism and patient population. Delayed diagnosis, usually causes chronic MLL recurrence and peripheral capsule formation, which would have prevented successful conservative treatment. Untreated MLLs often go unidentified and can result in infection, fat necrosis, and/or chronic recurring MLLs. Initial skin bruising can mask significance of the underlying soft tissue injury. Additionally, research findings regarding shearing forces on turf, and the common use of turf as a playing surface, should keep MLLs in the bank of differential diagnoses when presented with similar signs and symptoms.

## Mesenteric Lymphadenitis in a Male High School Tennis Player

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**Background:** A 17-year-old, male, high school, tennis player with no previously associated medical history reported to the athletic training staff complaining of right abdominal pain. The athlete complained of a sudden onset of severe, constant stabbing pain. He rated the pain as 8/10 with accompanying nausea and fatigue that began while he sat watching a basketball game. The athlete disclosed that he participated in his team's weight lifting session earlier in the day without pain or injury to the abdominal area. He preferred sitting to standing and slouched to his right side. The Athletic Training staff's initial examination revealed painful palpation of the right lower quadrant, pain relief with steady pressure and increased pain with pressure release, point tenderness around McBurney's point, and a positive rebound test and jar test. **Differential Diagnosis:** Appendicitis, acute gastroenteritis, constipation, flatulence. **Treatment:** Suspecting appendicitis, the Athletic Trainer referred the patient to the local emergency department where the attending Physician's evaluation reported the patient had moderate right upper and right lower quadrant pain that did not radiate. The patient denied bloating, constipation, flank pain, flatulence, headache, kidney stones, vomiting, and recent illness or injury. Inspection revealed normal bowel sounds and no fever. Palpation revealed moderate abdominal tenderness in the epigastric area, left upper quadrant, and right lower quadrant, rebound tenderness, and mild right low back pain. All other systems were negative. Blood work, urinalysis, and a CT scan were ordered to rule out appendicitis. Below normal HGB, HCT, MPV, and lymph% values, abnormal ketone levels of 1+, a normal appendix, and right lower quadrant subcentimeter mesenteric lymph nodes were revealed by the blood tests, urinalysis, and CT scan respectively. These findings were consistent with mesenteric adenitis

and the patient was diagnosed with mesenteric lymphadenitis. The patient's pain was treated with fentanyl 50 mcg twice in the right antecubital fossa. Discharge from the emergency department included a prescription for TORADOL 10 milligrams to be taken orally every six hours as needed. The patient had improved symptoms with the pain medication. A follow up appointment with his primary care physician took place days later to ensure the patient remained asymptomatic. **Uniqueness:** Mesenteric lymphadenitis is commonly mistaken for appendicitis. The two conditions present with right lower quadrant pain and symptoms of malaise, tiredness, and nausea. This condition occurs more often in male than female patients and is most commonly reported in children and teens. True incidence rates are unknown, because it is easily mistaken for other diagnoses or missed. The condition's suggested mechanism is an infection that causes acute inflammation of the lymph nodes within the right abdominal region. Sharp, intense spasms of colic in combination with the patient's ability to move freely and constantly change position without pain, tenderness elicited higher and more medial than McBurney's point, and pain relief with steady pressure on the muscles in spasm are discrete differences that can help differentiate mesenteric lymphadenitis from acute appendicitis. Prompt referral is still necessary to rule out an acute surgical abdomen. Treatment primarily entails rest and hydration, but medication for relief of pain, inflammation, fever, and/or antibiotics may be prescribed by a physician. Most patients recover completely without any complications. **Conclusions:** A male, high school, tennis player presented with signs and symptoms that warranted immediate referral to the emergency department for acute appendicitis. After reviewing his blood tests and diagnostic scans, he was diagnosed with mesenteric lymphadenitis. It is important for athletic trainers to know this differential diagnosis and its discrete differences in signs and symptoms because it is a common cause of acute abdominal pain that is often mistaken for appendicitis.

## Division I Collegiate Volleyball Player With Complications From Type I Diabetes: A Clinical Case Report

Pforr M, Joseph C: University of Central Florida, Orlando, FL

**Background:** The patient is an 18-year-old female collegiate indoor volleyball player. She presented during her competitive season with syncope, nausea, fatigue, and headaches. Her previous medical history includes late onset Type I Diabetes Mellitus, two months prior, with no family history of Type 1 diabetes. Her glucometer readings showed normal ranges, averaging 100 mg/dL. She is 6 foot 2 inch tall and 170 pounds, with a BMI of 22. **Differential Diagnosis:** Mismanaged diabetes, Celiac disease, hypothyroidism, pituitary tumor. **Treatment:** Based on her clinical presentation, the endocrinologist diagnosed her with Celiac Disease and started her on a gluten free diet. After the elimination of gluten, her symptoms quickly resolved and she was able to return to athletics. Further testing for Celiac Disease was not completed due to the risk of worsening symptoms during her competitive season. To regulate her blood glucose levels she uses a small, lightweight, waterproof OmniPod insulin pump and a Dexcom continuous glucose monitor. Both are worn on her triceps with unattached monitors, allowing her to fully participate in athletics. Weight training causes a spike in blood glucose during participation with a drop after completion. To manage this she doses prior to weights according to her normal carbohydrate to insulin ratio. Participation in athletics causes downward trends in her blood glucose levels so she proactively decreases her insulin to carbohydrate ratio for pre-activity meal dosing. During activity she drinks PowerAde that contains 14 grams of sugar and 14 grams of carbohydrates and eats Honey Stinger Organic Energy Chews that contain 27 grams of sugar and 39 grams of carbohydrates, both of which are gluten free. A rapid decline in blood glucose occurs after exercise, so she eats post-activity meals including complex carbohydrates, such as gluten free bread or pasta, rice and potatoes. This combination of diseases creates a complication for pre-game meals and eating while traveling. For catered meals we request gluten free chicken, salad dressing, and a starch. When ordering individual meals, she selects gluten free options, and notes that they need to change their gloves and decontaminate surfaces to prevent cross contamination. **Uniqueness:** She was diagnosed with type 1 diabetes at nearly 18 years old; adult-onset is atypical especially for an individual with a healthy BMI. In addition, she has an extremely unique combination of Type 1 diabetes and Celiac Disease which statistically only occurs in approximately 4 out of 10,000 people. In America 9.3% of people have diabetes with only 5% of these diagnosis's being type 1. Out of these cases of type 1 diabetes only approximately 8% also have Celiac Disease. In addition to this, she is a Division 1 athlete, which brings about additional complications with training, eating, traveling, and competing. Based on the demands of her sport she can not wear a standard monitoring systems, so she uses a Omnipod pump and Dexom continuous glucose monitoring system which can be used on her arms, allowing for full participation, including diving and rolling. **Conclusions:** It is important for athletic trainers to understand the effects that the variety and frequency of exercise in athletics have on type 1 diabetics. Once the effects are understood it is important to maintain a schedule and routine so that the patient is able to maintain healthy blood glucose levels and limit fluctuations. With the addition of Celiac disease, it is important that in the maintenance of blood glucose extreme caution is taken to provide carbohydrates and glucose without gluten.

## Pseudotumor Cerebri in a Female High School Athlete

Gildard MJ, Rubin S: Marist College, Poughkeepsie, NY

**Background:** A seventeen-year-old interscholastic crew athlete (167cm, 59kg) with a history of exercise-induced asthma and menorrhagia and a family history of ocular migraines began suffering from severe headache pain. The headaches began upon waking and would be exacerbated when laying down. The patient also began experiencing aura-like symptoms prior to onset of the headache. After the symptoms had lasted for over two weeks, the patient underwent evaluation by her primary care physician who diagnosed her with ocular migraine headaches. The patient's symptoms progressed for nearly one year and by this time included weight loss, nausea, binocular vision impairment and pupil asymmetry as well as left-sided ptosis and decreased motor control. Following a referral to a neurologist, the patient underwent Magnetic Resonance Imaging (MRI) and a lumbar puncture (LP). **Differential Diagnosis:** Ocular migraine, status migrainosus, pseudotumor cerebri (idiopathic intracranial hypertension), tension headache, facial nerve palsy, optic nerve palsy, papilledema, malignancy **Treatment:** The neurologist's exam included a funduscopic evaluation which revealed no papilledema. Additionally, the MRI findings were normal. Because the patient's severe ocular migraines often lasted for several days at a time, she was diagnosed as status migrainosus. Due to the progression of the patient's symptoms as well as her lack of response to prescription oral anti-migraine medications, a LP was performed which revealed an elevated opening pressure indicative of pseudotumor cerebri (PTC), also known as idiopathic intracranial hypertension. The LP was successful in minimally decreasing the patient's symptoms but only for a short duration. An intravenous dihydroergotamine (DHE) procedure was performed but produced no relief in symptoms. Prescription oral medications including verapamil hydrochloride, a calcium ion influx inhibitor and butalbital, a barbiturate, were prescribed but also proved unsuccessful. A relief in symptoms was noted after the patient was placed on acetazolamide, a carbonic anhydrase inhibitor often used in the treatment of epilepsy. The patient was also treated by her secondary school's Certified Athletic Trainer utilizing thermotherapy, electrical stimulation, range of motion and strengthening therapy, and balance and proprioceptive training with the goals of decreasing pain, and increasing strength and neuromuscular control. **Uniqueness:** Pseudotumor cerbri, or idiopathic intracranial hypertension, is a rare condition accounting for approximately 0.9 cases in 100,000 patients annually. The etiology is unknown though it has been speculated that the symptoms could be due to a narrowing of the transverse cerebral sinus. This condition displays a predominance in females over males, particularly in obese and hypertensive females. This makes the prevalence of PTC in athletes rare. Normal funduscopic evaluation in patients with PTC is uncommon. Despite high success rates in symptom reduction and strong evidence to support the use of DHE in the treatment course for migraine headaches and PTC, this patient had no relief in her symptoms. **Conclusions:** Headaches are a common complaint of patient's seen in health care facilities. Athletic trainers must be cognizant of conditions such as status migrainosus and pseudotumor cerebri despite their rarity in the athletic setting. Currently the patient's symptoms remain well-controlled via oral medication though she does suffer from severe migraine symptoms occasionally. She was cleared by her neurologist to return to rowing activities.

## Medulloblastoma in an Adult Collegiate Gymnast

Harris JB, Poole KL, Butterfield TA: University of Kentucky, Lexington, KY

**Background:** A 21 year old female Division I collegiate gymnast presented to the Athletic Trainer (AT) complaining of constant headaches for two weeks, which had progressed to interfering with her quality of sleep. She reported that she felt worse when lying down, but felt better once she got up and moved around. The AT's evaluation revealed no posterior cervical tenderness but general pain with palpation of the upper trapezius, levator scapula and scalene muscles. The athlete presented with full grip strength bilaterally and no deficits neurologically or in vestibular function. She had been participating in gymnastics with no issues, but experienced painful headaches when she inverted her position (e.g. handstand). The athlete was referred to the university health services due to her general medical symptoms. She was diagnosed with tension headaches and was prescribed metaxalone and naproxen. Forty-eight hours later, immediately prior to travel with the team, the athlete reported additional instances of insomnia due to continued neck pain and headaches. However, the athlete reported no symptoms prior to the meet, and experienced no symptoms during warm up and competed in vault with no issues. During the floor routine, the athlete landed on the back of her head with her neck in a flexed position, but stood up under her own volition. However, upon standing she fell to the mat, lying in a supine position, where she was immediately immobilized by the AT, and evaluated. The athlete presented with no loss of consciousness, but reported pain and paresthesia down her right arm. In line stabilization of the cervical spine was maintained as the athlete was secured to a spine board, immobilized, and transported to the emergency room by emergency medical services. **Differential Diagnosis:** Tension headaches, migraines, c-spine fracture, brain injury. **Treatment:** CT Scan showed no signs of neurological

injury or fracture but demonstrated a slight blur over the cerebellum. Magnetic Resonance Imaging (MRI) showed unusual tumors, and a subsequent needle biopsy confirmed these tumors to be classic medulloblastoma. It was reported that she had four tumors, but they were unable to be removed due to the location and risk. She started radiation one week following diagnosis, which lasted for six weeks followed by four rounds of chemotherapy, lasting a total of four months. Seven months following initial diagnosis, an MRI and spinal tap confirmed that the athlete was in remission. **Uniqueness:** Medulloblastoma is a rapidly growing tumor of the cerebellum, which coordinates voluntary motor movements including posture, balance, coordination and speech. It arises from immature cells at the earliest stage of development and the median age at time of diagnosis is seven. Furthermore, 70% of all diagnoses are under the age of 10. The prevalence of medulloblastoma in adults is 1 in 20 million. Typical symptoms of medulloblastoma mimic early flu like signs (lethargy, irritability, and loss of appetite), headaches and vomiting upon awakening, but symptoms typically resolve as the day progresses. Delayed symptoms include loss of proprioception and balance, and associated dizziness. The median survival rate is 7.9 years with a survival rate of 62% and 41% at 5 and 10 year respectively. **Conclusions:** Although rare, medulloblastoma can affect adults and it will typically present with symptoms mimicking migraines, the flu and other common disorders. Therefore, although assessment of chronic, daily headaches can be challenging, ATs should consider secondary causes such as infections and tumors in the initial differential diagnoses.

## Commotio Retinae and Corneal Abrasion in an NCAA Division II Intercollegiate Women's Soccer Player

Gruber D, Vanata D, Denbow D, Stotts D, Worthman M: Ashland University, Ashland, OH

**Background:** A 20-year-old female soccer player suffered a blunt force trauma to the left eye, by the ball, during a match in October of 2013. The patient presented with signs of swelling within the eyelid and increased lacrimation. Patient complained of pain upon opening and closing of the eyelid. During the initial evaluation, the athletic trainer noted the patient's sclera was red and a penlight test produced photophobia. The athletic trainer treated the patient's pain and swelling with ice. The patient was referred to a Doctor of Optometry following the athletic trainer's evaluation. **Differential Diagnosis:** Retinal Detachment, Corneal Abrasion, Retinal Hemorrhage, and Pupil Anisocoria. **Treatment:** On October 25, 2013, the patient was examined by the Optometrist. The diagnosis was Commotio Retinae, retinal hemorrhage, corneal abrasion, contusion of the eyelid, the periocular area, the orbital tissue, as well as periorbital hematoma. The patient experienced no headaches, double vision, visual floaters, light flashes, or blurry uncomfortable vision. Extraocular muscle motilities and versions were normal. Pupils were normal, round, and reacted briskly to light. The patient was required to follow up with the Optometrist to ensure the retina was healthy and no subsequent hemorrhage or deterioration was occurring. On the two subsequent examinations of October 28 and November 2, the patient was diagnosed with the same pathologies along with the addition of pupil anisocoria. At this time, the Optometrist felt Rx artificial tears and antibiotic/steroid drops were optimum for management. The patient was then referred to an ophthalmologist specializing in vitero-retinal disease. This was again a precaution to ensure the retina was intact and healthy. On November 6, 2013, the patient's initial retinal consultation revealed 20/20 vision in both eyes. Extended ophthalmoscopy of the left eye with scleral depression displayed intraretinal hemorrhaging, retinal pigment epithelium disruption peripherally, and resolving Commotio Retinae. Following evaluation by the ophthalmologist, the patient was considered at high risk for retinal tearing or detachment and halted from any type of exertion or head jarring activities for a month to prevent retinal tearing and detachment. **Uniqueness:** There have been limited studies describing Commotio Retinae secondary to blunt force trauma in athletics. The research that has been identified found that Commotio Retinae occurring from a blunt trauma is rare, and treatment options for Commotio Retinae in a young and active patient population are limited. Studies that were examined suggested that the soccer ball is unique among the projectiles utilized in athletics. The soccer ball is unique due to its shape and construction, orbital penetration is lower but the time in the orbit is longer. This time spent within the orbit causes a secondary suction effect that impacts the orbital contents and creates the Commotio Retinae. Athletic trainers will benefit from the knowledge of management and treatment protocols for eye injuries related to projectiles like the soccer ball. **Conclusions:** On December 4, 2013, after a month of inactivity, extended ophthalmoscopy revealed no peripheral retinal detachment nor tearing in the patient's left eye. The patient's retinal hemorrhaging had resolved. The ophthalmologist released the patient to full activity. The patient was required to follow up after three months. On February 19, 2014 during a follow up appointment, the athlete reported on-going symptoms seeing flashes of light and 'floaters' when walking from light to dark rooms. Extended ophthalmoscopy revealed traumatic retinal scarring, a common occurrence for this injury. Finally, on May 21, 2014, the patient reported symptoms had diminished and vision was returning to pre-injury state.

## Collegiate Volleyball Player Experiencing Unilateral Blindness With Strenuous Activity

Posey KG, Craddock J, Guadalupe IC, Felton SD: Florida Gulf Coast University, Fort Myers, FL, and Ave Maria University, Ave Maria, FL

**Background:** Athlete is a 20 year-old (175.3 cm and 63.5 kg) female NAIA collegiate volleyball player. Athlete's prior medical history includes two blunt traumas to the right side of her head. These traumas were sustained during a volleyball practice and game within the same week. No symptoms were present until one week later, when athlete experienced blurry vision and eventually, complete loss of vision in her left eye. Athlete was immediately referred to emergency room. **Differential Diagnosis:** Amblyopia, cataract, macular degeneration, retinal detachment, post-concussion syndrome, traumatic optic neuropathy. **Treatment:** CT scan without contrast was completed with no abnormal findings. A concussion symptom score sheet was kept by the athletic training staff. Symptoms amplified with an increase in mental or physical activity. Athlete completed conservative treatment through management of daily symptoms of headaches and nausea, along with monitoring physical and mental activity in order to limit loss of vision. After symptoms did not subside with conservative treatment, athlete was seen by multiple ophthalmologists and family physician. Athlete was being treated for a slow recovery from concussion symptoms with various prescribed pain and anti-inflammatory medications. Athlete also completed vestibular therapy, which caused an increase in her symptoms. After two years of minimal relief of symptoms, athlete stopped taking all medications and was seen by a neuro-ophthalmologist. Athlete was eventually diagnosed with shearing of the optic nerve sheath within the optic canal with an increase in body temperature from activity. The shearing of the optic nerve was disrupting blood supply, creating an ischemic nerve. This led to an optic neuropathy associated with any mental or physical activity lasting more than twenty minutes, causing her to lose vision in her left eye. The athlete has been cleared to return to play by the neuro-ophthalmologist. An attempt at covering the left eye with a patch during exercise was not successful with limiting symptoms. The athletic training staff is continuing to treat symptomatically. Treatment consists of gradually increasing time and intensity of physical activity. **Uniqueness:** This is unique because of the relatively low occurrence of partial blindness in sports following blunt cranial trauma. Traumatic optic neuropathies only occur in .7 - 2.5% of recorded head injuries.1 In this case, the symptom of impaired vision did not present until one week after the second blunt trauma. Secondly, there was a team of multiple health care providers working towards a diagnosis over two years. Lastly, the anti-inflammatory and pain medications did not decrease symptoms due to the cause of vision loss resulting from a limited blood supply with an increase in body temperature. **Conclusions:** This case highlights the long term diagnosis and attempted treatment of an athlete suffering from a traumatic optic neuropathy in the left eye. The neuro-ophthalmologist suggested there is no surgical intervention to relieve symptoms due to the optic nerve dural sheath being tethered to the optic canal. Athlete is currently engaged with the athletic training staff to minimize symptoms during physical activity to return to play. This case may be used to help differentiate signs and symptoms of optic neuropathies from concussions.

## Odontogenic Keratocyst in a Division I Softball Athlete

Niss NR: University of Central Florida, Orlando, FL

**Background:** A 19-year old, Hispanic, female, collegiate softball athlete complained to the athletic trainer of lower left molar pain that had been persisting approximately two weeks. She was referred to a general dentist and initial radiograph revealed a large radiolucency of the left ascending mandibular ramus. Purulent discharge was noticed upon probing of erupted wisdom tooth #17, and the soft tissue of the lower left jaw presented with diffuse inflammation. Multiple Panographic radiographs subsequently obtained by an oral surgeon displayed a large, multilocular radiolucency extending from the coronoid process posteriorly to the distal portion of tooth #17. Follow-up biopsy confirmed suspicion of odontogenic keratocyst (OKC), a neoplastic, intraosseous, benign tumor, characterized by a thin, corrugated surface layer of parakeratin. **Differential Diagnosis:** Ameloblastoma, dentigerous cyst, odontogenic or non-odontogenic cyst/tumor. **Treatment:** The patient underwent enucleation and curettage to ensure complete removal of the lesion. Extraction of teeth #16 and #17 were also performed under general anesthetic. No complications were reported and two-week follow-up radiographs showed no remnants of the cyst. Patient reported hyposthesia on the left side of the lip, likely due to inferior alveolar nerve trauma common during the process of enucleation. This resolved several weeks later. The athlete rested for the duration of summer break and consulted with a sports medicine physician at the beginning of fall training. It was ordered that she refrain from activities with limited ball control, including live batting and fielding grounders. She was also instructed not to perform exercises which place weights in close proximity to the jaw, such as bench press. Three weeks later, the physician determined that there was sufficient integrity of the jaw

based on visual examination and review of radiographs which depicted some regrowth of bone. She was given medical clearance to participate in the sport of softball, with the provision that she must wear a mask on the batting helmet indefinitely. **Uniqueness:** The epidemiology of odontogenic cysts as a whole is not well-documented, but research estimates they affect approximately 0.04% of the population. The OKC is one of the rare, aggressive, odontogenic cysts, predominantly found in white individuals of Northern European descent. It is often asymptomatic and incidentally discovered on radiograph. In this case, the expansive nature of the lesion caused significant discomfort of the jaw and lead to concern regarding its etiology. **Conclusions:** A healthy, female, collegiate athlete, with no pre-existing conditions or history of oral pathology, was referred to a general dentist with the primary complaint of lower left molar pain. Imaging revealed the presence of a large, destructive mass, later determined to be an odontogenic keratocyst (OKC). Surgical removal of the OKC was successful and the patient has resumed normal participation in competitive softball. This case highlights the importance of prompt referral by the athletic trainer when a patient presents with dental pathology. Wisdom teeth typically erupt between the ages of 17 and 25; thus, complaints of molar pain by a collegiate athlete often do not illicit serious concern. It is also worth noting that the patient presented with decay of multiple teeth at her initial evaluation, which could indicate poor oral hygiene practices and/or lack of access to professional care prior to her athletic career. An investigation into the cost-benefit of providing routine dental examinations to Division I student-athletes may be warranted based on this case.

## Miscellaneous Evidence-Based Forum: Strategies for Continuous Reduction of Sports Injury Risk

Thursday, June 23, 2016, 8:00AM-9:00AM, Room 315; Moderator: Jennifer McKeon, PhD, ATC, CSCS
Discussants: Marisa Colston, PhD, ATC; GaryWilkerson, EdD, ATC

### Effect of Low-Level Laser Therapy on Superficial Tissue Temperature

Gear WS: New Mexico State University, Las Cruces, NM

**Context:** Low-Level Laser Therapy (LLLT) is thought to cause an increase in microcirculation, which could lead to an increase in tissue temperature. Increased tissue temperature by even 1° C can have beneficial healing effects. **Objective:** The purpose of this study was to examine if LLLT has an effect on superficial tissue temperature (STT). **Design:** Repeated measures design. **Setting:** Laboratory setting. **Patients or Other Participants:** 18 healthy participants [8 males (21.0 + 1.41 yrs. old, 180.34 + 7.18 cm, 102.29 + 0.32 kg) and 10 females (19.40 + 0.55 yrs. old, 155.19 + 17.51 cm, 67.13 + 8.58 kg)]. **Interventions:** Low-Level Laser Therapy was administered 1 cm above the dorsal aspect of each participant's left hand using a 1200 mW, 830 nm Gallium-Aluminum-Arsenide (GaAlAs) BTL 5000 series (BTL Industries, Ltd., Hertfordshire, UK) laser at a power output of 1 J/cm2. Treatment time for this protocol was 24 seconds. **Main Outcome Measures:** Superficial temperature change was measured using a FLIR A320 Infrared Imaging Camera (FLIR Systems, Inc., Wilsonville, OR). Superficial temperature measures were taken prior to treatment, immediately following treatment, and at 1 min., 2 min., and 4 min. post treatment. Each temperature measurement was taken for 5 sec. The maximum temperature measured during each measurement window was used for further analysis. A repeated measures analysis of variance was utilized to determine statistical significance. All tests of significance were carried out at an alpha level = 0.05. **Results:** A significant superficial tissue temperature change was found between the pre-treatment STT (30.45 ± 2.08° C) and all post-treatment STT measurements (immediately post-treatment = 31.33 ± 2.19° C, 1 min. post-treatment STT = 31.33 ± 2.31° C, 2 min. post-treatment STT = 31.40 ± 2.37° C, and 4 min. post-treatment STT = 31.50 ± 2.42° C). Pairwise comparisons between measurements showed that tissue temperature was significantly different between the pre-treatment STT and the post-treatment STT ($p = 0.000$), between the pre-treatment STT and 1 min. post-treatment STT ($p = 0.012$), between the pre-treatment STT and 2 min. post-treatment ($p = 0.017$), and between the pre-treatment STT and 4 min. post-treatment ($p = 0.015$). **Conclusions:** Low-level laser therapy at 1 J/cm2 caused an increase in superficial tissue temperature post treatment and at 1, 2, and 4 min. post treatment. As the average increase in superficial tissue temperature was greater than 1° C for up to 4 minutes, this may indicate that an increase in metabolic activity may occur in superficial tissues following LLLT.

### A Comparison of Two Deep-Heating Modalities: ReBound Continuous Shortwave Diathermy and MegaPulse II Pulsed Shortwave Diathermy

Ostrowski JL, Ely CG, Evans H, Bocklund D: Weber State University, Ogden, UT; Muir Orthopaedic Specialists, Walnut Creek, CA; Virgin Valley High School, Mesquite, NV; East Ridge High School, Woodbury, MN

**Context:** Continuous Shortwave Diathermy (ReBound) is a relatively new diathermy modality designed to provide vigorous heating to deep tissues via anatomically-designed garments (sleeves). Research has shown that MegaPulse II Pulsed Shortwave Diathermy (PSWD) is able to vigorously heat deep tissues, but little research exists on the ReBound and its intramuscular heating capabilities as compared to existing PSWD modalities. **Objective:** To evaluate two deep heating therapeutic modalities (ReBound and MegaPulse II) on intramuscular temperature heating and cooling. We hypothesize that (1) both modalities will reach equal max intramuscular temperature increase (4°C), with PSWD having the faster rate of heating; and (2) PSWD will have the faster rate of decay. **Design:** Repeated-measures counterbalanced design (crossover study). **Setting:** University research laboratory. **Patients or Other Participants:** Volunteer sample of 18 healthy participants (male, n = 8; female, n = 10; mean age, 22.56 ± 2.89 years; height 171.73 ± 6.53 cm, weight 65.77 ± 6.47 kg, subcutaneous fat 5.17 ± 1.68 mm) aged 18-26 were included in this study. **Interventions:** PSWD parameters were 800-pps, 400-µseconds, 48-watts, for 30-minutes. ReBound parameters were 100% intensity for 45-minutes. Each heating condition was applied to the posterior aspect of the non-dominant calf. Each participant

underwent both treatment conditions (counterbalanced order), with a minimum of 4-days days and maximum of 10-days between treatment sessions. Intramuscular temperature was measured via 21-gauge thermistor thermometer inserted into the medial aspect of the calf with the widest girth at a posterior depth of 3.0 ± 0.3 cm. Depth was verified via diagnostic ultrasound, then the needle was removed and thermistor remained in the calf. **Main Outcome Measures:** Intramuscular temperature was recorded at baseline, every 5-minutes during the heating period, and every 30-seconds during the 30-minute cooling period. A mixed-model analysis of variance with repeated measures was calculated for each dependent variable (intramuscular warming and intramuscular cooling). **Results:** There was no significant treatment-by-time interaction ($F_{2,35} = 1.40$, $P = .0.221$) during the heating period, however there was a significant treatment effect ($F_{1,17} = 9.04$, $P = 0.008$), with PSWD causing a statistically significant greater increase in intramuscular temperature with an average of 3.47 ± 0.92°C over the 30-minute treatment period compared to ReBound average increase of 3.08 ± 1.19°C over the 45-minute treatment period. There was a significant treatment-by-time interaction during the 30-minute cooling period following modality removal ($F_{1,24} = 8.58$, $P = .004$), but a non-significant main effect for treatment ($F_{1,17} = 0.248$, $P = 0.625$). PSWD temperatures decreased an average of 2.90 ± 0.95°C, ReBound temperatures decreased an average of 1.99 ± 0.75°C. **Conclusions:** MegaPulse II PSWD is an effective heating modality to vigorously heat muscles at a depth of 3cm. ReBound continuous diathermy is an effective heating modality when moderate heating (3°C) is required, but research to-date indicates it is not an effective vigorous heating (4°C) modality.

## Measuring Brachial Artery Blood Flow Following a 3MHz, 1/0 W/cm2 Thermal Therapeutic Ultrasound Treatment

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**Context:** Ultrasound has been suggested to be one of the most commonly used therapeutic modalities in clinical practice. One of the purported benefits of thermal ultrasound, is the ability to increase blood flow to tissue. This benefit however, has not been sufficiently supported by current literature and research. **Objective:** The purpose of this study was to determine if there is a significant increase in blood flow to the brachial artery following a 3MHz thermal ultrasound at 1.0 W/cm2 treatment over the brachial artery. **Design:** A pre-test/post-test experimental designed was conducted to compare rates of blood flow through the brachial artery prior to and following insonation. The dependent variable was the time-averaged mean velocity reading that was collected to measure the change in blood flow. The independent variable was the thermal ultrasound treatment. **Setting:** University Research Laboratory. **Patients or Other Participants:** A convenience sample of 30 healthy individuals (age 22.3 ± 3.1 years; 15 males, 15 females) volunteered for participation in this study. The average depth of the brachial artery of study participants was 0.96 ± 0.3292cm. **Interventions:** Thermal ultrasound was performed on the subject's dominant arm over the distal portion of the brachial artery located in the upper arm using a Dynatron Solaris® 700 Series ultrasound machine at continuous, 3MHz, 1.0W/cm2, for 5 min. **Main Outcome Measures:** Blood flow was measured using a Phillips HD11 XE Diagnostic Ultrasound System in time-averaged mean velocity (cm/sec) prior to, and following a thermal ultrasound treatment. A paired samples dependent T-Test was performed with the level of significance set a priori at $p \leq .05$ to identify any significant changes in blood flow. **Results:** Results indicated that ultrasound performed at 3MHz, 1.0W/cm2, for 5 min caused a statistically significant increase in blood flow ($\alpha = .015$). **Conclusions:** This study demonstrated that ultrasound performed at 3MHz, 1.0W/cm2, for 5 min can be effectively used to increase blood flow. The benefits of increased blood flow include the transport of nutrients, hormones, metabolic wastes, oxygen, and carbon dioxide in order to maintain cell metabolism, osmotic pressure, and body temperature, regulation of pH levels throughout the body, and protection from microbial and mechanical threats. Although it is currently unknown how ultrasound affects injured tissue, it can be assumed that based on the physiological benefits, it could immensely contribute to the healing and repair of such tissue.

## The Dynatron Solaris® Ultrasound Machine Heats Slower Than Textbook Recommendations at 3 MHz, 1.2 W/cm²

Kjellerson M, Gange K, Poirier K: North Dakota State University, Fargo, ND

**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. Our previous study using the Dynatron Solaris at 1.0 W/cm² indicated it heated slower than the Omnisound, therefore we increased the intensity. **Objective:** To determine the rate of tissue temperature increase in the medial triceps surae with the parameters of 3MHz, 1.2 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 (15 females, 15 males; 21.93 ± 2.16 years). The adipose thickness was 0.55 ± 0.16 cm measured by a Diagnostic Ultrasound. **Interventions:** 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, 1.2 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 4.16 ± 2.56°C in 8 minutes at a rate of 0.52°C/min. The 1.75 cm depth increased 4.36 ± 2.24°C in 15 minutes at a rate of 0.29°C/min. The 2.5 cm depth did not reach a 4°C increase in the 20 minute treatment. It reached 3.35 ± 2.14°C with a rate of 0.17°C in 20 minutes. There was a significant main effect of depth $F(2,58) = 12.11$, $p < .001$, and time $F(12,348) = 104.67$, $p < .001$. There also was a significant interaction between times and depths $F(24,696) = 21.88$, $p < .001$. **Conclusions:** The Dynatron Solaris® 708 heated at varying rates within the 3 MHz depth. When comparing the results of this study to the Omnisound heating rates, we concluded the Dynatron heated 1.5 times slower at the 1.0cm depth and 3 times slower at 1.75cm depth. The 2.5 depth did not reach the 4°C increase so no rate was determined. This may be attributed to the quality of the crystal, BNR, or the half-value depth. The 1.0 cm depth is the only depth that heated at rates similar to the Omnisound research. More research is needed on heating rates and machine variability.

## Heat/Hydration/Hip Evidence-Based Forum: Sports Hernia and Groin Pain: Emerging Evidence on an Elusive Diagnosis

Thursday, June 23, 2016, 10:30AM-11:30AM, Room 315; Moderator: Barton Anderson, DHSc, ATC
Discussants: Wade Green, MEd, ATC; Bryan Lange, MPT, ATC

# Free Communications, Oral Presentations: Hip Function Effects on Lower Extremity Performance

Thursday, June 23, 2016, 11:45AM-1:15PM, Room 315; Moderator: Anh Nguyen, PhD, ATC

### Does Hip Strength Predict Performance on the Landing Error Scoring System in Collegiate Athletes?

Thorpe J, O'Connor M, Trueben-bach C, Arvinen-Barrow M, Earl-Boehm J: University of Wisconsin-Milwaukee, Milwaukee, WI

**Context:** The Landing Error Scoring System (LESS) is a valid movement screening tool used to assess non-contact anterior cruciate ligament (ACL) injury risk. Research has suggested that proximal hip strength can influence mechanics of the lower extremity during a dynamic task. The influence of hip strength on LESS score is not well understood in the existing literature, especially in the collegiate athletic population. The LESS scoring rubric consists of 17 items, some of which have little connection to hip strength (i.e. symmetrical foot contact). Therefore, the relationship between the subgroup of items that are most likely related to hip strength should be examined. **Objective:** To determine if isometric hip strength predicts total LESS score as well as the hip subscore. **Design:** Cross-sectional. **Setting:** Midwestern D-I University. **Patients or Other Participants:** 83 intercollegiate athletes (39 males, 44 females; 18.02 + 4.95 years old, height 174.39 + 16.97 cm, weight 76.39 + 16.38 kg) with no current lower extremity injuries. **Interventions:** The LESS was used assess jump landing mechanics. Each participant was instructed to perform a drop-landing froma 30cm platform placed at 50% of their height behind the landing target. Three jumps were recorded and a trained rater determined the total score using the standardized rubric. Hip subscore was calculated by summing 6 items of the rubric (trunk flexion, hip flexion, and knee valgus at initial contact, trunk and hip flexion, and knee valgus at maximum knee flexion). Hip strength was measured using a hand-held dynamometer and stabilizing straps for hip extension, abduction, internal rotation, and external rotation. Each strength test was performed three times, and the average was normalized to body weight. **Main Outcome Measures:** The dependent variables were LESS total score and hip subscore. The independent variables were normalized force measures for hip extension, abduction, internal and external rotation. Separate multiple regressions were used to determine predictive values for each strength measure on both LESS total score and hip subscore for both males and females for the right limbs. The alpha level was set at $p < 0.05$. **Results:** None of the strength measures were predictive of total LESS score or hip subscore (TOTAL SCORE: males $F(4,34) = .424$, $R2 = .047$; females $F(4,36) = .967$, $R2 = .097$; HIP SUBSCORE: males $F(4,34) = .448$, $R2 = .050$; females $F(4,39) = .598$, $R2 = .058$). **Conclusions:** The results suggest total LESS score and hip subscore are not predicted by strength of the hip muscles that were tested. These findings are consistent with previous studies in non-athletic populations. It is possible that a different measure of hip muscle function (i.e. eccentric, endurance) would be more predictive, or that the LESS scoring isn't sensitive to subtle differences. Future studies should examine the psychometric properties of the LESS instrument to determine if certain items should be revised or eliminated.

### The Influence of Femoral Anteversion and Hip ROM on Dynamic Knee Valgus in Females During a Single-Leg Forward Hop

Hogg JA, Schmitz RJ, Shultz SJ: University of North Carolina, Greensboro, NC

**Context:** Dynamic knee valgus has been associated with anterior cruciate ligament (ACL) injury, and represents coupled motions between the hip and knee, comprised of hip adduction and internal rotation, and knee abduction and external rotation. Factors that contribute to an individual having greater dynamic knee valgus have not been fully unearthed. **Objective:** To quantify the combined impact of femoral anteversion, hip internal rotation ROM (ROMIR), and hip external rotation ROM (ROMER) on components of dynamic knee valgus during a single-leg forward hop. We hypothesized that participants with greater femoral anteversion and ROMIR and lesser ROMER would display greater dynamic knee valgus. **Design:** Cross-sectional. **Setting:** Single session laboratory study. **Patients or Other Participants:** Young females with no history of ligamentous knee injury or lower extremity surgery and injury-free over the previous six months ($N = 20$; 25.1 ± 4.1yrs, 168.7 ± 8.0cm, 63.8 ± 11.6kg). **Interventions:** All measures were obtained with an inclinometer with the participant prone and the knee flexed to 90°. For femoral anteversion, the lower leg was passively internally rotated until the greater trochanter was palpated to be at its most lateral position. For ROM, the lower leg was passively rotated internally and externally until initial sacral movement was palpated by the tester. For each measure, the transverse angle formed by the tibial diaphysis and true vertical at the previously specified points was recorded. One tester with good to excellent reliability

[ICC2,3(SEM); .92(1.2°) for femoral anteversion, .97(1.6°) for ROMIR, .85(3.3°) for ROMER] measured all subjects. 3D motion capture was used to measure hip and knee joint biomechanics during a single-leg forward hop over a barrier onto a forceplate. Barrier height and take-off distance from the force plate were equal to 15% and 40% of participant's height, respectively. Five trials were obtained and variables were averaged across trials. **Main Outcome Measures:** Separate backward-stepwise multiple linear regressions (P out=.20) determined the extent to which femoral anteversion, ROMIR, and ROMER contributed to hip and knee initial and peak angles, excursions, and internal moments (normalized to HeightWeight) in frontal and transverse planes. **Results:** Greater ROMIR predicted higher peak knee abduction moments (.010 ± .01 Nm(mN)-1)(R2 = .20, p = .05), while the combination of greater ROMIR (31.3 ± 8.4°) and greater ROMER (44.6 ± 9.8°) predicted lower peak knee internal rotation moment (.072 ± .04 Nm(mN)-1)(R2 = .38, p = .02, y = .226 + -.002(ROMIR) + -.002(ROMER)). There were trends for greater femoral anteversion (10.3 ± 5.8°) to predict greater hip adduction excursion (1.4 ± 1.7°)(R2 = .14, p = .11), greater initial hip internal rotation (9.4 ± 7.4°)(R2 = .11, p = .16), greater peak hip internal rotation (11.2 ± 7.0°)(R2 = .12, p = .13), and greater peak hip internal rotation moment (.128 ± .08 Nm(mN)-1)(R2 = .18, p = .07). **Conclusions:** Greater hip ROMIR and ROMER are predictive of potentially injurious frontal and transverse plane knee moments, while femoral anteversion exhibits a small effect on hip kinematics. Future studies should examine the extent to which these factors can be modified by gluteal muscle activation.

## Muscle Activation and Range of Motion Patterns of Individuals Who Display a Lateral Hip Shift During an Overhead Squat

Peterson KJ, Mauntel TC, Prentice WE, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Dysfunctional lower extremity biomechanical patterns are known risk factors for non-contact injuries. A lateral hip shift during squatting assessments is a commonly observed dysfunctional biomechanical pattern. Neuromuscular control and lower extremity range of motion deficiencies contribute to dysfunctional biomechanics. However, the underlying neuromuscular (electromyography [EMG]) and range of motion characteristics associated with a lateral hip shift during a squatting assessment are unknown. **Objective:** To determine modifiable factors (EMG and ranges of motion) that contribute to a lateral hip shift during an overhead squat. **Design:** Case control. **Setting:** Laboratory. **Patients or Other Participants:** 40 healthy, physically active males (n = 20; control = 10, hip shift = 10) and females (n = 20; control = 10, hip shift = 10) aged 18-35 participated in this study. Group assignment was based on the participants' performances of the overhead squat assessment. Individuals whose mid-sagittal line deviated laterally during the descent phase of the squat were placed in the hip shift group. **Interventions:** Participants completed 3 sets of 5 overhead squats. EMG of the gluteus maximus (GMAX), gluteus medius (GMED), and hip adductors (HADD) was sampled during the descent phase of the overhead squat. Passive range of motion measurements were recorded for hip internal and external rotation, hip abduction, knee extension, and standing weight bearing lunge ankle dorsiflexion. **Main Outcome Measures:** Normalized average EMG amplitude of the GMAX, GMED, and HADD as well as passive range of motion measurements were averaged across their respective limbs. Separate mixed-model ANOVAs with 1-between subject factor (group: hip shift, control) and 1-within subject factor (limb: leg shifted toward, leg shifted away from) were used to compare each dependent variables ($p < 0.05$). **Results:** A significant group-by-limb interaction was found for hip abduction passive range of motion ($F(1,34) = 21.35$, $P < 0.005$). The hip shift group had less hip abduction motion in the leg shifted toward (39.0 ± 8.1) compared to the leg shifted away from (45.5 ± 7.1). Within the hip shift group, the leg shifted toward had greater passive hip internal rotation ($F(1,34) = 4.78$, $P = 0.035$; toward = 35.3 ± 11.8, away = 31.7 ± 13.3), greater passive total hip rotation arc ($F(1,34) = 4.15$, $P = 0.049$; toward = 85.1 ± 11.4, away = 80.5 ± 13.2), and less passive weight bearing lunge dorsiflexion ($F(1,34) = 4.70$, $P = 0.036$; toward = 43.1 ± 5.3, away = 44.9 ± 6.6) compared to the limb being shifted away from. Between groups, the hip shift group had less normalized GMED activation compared to the control group ($F(1,34) = 3.17$, $P = 0.084$; hip shift = 7.4 ± 3.8, control = 9.0 ± 5.0). No other differences were observed. **Conclusions:** The EMG and range of motion measurement differences between groups may further increase the hip shift group's injury risk. The differences observed may increase injury risk of both the leg shifted toward as well as the contralateral leg. Clinicians can use this information to develop targeted interventions to correct the lateral hip shift and reduce injury risks.

## Relationships Among Isometric Hip Strength Measures in Division-I Collegiate Athletes

Earl-Boehm J, O'Connor M, Thorpe J, Truebenbach C, Arvinen-Barrow M: University of Wisconsin-Milwaukee, Milwaukee, WI

**Context:** Posterio-lateral hip strength is related to lower extremity injury and typically measured with isometric assessment during clinical exam, and as part of an injury risk-factor screening. Quantifying hip strength provides reliable and valid information, but often takes between 10-15 minutes/per person, which may hinder its usefulness as part of a mass-screening protocol. Knowing whether isometric measures of hip muscle strength are related to one another would be useful in determining whether some tests could be eliminated. **Objective:** To describe isometric hip strength norms for Division-I athletes, and to determine relationships among hip abduction(ABD), extension(EXT), internal(IR), and external(ER) rotation. **Design:** Cross-sectional. **Setting:** Field based, Division-I university. **Patients or Other Participants:** 260 intercollegiate athletes (124 males, 136 females; 19.4 + 1.4 years, 174.4 + 18.2cm, 74.4 + 14.5kg) with no current lower extremity injuries. **Interventions:** Isometric hip strength was measured in a combine-style testing session aimed to identify potential psychosocial and physical injury risk factors. Hip strength was measured using a hand-held dynamometer and stabilizing straps for four different motions: ABD-side-lying, EXT-prone, IR-seated, and ER-seated and completed by testers who had been trained in the standard protocol. **Main Outcome Measures:** Most participants reported the right side as dominant, and it was therefore used for analysis. The average of three trials was normalized to body mass (%BW). Descriptive statistics were calculated and Pearson product moment correlation was used to investigate relationships among hip strength variables. Alpha was set at $p < .05$. **Results:** Average strength scores for males: ABD 47 ± 10%, EXT 39 ± 12%, ER 15 ± 4%, IR 16 ± 5%, and females: ABD 39 ± 10%, EXT 33 ± 12%, ER 11 ± 3%, IR 14 ± 5%. All of the measures were positively correlated, as strength increased for one motion it also increased for the other motions. Strong correlations were found between ABD and ER ($r = .55$, $r^2 = .30$ $n = 254$, $p < .005$) and ER and IR ($r = .57$, $r^2 = .32$, $n = 254$, $p < .005$). Moderate correlations were found between ABD and EXT ($r = .49$, $r^2 = .24$, $n = 255$, $p < .005$), ABD and IR ($r = .39$, $r^2 = .15$, $n = 256$, $p < .005$), and EXT and ER ($r = .37$, $r^2 = .13$, $n = 251$, $p < .005$). Correlation between EXT and IR was weak ($r = .22$, $r^2 = .04$, $n = 253$, $p < .005$). **Conclusions:** About 30% of the variance in ER strength was explained by ABD or IR strength, while less was explained by EXT strength. This was expected, as the gluteus medius serves a dual role as the primary ABD and the IR in a seated position. Variance in ABD strength was most explained by EXT(24%) and IR(15%). Although these results indicate the close relationship between the hip muscles and how they perform during isometric testing, there also appears to be a significant amount of unexplained variance in each measure to conclude that each measure is in fact unique Therefore current results are not strong enough to justify eliminating any of the tests from a posterior-lateral hip strength assessment.

1. Boling MC, Padua DA, Alexander Creighton R. Concentric and eccentric torque of the hip musculature in individuals with and without patellofemoral pain. J Athl Train. Jan-Feb 2009;44(1):7-13.

2. Lanning CL, Uhl TL, Ingram CL, Mattacola CG, English T, Newsom S. Baseline values of trunk endurance and hip strength in collegiate athletes. J Athl Train. Oct-Dec 2006;41(4):427-434.

## The Effect of Verbal Feedback and Hip Abductor Strengthening Exercise on Patellofemoral Pain Patients: A Randomized Controlled Trial

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**Context:** Poor hip biomechanics are a contributing factor to patellofemoral pain (PFP) and individuals with PFP demonstrate hip strength deficits and poorer neuromuscular control. **Objective:** Compare the effect of lateral hip muscle strengthening versus activation of hip muscle with verbal feedback motion retraining. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty participants with PFP were randomly allocated into strengthening group (ST) and feedback training group (FB). **Interventions:** Both groups received conventional knee rehabilitation in addition to group-specific training. The volume and intensity of all exercises adjusted in every 2 weeks for 6 weeks. ST group received solely hip abductor strengthening exercises and the FB group received feedback motion retraining to restrict dynamic knee valgus and internal rotation. **Main Outcome Measures:** Three trials of maximum hip abductor strength using a hand-held dynamometer, visual analog scale (VAS) for pain, anterior knee pain scale (AKPS), lower extremity functional scale (LEFS) and three-dimensional kinematics of the knee joint of single leg landing with motion analysis. A repeated measures analysis of variance was used to assess differences ($p < .05$) in the dependent variables between ST and FB groups from pre-training to post-training. **Results:** There were no significant differences in demographic information (ST: age = 25.8 ± 9.2 years, mass = 74.9 ± 11.8 kg, height = 173.7 ± 9.5 cm; FB: age = 28.4 ± 3.6 years, mass = 70.5 ± 11.2 kg, height =

172.4 ± 5.4cm). Significant group-by-time interactions were found in AKPS, LEFS, strength, knee rotation angle at initial contact (ICKR) and knee flexion angle at initial contact (ICKF) (AKPS: ST pre-training:76.2 ± 6.76, post-training:85.3 ± 7.58, FB pre-training: 68.6 ± 11.43, post-training: 88.9 ± 6.29, F1,19 = 4.93, p = .04; LEFS:ST pre-training:66.1 ± 11.55, post-training: 66.2 ± 9.55, FB pre-training: 52.6 ± 15.37, post-training: 74.8 ± 3.15, F1,19 = 8.19, p = .01; Strength: ST pre-training: 39.35N ± 13.43, post-training: 46.9N ± 14.93, FB pre-training: 38.53N ± 14.07, post-training: 37.94N ± 12.42: F1,19 = 16.32, p = .001; ICKR: ST pre-training: 13.64° ± 6.98, post-training: 10.33° ± 5.65, FB pre-training: 5.09° ± 5.01, post-training: 7.26° ± 4.68, F1,19 = 5.84, p = 0.03; ICKF: ST pre-training: 15.37° ± 2.92, post-training: 12.93° ± 2.95, FB pre-training: 13.94° ± 3.52, post-training: 14.93° ± 4.26 F1,19 = 5.41, p -0.03). Change of AKPS was larger in FB (t = -2.22, p = .04), LEFS was larger in FB (t = -2.86, p = .01), Strength improvement was greater in ST (t = 5.54, p < .001). ST group showed more externally rotation at initial contact (t = 2.42, p = .03) and FB group showed more flexed knee at initial contact (t = 2.33, p = .03). **Conclusions:** Both interventions improved lower extremity function, but the effect was greater in FB group. Interestingly, there were no differences between two groups in frontal plane knee motion which indicates FB may be enough to control frontal plane motion in PFP patient. However, control of knee rotation was greater in ST group which may imply that lack of hip abductor strength is related to improper biomechanics of the knee. Therefore, along with strengthening, clinicians should aware of the effectiveness of feedback motion retrain in the treatment of PFP patient.

### Joint Mobilizations Improves Internal Rotation at the Hip, But Not Strength Following One Treatment Session

Bestenlehner M, Selkow N, Laurson K: Illinois State University, Normal, IL

**Context:** Joint mobilizations are a popular technique for clinicians to help increase range of motion (ROM) of a joint and is recently being incorporated for strength gains. Due to the unique anatomy of the hip, the correct utilization of joint mobilizations may be difficult to achieve. Distraction is a mobilization technique theorized to have similar effects as joint mobilization, however, the two techniques have not been compared together. **Objective:** To determine the effect of joint distraction and joint mobilization on hip flexion and internal rotation ranges of motion and strength. **Design:** Controlled laboratory study. **Setting:** Athletic Training Laboratory. **Patients or Other Participants:** Forty-nine participants between 18-30 years old with no previous hip surgery, and had no lower extremity or back injury within the past six months volunteered. Participants were screened for hypermobility with the Beighton scale and were only included if they had a score less than 7. Participants had at least a five-degree deficit in either hip internal rotation or flexion from normative passive ROM values. **Interventions:** Participants meeting the inclusion criteria either received a grade IV posterior joint mobilization, hip distraction, or no treatment. The posterior mobilization was performed with the participant supine with hips off the edge of the table and the non-treated leg propped up for support on a stool. The researcher placed a belt under the distal thigh of the treatment leg and performed 4-30 second posterior mobilizations at the proximal thigh. Distraction was performed hook-lying with the belt around the participant's thigh. The researcher stabilized the participant's knee while pulling the belt away from the participant (abduction) to distract the femur. Four-30 second holds were performed for distraction. The control group sat for two minutes. **Main Outcome Measures:** Hip internal rotation and flexion ROM and strength were measured. ROM was measured with a digital inclinometer and strength was measured with a handheld dynamometer. All measurements were taken three times with the average being recorded for both pre and post treatment. **Results:** Four one-way between groups ANCOVAs were conducted to determine the effectiveness of 2 mobilization techniques on hip ROM and strength. The pre-treatment value was used as the covariate. There were significant findings for IR ROM (p = .026) but not flexion ROM (p = .837), IR strength (.259), or flexion strength (.254). Pairwise comparisons were run on IR ROM and both distraction (30.0 ± 0.7°, p = .009) and joint mobilization (29.3 ± 0.7°, p = .043) were more effective than the control (27.3 ± 0.7°) but were not different from each other (p = .497). **Conclusions:** Both a posterior joint glide and distraction can be used when seeking improvements in internal rotation ROM at the hip. However, changes in hip flexion or strength in either direction were not improved.

### Trunk Performance in Players With Superior and Poor Serve Mechanics


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**Context:** During the service motion the legs and trunk contribute more than 50% of force and kinetic energy delivered to the hand. Current research has demonstrated that proper mechanics within the kinetic chain improve serve performance and decrease upper extremity joint kinetics; however, no study has investigated the contributions of trunk flexibility and power on serve mechanics **Objective:** To determine if players with better serve mechanics demonstrate increased trunk flexibility and power than players with poor mechanics. We hypothesize that tennis players with better mechanics will demonstrate increased flexibility and power compared to those with poor mechanics **Design:** Cross-sectional **Setting:** Tennis Courts **Patients or Other Participants:** Thirty healthy players were enrolled in this study, 14 were categorized as high performers (females: 4, males: 10, age: 24 ± 9) and 16 as low performers (females: 11, males: 5, age: 38 ± 16). **Interventions:** One member of the research team assessed serve mechanics via video-recording using a reliable observational serve analysis (Kappa = 0.61). A recording on one tennis serve was scored from 0-9 based on players achieving specific body positions; each position was scored as present or absent. Players with a score of ≥5 were categorized as high performers while players with a score of ≤4 were categorized as low performers. Trunk rotation flexibility measures were assessed using ImageJ. Players were instructed to kneel on the dominant leg, place the hands on the hips, and rotate the trunk so the serving shoulder moved backwards. An investigator took a still image at the end of rotation. The averages of 3 trials were used for analysis. Players were video-recorded performing 3 seated trunk rotation power throws with a 6 lbs. medicine ball. Trunk rotation power was calculated using the weight of the medicine ball multiplied by the distance traveled divided by the medicine ball total time in air. The averages of 3 trials were used for analysis. All videos were assessed using Dartfish software. **Main Outcome Measures:** An analysis of covariance was utilized to determine if differences existed in trunk flexibility and trunk rotation power between the two groups while adjusting for sex and age. **Results:** Trunk flexibility was greater in the high performers (60 ± 10°) compared to the low performers (50 ± 15°) ($p = 0.03$). There were no differences in trunk rotation power between the high performers (256.89 ± 45.58Watts) and the low performers (206.74 ± 34.84Watts) ($p = 0.09$). **Conclusions:** Players with superior mechanics demonstrate 10° more trunk rotation flexibility than those with poor mechanics. Trunk rotation power approached significance, but does not seem to be an indicator of player mechanics. When improving serve mechanics, trunk flexibility should be a priority as players with superior mechanics display more trunk rotation.

### Isolated Fatigue of Trunk Muscles Does Not Alter Pitching Biomechanics in High School Baseball Pitchers


Oyama S, Kuehne J, Musser H, Waldhelm GA: Department of Kinesiology, Health, and Nutrition, University of Texas San Antonio, San Antonio, TX, and School of Physical Therapy, University of Incarnate Word, San Antonio, TX


**Context:** Pitching technique is one of many factors that affect risk of shoulder and elbow injuries among pitchers. Recent biomechanical studies suggest that the trunk motion, specifically an early trunk rotation and excessive contralateral tilt, may be linked to increased joint loading at the shoulder and elbow. Since these movement patterns are controlled by the trunk musculature, the role that these muscles play in pitching biomechanics needs to be investigated. **Objective:** To investigate the effects of isolated trunk muscle fatigue on pitching biomechanics in high school baseball pitchers. **Design:** Within-subject study. **Setting:** Biomechanics research laboratory. **Patients or Other Participants:** Thirteen high school baseball pitchers (age = 16.0 ± 1.2 years, height = 1.8 ± 0.1m, mass = 73.1 ± 17.5kg, years of experience = 5.7 ± 2.0 years, right/left dominance = 6/7). **Interventions:** The participants were fitted with reflective markers on anatomical landmarks for a data capture using a three-dimensional optical motion capture system, went through a warm-up, and performed 15 pre-fatigue pitches from a mound. After the trials, the pitcher's baseline maximal isometric trunk flexion strength was measured using a dynamometer. The pitchers then performed circuits of seven abdominal muscle exercises that targeted rectus abdominis and internal/external oblique until their trunk strength dropped below 70% of the baseline. At that point, the pitchers performed 10 post-fatigue pitches. **Main Outcome**

**Measures:** Five fastest pitches from the post-fatigue trials and five pre-fatigue pitches matched to the post-fatigue pitches with ball velocity were analyzed for each pitcher. The marker coordinate data were filtered and used to calculate biomechanical variables. Specifically, trunk rotation, lateral flexion, and flexion angles, shoulder elevation and external rotation angles at stride foot contact, maximal arm cocking, and ball release, peak shoulder and elbow distraction forces, and peak elbow valgus and shoulder external rotation moments were calculated and averaged across five trials. Paired t-tests were used to compare the variables before and after the isolated trunk muscle fatigue. **Results:** The participants fatigued after 5.7 ± 2.0cycles of exercises. After fatigue, participants' maximal isometric trunk strength decreased by 33.3 ± 14.0% ($t = 6.6$, $p < .001$). However, there were remarkably no changes in the kinematics or kinetic variables before and after fatigue (effect sizes: 0.03-0.24, $p > 0.05$). **Conclusions:** Despite the suggested role that trunk musculature plays in controlling trunk motion, decreased force production capability of the trunk muscles did not result in alteration of the pitching biomechanics. This may be due to the fact that the trunk muscles are not contracted maximally during pitching, and thus were still able to produce sufficient force to pitch, or other factors, such as technique (motor control) has a stronger influence on the trunk movement. In order to improve trunk movement and reduce stress on the shoulder and elbow joints, strengthening of the trunk musculature may need to be combined with technical instructions and practice.

## The Relationship Between Diaphragmatic Breathing and Lumbopelvic Control in Physically Active Patients With and Without Low Back Pain

Wyatt B, Vela LI: Trinity University, San Antonio, TX, and University of Texas at Arlington, Arlington, TX

**Context:** The lumbopelvic hip complex is an essential component to function. However, chronic low back pain (LBP) alters recruitment patterns of the trunk stabilizers and postural changes. Limited research has been conducted to understand the role the diaphragm plays on trunk stability in physically active patients with LBP. **Objective:** To determine the effects of diaphragmatic breathing (DB) on lumbopelvic control, differences in DB patterns in participants with and without chronic LBP, and differences in lumbopelvic control in participants with and without chronic LBP. **Design:** Case control. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Twenty-one participants with LBP ($n = 21$; age = 20.19 ± 1.33; height = 68.18 ± 4.38; weight = 167.33 ± 34.32) and 21 healthy participants ($n = 21$; age = 19.71 ± 1.10; height = 68.48 ± 4.25; weight = 166.76 ± 30.87). Participants were between 18-30 years old and were involved in collegiate sports. The LBP participants had LBP for at least 3 months, a score of 2 or greater on a VAS, met nociceptive LBP criteria, and scored less than 12 points on the Leeds Assessment for Neuropathic Symptoms and Signs. **Interventions:** The independent variables were group assignment (LBP vs healthy participants) and breathing styles (DB vs non-DB). At rest, breathing was examined with the Hi-Lo Breathing Assessment, a clinical tool used to assess the movement of the ribcage and abdomen during respiration. Breathing patterns were characterized dichotomously as DB or non-DB based on the relative excursion of the abdominal and thoracic areas during breathing. **Main Outcomes Measures:** The dependent variables were 2 lumbopelvic motor control test scores for each limb: the active straight leg raise (ASLR) and knee lift abdominal test (KLAT). Reliability for the ASLR (ICC = 0.61-0.98) and KLAT (ICC > 0.85) have been established. Participants repeated each test 3 times and a pressure biofeedback unit inflated to 40 mmHg was used to determine pressure variation. Independent samples t-tests and Chi Square analysis with an -priori value of $p < 0.05$ were used to answer the research questions. **Results:** VAS [$t(38) = 8.04$, $p < .001$] and Modified Oswestry scores [$t(32.7) = 7.48$, $p < .001$] were significantly higher in LBP participants who demonstrated moderate levels of pain (4.8 ± 1.8) and disability (13.0 ± 6.0) when compared to the healthy controls (0.90 ± 1.40 and 2.00 ± 3.0 respectively). Breathing pattern and LBP history did not significantly affect motor control test performance. LBP participants did not demonstrate significantly different breathing patterns compared to healthy controls. **Conclusions:** The results revealed that physically active patients with chronic LBP display correct breathing patterns and have similar lumbopelvic stability when compared to healthy participants. Future research should consider more challenging lumbopelvic stability tests for physically active patients, establish better breathing assessment tools, and investigate populations with greater levels of LBP disability.

## Changes in Muscle Thickness Across Positions Between Individuals With and Without a History of Low Back Pain

Sutherlin MA, Gage MJ, Hertel J, Mangum LC, Russell S, Saliba S, Hart JM: University of Virginia, Charlottesville, VA, and Liberty University, Lynchburg, VA

**Context:** Muscle dysfunction of the transversus abdominis (TrA) and lumbar multifidus (LM) has been reported in individuals with a history of low back pain (HxLBP). HxLBP individuals present with smaller changes in TrA and LM muscle thickness between contracted and resting measures through ultrasound imaging in the tabletop position; however, HxLBP individuals may be susceptible to injury or recurrent episodes during gravity dependent positions. Understanding muscle function across multiple positions would give clinicians a better awareness of modifiable risk factors among HxLBP individuals. **Objective:** To compare changes in TrA and LM muscle thickness across multiple positions between healthy and HxLBP individuals. **Design:** Descriptive. **Setting:** Laboratory. **Patients or Other Participants:** Fifty-nine participants, 34 healthy (24 females, 10 males): age: mean = 22 ± 7 years; body mass index: mean = 23.7 ± 2.7 kg/m$^2$, 25 HxLBP (16 females, 9 males): age: mean = 25 ± 10 years; body mass index: mean = 24.0 ± 3.2 kg/m$^2$). **Interventions:** Resting ultrasound images were recorded of the TrA and LM after exhalation and during the abdominal drawing-in maneuver in tabletop, seated, standing and walking measures. **Main Outcome Measures:** Activation ratios (AR) of the TrA and LM were calculated as the ratio of the contracted muscle thickness during the abdominal drawing-in maneuver divided by the resting muscle thickness. Preferential activation ratios (PAR) were measured as the difference in the ratios between the TrA and total lateral abdominal wall thickness from the contracted and resting states expressed as a percentage. TrA and LM AR modulations were calculated as the percent change by subtracting the tabletop AR from the functional position AR, then dividing by the tabletop AR and presented as a percentage. **Results:** HxLBP individuals had lower ARs during tabletop (HxLBP: median = 1.27 (range = 0.76-1.94), Healthy: median = 1.43 (range = 1.02-2.10), P = .01) and seated (HxLBP: median = 1.12 (range = 0.72-1.43), Healthy: median = 1.24 (range = 0.89-2.12), P = .01) positions, but not for standing or walking (P > .05). Similarly, HxLBP PAR (49 participants: 27 healthy, (23 females, 4 males); 22 HxLBP, (15 females, 7 males) was lower only during tabletop (HxLBP: median = 2.1% (range = -3.1-7.5%), Healthy: median = 3.0% (range = 0.4-11.5%, P = .04) and seated positions (HxLBP: median = -0.1% (range = -4.3-4.4%), Healthy: median = 1.6% (range = -2.9-8.1%, P = .04). No differences were observed between groups for the LM AR across any of the four positions (P > .05). Tabletop TrA AR and PAR were greater among all individuals compared to the other three positions (P < .01), while standing TrA AR was lower than walking (P = .01). Tabletop LM AR was higher than standing measures across all individuals (P = .03). However, HxLBP status influenced AR values across positions when observed individually. HxLBP participants also had a smaller percent change between the tabletop and the standing positions (HxLBP: median = -9.0% (range -32.3-20.5%), Healthy: median = -18.9% (range -55.1-31.93), P = .03) **Conclusions:** HxLBP status and position influence changes in muscle thickness through the use of the abdominal drawing-in maneuver. Multiple positions should be considered when assessing muscle function between HxLBP and healthy individuals.

## The Function of the Transverse Abdominis During a Single Leg Squat: An Ultrasound Imaging Study

Henderson K, Mangum LC, Hart J, Saliba S: Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville, VA

**Context:** The transverse abdominis (TrA) muscle is an important component of lumbopelvic hip stability. The TrA contracts in a preparative manner in healthy individuals during movement of the extremities and promotes postural stability. Lumbopelvic hip stability plays a role in functional performance as a lack of stability can contribute to altered movement patterns that can lead to increased injury risk. Ultrasound imaging (USI) is a reliable, efficient, and easy to use diagnostic tool often used to examine TrA activation and muscle thickness. The relationship of TrA activation and lower extremity movement patterns, such as a single leg squat (SLS), however is unknown. **Objective:** To determine the relationship between TrA activation ratio (AR) using USI in right and left sides and peak knee flexion, peak knee valgus, and forward trunk lean during a SLS at peak knee flexion performed bilaterally. **Design:** Descriptive laboratory study. **Setting:** University research laboratory. **Patients or Other Participants:** Volunteers included 35 healthy participants (Age = 21.3 ± 2.7 yrs, Mass = 61.3kg, Height = 1.68m, 12M, 23F) with no history of lower extremity joint injury or surgery within the last year. **Interventions:** USI of the TrA was assessed simultaneously with a SLS. The TrA was measured on the side ipsilateral to the support limb during the SLS. **Main Outcome Measures:** TrA AR, in both a quiet single leg standing and during the SLS at peak knee flexion, was measured via USI. AR was determined by dividing the contracted TrA muscle thickness at peak knee flexion by the resting TrA thickness at the same point in a SLS. Kinematics were measured via flock of birds electromagnetic

tracking system sensors on spine and lower extremity. The kinematics collected included peak knee flexion, peak knee valgus and forward trunk lean at peak knee flexion during the SLS on both sides. Pearson's correlation was used to determine any relationship between TrA measures and the kinematics at peak knee flexion. **Results:** There were no significant correlations between the TrA activation ratio and kinematics. There were significant moderate correlations between total TrA activation ratio in quiet standing and SLS. ($r = .51$; $p = .01$). The TrA activation ratios at peak knee flexion during the SLS on the right and left stance legs had significant weak correlations to the contralateral leg ($r = .37$; $p = .05$). TrA activation ratio in left quiet standing had a weak correlation ($r = .34$ and $.41$, respectively) to TrA activation ratio in the left SLS. **Conclusions:** In healthy participants, there were no significant correlations between TrA activation ratio and kinematic values at the knee. Future research should be done in order to examine the relationship between activation of the TrA and kinematic values in pathologic populations to determine whether there is an association between lumbopelvic hip stability and lower extremity movement dysfunction or injury.

## Shoulder Evidence-Based Forum: Evidence-Based Interventions to Address Alterations in Physical Characteristics in Baseball Players

Friday, June 24, 2016, 8:30AM-9:30AM, Room 315; Moderator: Kevin Laudner, PhD, ATC
Discussants: Elizabeth Hibberd, PhD, ATC; Sakiko Oyama, PhD, ATC

### Physical Characteristics and Injury Rate in High School Baseball Pitchers Who Play Catcher as a Secondary Position

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

**Context:** Many high school pitchers play another position after the have finished pitching for the day or on their rest days from pitching. Pitchers who also play catcher have previously been reported to have a higher risk of serious shoulder/elbow injury resulting in surgery or retirement. No previous studies have evaluated the risk of developing a throwing-related time-loss injury in pitchers who also play catcher or evaluated their physical characteristics. **Objective:** To compare pre-season physical characteristics and injury rates between high school baseball pitchers that also play catcher as a secondary position and those who do not play catcher. **Design:** Prospective Cohort Study. **Setting:** Field Laboratory. **Patients or Other Participants:** 311 high school baseball pitchers were recruited from 51 high school baseball teams for participation. Pitchers who reported their secondary positions as a catcher were classified into the pitcher/catcher group (n = 27; age = 16.9 ± 1.0 years; height = 182.7 ± 5.26cm; mass = 81.5 ± 8.7kgs; baseball years participation = 11.9 ± 1.1years). Participants who did not report playing catcher as a secondary position were classified into the other group (n = 284; age = 16.7 ± 1.0 years; height = 182.4 ± 6.46cm; mass = 78.6 ± 12.2kgs; baseball years participation = 11.4 ± 1.8years). **Interventions:** Participant demographics, internal rotation (IR) and external rotation (ER) range of motion (ROM) and humeral retrotorsion were measured during preseason screenings. Athlete participation and injury were then tracked by the ATC at each high school. ATCs reported athlete exposure (AE), which was defined as full participation in a practice session or a game, missed and limited participation and throwing-related shoulder/elbow injuries that resulted in at least 1 missed AE. **Main Outcome Measures:** Independent samples t-test were used to evaluate differences in groups between glenohumeral IR Deficit (GIRD), glenohumeral ER Gain (ERG), total rotational ROM (TROM), humeral retrotorsion, and AEs. An Injury proportion rate (IPR) was calculated to evaluate the risk of injury between groups. **Results:** There were no significant differences in GIRD (p = 0.649), ERG (p = 0.134), TROM (p = 0.859), and humeral retrotorsion (p = 0.357), and season AEs between groups (p = 0.796). The proportion of pitchers with injury was 2.7 times greater in pitcher/catchers compared to the others (18.5% vs 6.6%; IPR = 2.7; 95% CI: 1.03, 7.43). **Conclusions:** Pitchers that reported playing catcher were at a greater risk of injury than the other pitchers. The greater risk of injury may be due to the amount of throws performed without adequate time for recovery in athletes that play pitcher and catcher. These findings support the recommendation that pitchers should not play catcher on the days they do not pitch or stay in game as a catcher after they finish pitching. Serial physical examinations in pitcher/catchers during the season may be useful in determining if physical characteristics are changing during the season due to the cumulative throwing load and could help in the development of interventions used to decrease the risk of injury.

### The Relationship Between Pitching Participation and Volume Variables on the Functional Arm Scale for Throwers© (FAST©) Scores in Baseball Pitchers

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

**Context:** Increased participation in baseball has impacted sport-related upper extremity (UE) injuries, particularly in pitchers, which can negatively impact one's health-related quality of life (HRQOL). Excessive participation in pitching across a year and excessive pitching volume may place baseball pitchers at risk for UE injuries. However, the relationships between pitching participation, pitching volume, and HRQOL are unknown. **Objective:** To examine the relationship between pitching participation, pitching volume and HRQOL in healthy baseball pitchers. **Design:** Retrospective study design. **Setting:** Athletic training clinics across the U.S. in high schools, colleges/universities and professional organizations. **Patients or Other Participants:** Convenience sample of fifty healthy baseball pitchers (age: 18.8 ± 4.2 years, height: 184.1 ± 8.3 cm, mass: 82. 9 ± 13.0 kg) with 12.5 ± 4.9 years of competitive experience and no present limitations in pitching participation. **Interventions:** Pitchers completed a 36-item demographic, injury, and playing history form and the Functional Arm Scale for Throwers© (FAST). Bivariate correlations were used to examine the relationships between pitching participation and pitching volume responses and FAST scores. **Main Outcome Measures:** The FAST is a reliable and valid population- and region-specific UE patient-reported outcome scale. It contains 22-items across five subscales (throwing, pain, activities of daily living, psychological impact, advancement) to produce

a total score (FAST-TS) and a separate 9-item Pitcher Module (FAST-PM) for pitchers only. The FAST-TS, individual subscales, and the FAST-PM, scored from 0–100, with higher scores indicating lower HRQOL, were calculated and used in correlational analyses. **Results:** Pitching participation: The number of months regularly playing baseball over the past 12-month period exhibited fair to good significant correlations with the FAST-TS ($r = -.51$, $P < .01$), throwing subscale ($r = -.42$, $P < .01$), pain subscale ($r = -.30$, $P = .03$), activities of daily living subscale ($r = -.37$, $P < .01$), psychological impact subscale ($r = -.55$, $P < 01$), advancement subscale ($r = -.56$, $P < .01$), and the FAST-PM ($r = -.49$, $P < .01$). Pitching volume: There was a significant negative correlation between the number of innings pitched per game and the FAST-TS ($r = -.35$, $P = .01$), psychological impact subscale ($r = -.38$, $P < .01$), advancement subscale ($r = -.42$, $P < .01$), and the FAST-PM ($r = -.35$, $P = .01$). The amount of times pitched per week was only significantly correlated with the pain subscale ($r = .28$, $P = .04$). Finally, any limited pitching time over the last month was significantly correlated with the psychological impact subscale ($r = .28$, $P = .05$) and advancement subscale ($r = .32$, $P = .02$). **Conclusions:** The results of this study indicate that regularly playing baseball and maintaining participation levels is associated with higher levels of HRQOL in healthy pitchers. Limited participation is associated most with negative psychological impact and advancement. Clinically, it is important not only to monitor pitching participation and pitching volume, but also HRQOL in pitchers, particularly if participation is limited.

## Excessive Glenohumeral Internal Rotation Deficits Among Baseball Pitchers Negatively Effects Subacromial Joint Space and Forward Scapular Posture

Laudner K, Wong R, Latal J, Meister K: Illinois State University, Normal, IL; Texas Metroplex Institute for Sports Medicine and Orthopedics, Arlington, TX; Texas Rangers Baseball Organization, Arlington, TX

**Context:** Baseball pitchers frequently present with varying levels of glenohumeral internal rotation deficits (GIRD) in their throwing arms when compared to their non-throwing arms. However, excessive bilateral differences in internal rotation motion have been associated with several shoulder pathologies including both subacromial and internal impingement. Additonally, patients diagnosed with subacromial impingement commonly present with decreased subacromial joint space and increased forward scapular posture. These characteristics have not been, as of yet, evaluated and associated to those pitchers who present with excessive GIRD. **Objective:** To determine if a group of baseball pitchers with excessive GIRD have differences in subacromial joint space and forward scapular posture when compared to a control group. **Design:** Cross-sectional. **Setting:** Athletic training room. **Patients or Other Participants:** Twenty-five asymptomatic professional baseball pitchers with excessive GIRD (age = 21.6 ± 3.0 yrs; height = 187.2 ± 4.7 cm; mass = 87.6 ± 10.1 kg) were matched with 25 pitchers with acceptable levels of GIRD (age = 22.8 ± 2.7 yrs; height = 187.5 ± 5.6 cm; mass = 91.4 ± 9.7 kg). **Interventions:** We classified excessive GIRD as an amount greater than 10% of the total arc of motion (i.e. dominant shoulder total arc = 160°; 0.10 x 160° = 16°; excessive GIRD = >16°). We used a digital inclinometer to measure glenohumeral internal and external rotation range of motion with participants in a supine position and their scapula stabilized. We used diagnostic ultrasound to measure the distance of the subacromial joint space with the throwing arm resting at the side of their body (0° abduction). We assessed bilateral forward scapular posture with each participant standing against a wall and then measured the distance between the wall and their anterior acromion. The bilateral difference between these measurements was used as the forward scapular posture for the dominant arm. We used separate t-tests to determine any significant differences between groups ($p < 0.05$). **Main Outcome Measures:** The dependent variables were subacromial joint space distance and forward scapular posture. **Results:** The total arc of motion and GIRD for the excessive group was 153.7° ± 13.4° and -23.5° ± 5.1°, and 160.5° ± 16.1° and -3.6° ± 9.0° for the acceptable level of GIRD group. The excessive GIRD group presented with significantly less subacromial space (9.4mm ± 2.6mm) than the acceptable level of GIRD group (11.1mm ± 2.4mm) ($p = .02$). The excessive GIRD group also had significantly more forward scapular posture (10.8mm ± 11.0mm) of their throwing arm than the acceptable level of GIRD group (3.9mm ± 8.8mm) ($p = .01$). **Conclusions:** We found that baseball pitchers with higher levels of GIRD had less subacromial space and more forward scapular posture in their throwing arms compared to pitchers with acceptable levels of GIRD. Our findings suggest that increased GIRD may be a precursor to pathologies associated with decreased subacromial space and forward scapular posture such as subacromial impingement. We suggest that players identified with excessive GIRD perform shoulder strengthening and stretching exercises designed to improve scapular positioning.

## Recovery of Infraspinatus Cross-Sectional Area, Echo Intensity, and Glenohumeral Range of Motion Following Overhand Pitching

Pexa BS, Myers JB, Ryan ED, Teel E, Rucinski TJ, Hibberd EE: University of North Carolina, Chapel Hill, NC, and The University of Alabama, Tuscaloosa, AL

**Context:** Eccentric exercise causes increased cross sectional area (CSA) and echo intensity (EI) when measured with diagnostic ultrasound. Eccentric loading similar to baseball pitching results in infraspinatus CSA increase with accompanying change in internal rotation (IR) flexibility. Changes in CSA, EI, and IR indicate muscle damage following eccentric exercise. Diagnostic panoramic ultrasound (DPUS) is a reliable method for measuring CSA and EI. Due to its superficial location, the infraspinatus can be evaluated with DPUS and serve as a marker of damage to the shoulder following pitching. Changes in CSA, EI and IR measurements may allow tracking of recovery following a bout of baseball pitching. **Objective:** To track changes in infraspinatus CSA, EI and IR when compared to baseline and to identify a relationship between these variables following bouts of baseball pitching. **Design:** Longitudinal Cross-Sectional Design **Setting:** Collegiate baseball stadium **Patients or Other Participants:** Ten varsity division 1 baseball players participating in the fall season (age: 18.8 years ± 1.2, height: 189.2cm ± 7.3, mass: 93.1kg ± 15.3) volunteered for this study. **Interventions:** Participants pitched a fall season game that consisted of a minimum of 25 pitches. Infraspinatus CSA, EI and IR flexibility were captured prior to and following the pitching bouts. All variables were tracked for 6 days following pitching bouts. Forty-five bouts of pitching were captured in this dataset. **Main Outcome Measures:** Previous work demonstrated reliability and precision of the DPUS obtained CSA and EI (CSA = ICC(2,1) = 0.781, SEM = 1.87 cm2) (EI = ICC(2,1) = 0.756, SEM = 1.93). IR flexibility was recorded with a digital inclinometer (ICC [3,1] = 0.985, SEM = 1.51°). Measurements were performed on the non-dominant side to act as a control. A general linear mixed model was run to compare baseline CSA and IR scores and one general linear mixed model regression was performed to determine relationship between CSA and IR change scores. **Results:** Dominant limb CSA significantly increased day 1 post pitching ($t62 = 3.51$, $p = 0.0008$; 3.3% change), with trends toward increased CSA lasting up to day 5 post pitching (day 2; $t62 = 2.06$, $p = 0.0434$, 2.9% change) (day 3; $t62 = 2.25$, $p = 0.0282$, 4.2% change) (day 4; $t62 = 1.71$, $p = 0.0927$, 3.0% change). Internal rotation was significantly lower day 1, day 2, and day 3 following pitching ($t59 = -3.92$, $p = 0.0039$, $t59 = -2.94$, $p = 0.0047$, $t59 = -2.88$, $p = 0.0055$, respectively). Despite similar trends, there was no significant relationship between the changes in CSA and IR ($b = -0.1065$, $t175 = -1.16$, $p = 0.2457$). There were no significant changes in the non-dominant CSA, EI, or IR. **Conclusions:** The results of the study showed that baseball pitching recovery may not occur until at least 2 days following pitching, and range of motion does not recover until 4 days following pitching. This indicates the need for stricter rules regarding pitching on subsequent days.

## Comparison of the Effects of Two Recovery Methods After Collegiate Baseball Pitching

Kawamura H, Harter RA, Vela LI, McCurdy K: Texas State University, San Marcos, TX

**Context:** The localized muscular fatigue, acute loss of glenohumeral strength and passive range of motion (PROM), and delayed onset muscle soreness (DOMS) that elite baseball pitchers experience following a game must be minimized or eliminated before they can safely pitch again. Cryotherapy, stretching, and light shoulder exercises have been used individually and in combination after baseball pitching to hasten the recovery of shoulder muscular strength and PROM, and reduce the symptoms of DOMS. However, the therapeutic benefits of light shoulder exercise programs for recovery after baseball pitching remain unknown. **Objective:** To compare the effectiveness of two recovery methods, stretching and cryotherapy (SC), and a light shoulder exercise program, stretching and cryotherapy (LSC), after simulated game pitching by collegiate baseball pitchers. **Design:** Repeated measures crossover trial **Setting:** Research laboratory. **Patients or Other Participants:** 20 healthy male collegiate baseball pitchers (age = 21.7 +/- 1.4 yrs, height = 1.85 +/- 0.06 m, mass = 88.3 +/- 8.8 kg) participated; 18 pitchers completed all aspects of the study. **Interventions:** Each participant threw 3 innings of a simulated game (45 pitches) and then was randomly assigned to receive either the SC or LSC post-pitching treatment. Participants returned at 24 and 48 hour intervals after the simulated game pitching to provide follow-up measures of glenohumeral joint strength and PROM, and complete patient-oriented measures of functional ability and pain level. Two weeks later, they repeated an identical bout of simulated game pitching and were treated with the alternate recovery method. **Main Outcome Measures:** Isometric glenohumeral internal, external rotation and scaption

strength, and PROM measurements were obtained on 4 occasions with each treatment regimen. Participants completed QuickDASH Sport™ questionnaires and a 100-mm VAS pain scales 6 times with each treatment method. **Results:** The LSC active recovery protocol produced significantly better results than the SC passive recovery protocol for 5 of the 8 outcome measures at 48 hours post-pitching ($P < 0.05$). Most notably, mean internal rotation PROM was 50.5 +/- 10.1 deg in the LSC group compared to 44.6 +/- 8.1 deg for SC, and mean external rotation isometric strength in the LSC group was 2.071 +/- 0.396 N/kg BW versus 2.014 +/- 0.399 N/kg BW in the SC group at 48 hours post-pitching ($P < 0.05$). **Conclusions:** The LSC treatment regimen was more effective than the SC method for post-pitching recovery of all 3 measures of glenohumeral strength and for both internal and external PROM. Active recovery with 13 light shoulder exercises after pitching was superior to a passive recovery method for a more rapid and complete return of shoulder strength and PROM among collegiate pitchers. Future studies should consider extending post-pitching observations to 72 or 96 hours in order to capture the complete recovery of these physiological qualities.

## Muscle Activation and Patient Rated Upper Limb Function in Those With and Without Scapular Dyskinesis

Grunloh LM, Games KE, Eberman LE, Krause AM, Fleming N: Indiana State University, Terre Haute, IN, and Trinity Dublin University, Dublin, Ireland

**Context:** Scapular dyskinesis (SD) leads to both chronic and acute upper extremity pathologies. SD is thought to occur as a result of several factors, one of which is a lack of neuromuscular control and asynchronous activation of the scapular stabilizers: upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA). **Objective:** To observe the scapular stabilizers during the visual inspection scapular dyskinesis (VISD) test and compare patient rated upper limb function in those with obvious, subtle, or no SD. **Design:** Cross sectional and ex-post facto design. **Setting:** University research laboratory. **Patients or Other Participants:** Twenty-eight healthy individuals (22.46 ± 2.56y; 13 male and 15 female; 27 right handed, 1 left handed; 1.72 ± 0.11m; 76.24 ± 18.69kg) participants. **Interventions:** Patients completed a patient rated upper limb functional outcome measure (Quick DASH-9) before we measured muscle activation using wireless surface electromyography. Participants completed three trials of maximal voluntary isometric (MVIC) contractions for each muscle. After a 10 minute rest period, participants performed the VISD test. The test was performed standing with five repetitions of glenohumeral flexion and abduction with either 3lbs (1.36kg) or 5lbs (2.27kg) weights (dependent on the participants' body mass). **Main Outcome Measures:** During the VISD test, a trained evaluator observed for obvious, subtle, or no SD. We calculated Quick DASH-9 scores and used a one-way analysis of variance (ANOVA) to determine differences in upper limb function between the different levels of SD. We also used separate one-way ANOVA for each muscle to compare the levels of SD. Significance was set at $p < 0.05$ a-priori. **Results:** A majority of participants demonstrated some level of dyskinesis: obvious dyskinesis (n = 18, 64.3%), subtle dyskinesis (n = 6, 21.4%), no scapular motion (n = 4, 14.3%). Our participants demonstrated high levels of upper limb function (1.6 ± 2.9pts out of 100) did not identify any differences between the levels of SD ($F_{2,24} = 1.187$, $p = 0.322$). There were also no significant differences in muscle activation between the UT ($p = 0.93$), MT ($p = 0.67$), LT ($p = 0.96$) and SA ($p = 0.25$) muscles amongst the different levels of SD during the VISD test; however, muscle activation of the UT ($p < 0.001$) and MT ($p = 0.001$) was significantly greater during abduction as compared to flexion. There were no significant differences in activation between the LT and SA muscles between the flexion and abduction positions. **Conclusions:** The VISD test is intended to evaluate the dynamic movement of the glenohumeral joint and the scapula in relation to one other. The results of this study indicate no significant difference between SD ratings and patient-rated upper limb function as well as scapular stabilizer muscle activation. Because SD is not an independent pathology, but likely a concomitant condition, pre-injury screening may not be clinically useful, but patient rated outcome measures may help in identifying symptoms affecting function beyond that of athletic participation.

# Free Communications, Oral Presentations: Interprofessional Education in Athletic Training

Saturday, June 25, 2016, 7:00AM-8:00AM, Room 315; Moderator: Cailee Welch Bacon, PhD, ATC

### Effects of an Interprofessional Living Learning Community With Athletic Training, Dietetics, Exercise Science and Nursing Students on Satisfaction With the University Experience

Snyder MM, Estridge KM: Western Carolina University, Cullowhee, NC, and Ashland University, Ashland, OH

**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 satisfaction with the university experience after participation in a living learning community during their freshman year. **Design:** Prospective cohort 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; there were 8 males and 13 females. They lived in the same dorm, took three classes together and participated in monthly sessions that were educational, service or social. Sixteen of the 21 students completed all of the activities associated with the LLC. Thirteen of the 16 completed the survey (81.25%). **Interventions:** Students completed the Mid-Year Student Assessment (MYSA) online during the second semester of their freshman year. The survey is a well validated study and used a seven point scale (1 = very satisfied, 4 = neutral, 7 = very satisfied) to examine student motivation, their specific interests and needs, and their institutional impressions after completing their first term of enrollment. **Main Outcome Measures:** The critical dependent variable was participation in the LLC. Answers from the students in the LLC were compared to the general freshman population using one-sample t-tests and analyzed using SPSS. **Results:** The MYSA asked 9 questions regarding satisfaction; 6 of which related to goals of the LLC; the students were highly satisfied with all areas. Most notably, students in the LLC were more satisfied with their level of interaction with faculty in class [$t(12) = 3.613$, $p = 0.004$, $6.46 \pm 0.66$] and greater satisfaction with their sense of belonging to the college community [$t(12) = 2.437$, $p = 0.031$, $6.31 \pm 0.75$]. Additionally, students in the LLC reported higher satisfaction with the level of interaction with other students [$t(12) = 4.238$, $p = 0.001$, $6.38 \pm 0.65$], a greater satisfaction with assistance in selecting a major [$t(12) = 2.602$, $p = 0.023$, $6.23 \pm 1.01$], and a higher satisfaction with opportunities for community service and other volunteer work [$t(12) = 5.251$, $p < 0.001$, $6.60 \pm 0.18$]. Surprisingly, there were no differences in the level of satisfaction with the level of interaction with faculty outside of class [$t(12) = 1.089$, $p = 0.297$, $5.62 \pm 1.04$]. 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 student satisfaction 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, such as interprofessional practice. In addition, there are potential benefits to the university, including higher retention and graduation rates.

### Institutional Factors Affecting Interprofessional Education in Nutrition and Dietetics and Athletic Training Programs

Eliot K, Breitbach A, Wilson M, Chushak M: Saint Louis University, Saint Louis, MO

**Context:** Interprofessional Education (IPE) is recommended to help promote collaborative patient-centered care. In turn, various external accreditors in the health professions have integrated IPE competencies into their standards. However, little is known about how Athletic Training (AT) and Nutrition and Dietetics (ND), professions with historically less direct institutional alignment to the health sciences, have incorporated IPE into their educational programs. **Objective:** The purpose of this study was to examine institutional factors affecting the level of IPE participation within accredited AT and ND education programs. **Design:** Cross Sectional Survey design. **Setting:** College of Health Sciences on Medical Center Campus at Large Research-Intensive University. **Patients or Other Participants:** Directors of accredited Professional and Post-Professional Athletic Training programs [162/398 (40.7%)] and directors of accredited Nutrition & Dietetics programs [167/526 (31.7%)] participated in the study. **Interventions:** The "Interprofessional Education Assessment and Planning Instrument for Academic Institutions" was distributed electronically to directors of accredited programs in ND and AT. Respondents answered survey questions providing demographic information and addressing their institutions' level of involvement and commitment to IPE. **Main Outcome Measures:** One major finding of this study was the similarity between ND and AT education programs with respect to current participation in IPE programs offered at their respective institutions. However, when

compared to other health professional education programs, ND and AT education programs revealed lower levels of participation in IPE. This study found that academic level and type of academic unit may play a role in the availability of IPE initiatives. **Results:** There was a statistically significant relationship between AT program type ($\chi2(1) = 4.21$, $p < 0.05$) and between the academic unit ($\chi2(1) = 12.84$, $p < 0.01$) in which an AT program was located and the availability of IPE initiatives. AT programs with Graduate or Post-Professional CAATE accreditation were 1.9 times more likely to have access to IPE initiatives than those who only possessed undergraduate-level CAATE accreditation AT programs included within the Health Professions/ Health Sciences/ Allied Health departments were 1.9 times more likely to have access to IPE programs/initiatives at their respective institutions. Study findings also revealed a statistically significant ($\chi2(1) = 14.64$, $p < 0.01$) relationship between the academic unit in which ND programs were located and access to IPE programs within those respective institutions. ND programs located within Health Professions/ Health Sciences/ Allied Health were about 2.2 times more likely to have access to IPE programs/initiatives than ND programs housed in other departments. Additionally, ND programs, as compared to AT, performed higher in components of IPE programs involving courses, clinical rotations and community education/service learning. **Conclusions:** Differences emerged between ND and AT programs for several items in the study. Institutional factors such as resource commitment, academic unit type and program level may affect the implementation, development and success of IPE initiatives.

## Student Readiness for Interprofessional Collaboration in an Experiential Learning Environment

Mokris RL, Mosinksi N, Williams K: Gannon University, Erie, PA

**Context:** Students enrolled in the health professions majors need to understand the role of interprofessional collaboration during their educational preparation. It is imperative to evaluate students' readiness to engage in interprofessional education (IPE) experiences. **Objective:** The purpose of this research is to determine if health professional students are ready and can identify value in engaging in an IPE experiential learning environment. **Design:** This research used a one group, pretest-posttest survey design. **Setting:** A public athletic event requiring a temporary medical facility (medical tent) for emergent intervention. This setting allowed hands-on skill sets developed within the athletic training and physician assistant curriculum to be used under supervision of Preceptors and physicians. **Patients or Other Participants:** The participants for the study were recruited using a purposeful, convenience sampling of a pool of students that are enrolled in the professional Master of Athletic Training Program and the Physician Assistant Program. There was a 100% response rate. **Interventions:** The participants were given a self-administered Adapted Readiness for Interprofessional Learning Scale (RIPLS) Questionnaire prior to the experiential learning event. RIPLS is a valid and reliable 19-item survey with a 5-point scale that is used to assess the readiness of health care students for IPE. The tool has 3 subscales: teamwork and collaboration, negative and positive professional identity, and roles and responsibilities. The RIPLS tool is available through open access so permission is not required. Participants filled out the RIPLS survey after the experiential learning event. **Main Outcome Measures:** The RIPLS survey instrument was administered as a pretest and a posttest. Paired t-tests were used to compare the means of the pre-test and post-test. The data was then examined with independent t-tests to compare the independent variables of gender and program enrollment. A one-way analysis of variance (ANOVA) was used to determine if there was difference between the independent variable of age. **Results:** There were 14 participants; 6 (42.9%) MAT students, 8 (57.1%) PA students; 10 (71.4%) females, 4 (28.6%) males that completed both the pre-survey and post-survey RIPLS. The mean age was 22.64 years old. One hundred percent of the participants reported they have never completed a RIPLS Questionnaire previously and have never been involved in a previous experience of IPE instruction. There were no significant differences found in the paired t-test. Independent t-tests of gender and program variables showed some statistical significance; however, overall each variable reported a positive readiness to engage in IPE on the RIPLS. **Conclusions:** The findings from this study show that students, when placed in an experiential learning environment, show a readiness for IPE learning.

## Using a Real-life Case Scenario to Integrate Athletic Training Students Into an Existing Interprofessional Team Seminar

Breitbach A, Pole D, Howell T: Saint Louis University, Saint Louis, MO

**Context:** Interprofessional collaborative practice (IPCP) has been identified as playing an important role in improving health care and patient outcomes. Interprofessional Education (IPE) is described as an essential component of preparing health professions students as "collaboration-ready" members of health care teams. Recent recommendations of the NATA Interprofessional Education and Practice in AT Work Group endorsed the integration of IPE and IPP into student learning experiences and acknowledged the lack of awareness of the extent to which ATs collaborate with multiple professions in clinical practice. **Objective:** (1) Collaborate to design a case-based module that demonstrates the scope of training of AT and develops student knowledge and skills at effective teamwork and IPCP. (2) Integrate AT students into and document the outcomes of a meaningful, real-life, case-based discussion with students from seven other professions to improve students' competency as collaboration-ready members of patient care teams. **Design:** A longitudinal Interprofessional Team Seminar (IPTS) course included post-baccalaureate students from 7 professions (medicine, nursing, PA, PT, OT, social work, and pharmacy) in the professional phase of their programs. IPTS course evaluations called for additional "real" patient cases, to better simulate IPCP. In response to those concerns, the IPTS faculty collaborated with AT faculty to develop a new module utilizing a real-life case that highlights the role and training of ATs. It engaged graduate professional AT students and addressed skills in: teamwork and communication; and patient transitions in rapidly forming care teams. **Setting:** Post-baccalaureate IPE course on Medical Center Campus. **Patients or Other Participants:** The 650 IPTS students each participated in 1 session. The 20 AT students participated in 3 sections of an IPTS seminar providing the opportunity to repeat the experience with 3 different teams. **Data Collection and Analysis:** IPTS students completed individual case-activity worksheets regarding team-based care and significant takeaway points from the seminar. AT students submitted a structured critical reflection paper after the three sessions. Qualitative analysis was performed on each of the documents looking for themes and frequently occurring terminology. **Results:** IPTS students' key takeaway points address: teamwork, understanding roles across the continuum of care, patient-centered care, and communication. AT students indicated a strong affirmation of their unique contribution to the care team and increased confidence to advocate for their professional contribution to patient care. **Conclusions:** Intentional design of an IPE course to focus on behaviors of collaborative practice can also introduce and highlight profession-specific strengths and unique contributions to team-based care. Outcomes included: (1) improved appreciation for roles and responsibilities across the professions, (2) development of skills at effective communication across care settings, (3) an appreciation for the complexity of patient care needs during the continuum of care that value of a collaborative, interprofessional approach to achieve optimal patient outcomes.

## Education Evidence-Based Forum: Facilitating Effective Debriefing

Saturday, June 25, 2016, 8:00AM-9:00AM; Moderators: Jessica Ragar, MS, ATC, PES
Discussants: Kirk Armstrong, EdD, ATC; Stacy Walker, PhD, ATC

### Debriefing After a Multi-Station Objective Structured Clinical Examination

Armstrong KJ, Walker SE: Indiana State University, Terre Haute, IN, and Ball State University, Muncie, IN

**Context:** An objective structured clinical examination (OSCE) is a reliable and valid performance-based summative or formative experience used to determine clinical skill and/or competence. Debriefing after an OSCE is an essential part of the learning process, facilitated through planned conversation where students analyze and reflect on their actions, thought processes, and emotions with the goal of improving patient care and outcomes. **Objective:** To explore athletic training (AT) students experiences during a debriefing session after participating in a three-station OCSE. **Design:** Phenomenology. **Setting:** Simulation lab. **Patients or Other Participants:** Fourteen senior AT students (4 males, 10 females; 21 + 1.30 years old) participated. **Data Collection and Analysis:** The OSCE consisted of three stations (patient with shoulder, low back, gall bladder pathologies), where students interacted with a standardized patient. The debriefing session, one day following the OSCE, consisted of questions regarding the student's perception of successes and challenges during each patient encounter (e.g., what went well, what did not go well) and impact of the encounters on patient care (e.g., what did you learn, how will you change your clinical practice). The debriefing session was audio recorded, transcribed verbatim and analyzed inductively using an interpretative coding method. Data were initially read by two researchers for understanding and then was coded with meaning units. Trustworthiness was established through data analyst triangulation, member checks, and peer review. Group responses were solicited until data saturation occurred. **Results:** Two major themes emerged, increased confidence and realism. The theme of increase confidence emerged due to participants learning to better organize their thoughts during the evaluation process and being challenged to critically think and made clinical decisions. Participants reported that following the OSCE they felt more confident in their ability to complete an independent patient evaluation. Specifically, the encounters emphasized the need to have a systematic approach while completing a patient evaluation. Participants reported the OSCE improved their ability to organize their thoughts, which allowed better synthesis of information. The theme of realism refers to how the participants believed the encounters mimicked real-time patient encounters. The encounters did not follow a prescriptive nature, where each patient's condition deviated from what was expected at times, which challenged participants to critically think through information gathered and make clinical decisions regarding a treatment plan of care. **Conclusions:** Debriefing facilitated the participant's ability to reflect on their actions and clinical decisions made during the OSCE. OSCEs would be beneficial to provide additional patient encounters in a controlled environment where students can then engage in debriefing to receive feedback on their performance. The feedback identifies performance gaps and reflection on clinical decisions, which informs decisions and performance during future encounters with patients.

Learning Objectives:

At the conclusion of this presentation, participants will:

1. Understand how an objective structured clinical examination is used for determining clinical skill or competence.
2. Appreciate the need for debriefing sessions following clinical encounters to promote learning.
3. Appreciate educational benefits students reported from participating in an objective structured clinical examination.

References:

1. Adamo G. Simulation and standardized patients in OSCEs: achievements and challenges 1992-2003. Med Teach. 2003;25(3):262-270.
2. Dreifuerst KT. Using Debriefing for meaningful learning to foster development of clinical reasoning in simulation. J Nurs Ed. 2012;51 (6): 326-333.

## Athletic Training Student Core Competency Implementation During Patient Encounters

Cavallario JM, Van Lunen BL, Hoch JM, Hoch MC, Manspeaker SA, Pribesh S: Old Dominion University, Norfolk, VA, and Duquesne University, Pittsburgh, PA

**Context:** Healthcare research evidence suggests early patient encounters (PEs), as well as the purposeful implementation of professional Core Competencies (CCs), for athletic training (AT) students may be beneficial to their ability to provide care. However, no existing research has related facets of the clinical education experience with CC implementation as a form of summative assessment of the clinical experience. **Objective:** To determine the relationship between the frequency and length of PEs; as well as the student's role and clinical site during PEs, with the students' perceived CC implementation during these encounters. **Design:** Panel design. **Setting:** Professional AT Program, Division I Institution. **Patients or Other Participants:** We purposefully recruited one AT program that utilizes Evalue software and 33 students (25 female, 8 male) enrolled in the professional phase (11-first year, 12-second year, 10-third year) participated. **Interventions:** Participants first viewed a 20-minute recorded CC educational module followed by educational handouts, which were also posted online for reference throughout the semester. Evalue was used to track PEs including type of encounter (actual patient, practice encounter, didactic practice scenario, etc.), the type of site where the encounter occurred (university, high school), student role (observed, assisted, performed), as well as an added block of questions indicating which, if any, of the CCs were implemented during the PE. **Main Outcome Measures:** Variables per patient included PE length (minutes), student role, site at which the encounter occurred, and whether any of the 6 CCs were implemented (yes/no). Variables per student included average encounter length (minutes), encounter frequency, modal role, clinical site assignment, and the number of times each CC was implemented. Separate one-way ANOVAs were utilized to examine the relationships between role or clinical site and implementation of total number of CCs. Multiple linear regressions were used to determine how the average length and frequency of PEs were related to the average and total number of implemented CCs. Binary logistic regression models determined how the length of each encounter, role of the student, and type of clinical site related to the implementation of each CC. **Results:** The role of the student during PEs was found to be significantly related to their ability to implement the total number of CC ($F = 103.48$, $p = 0.000$). Those who observed were likely to implement fewer total CC than those who assisted (M diff = -0.29, $p = 0.000$); those who assisted were likely to implement more total CCs than those who performed (M diff = 0.32, $p = 0.000$). Frequency of encounters was the only significant variable in the model examining all independent variables with CC implementation ($b(4,32) = 3.34$, $t = 9.46$, $p = 0.000$). **Conclusions:** The role of the student during PEs and the volume of PEs should be considered as a priority for students to promote greater CC implementation.

## Simulations Are the Predominant Method of Evaluating Athletic Training Students Clinical Integrated Proficiencies

Jarriel AJ, Armstrong KJ, Walker SE: Georgia College & State University, Milledgeville, GA; Indiana State University, Terre Haute, IN; Ball State University, Muncie, IN

**Context:** The clinical integration proficiencies represent the synthesis and integration of knowledge, skill, and clinical decision-making into patient care. Appropriate evaluation of the clinical integration proficiencies is an essential step in ensuring competence for professional practice. While previous research found the clinical integration proficiencies were rarely being evaluated during real-time patient encounters, follow-up research is needed to determine how they are currently being evaluated. **Objective:** To explore contemporary methods athletic training (AT) educators utilize to evaluate student's clinical integration proficiencies. **Design:** Phenomenological. **Setting:** Focus groups at a national convention. **Patients or Other Participants:** A total of 9 AT educators (6 males, 3 females; 12.3 + 5.24 years as an educator) currently using simulations (n = 5) or standardized patients (SPs) (n = 4) to evaluate the clinical integration proficiencies participated in one of three focus groups. **Data Collection and Analysis:** A semi-structured interview guide was used during the focus groups, which were audio recorded and transcribed verbatim. Data were initially read independently by three researchers for understanding and then was coded with meaning units. These meaning units allowed the data to be organized into emerging themes and subthemes. Trustworthiness was established through data analyst triangulation and peer review. Data saturation occurred during the third focus group. **Results:** Participants reported that simulations continue to be utilized as the predominant method for evaluating athletic training students clinical integration proficiencies over real-time patient or standardized patient encounters. Three themes emerged: 1) use of simulation technology, 2) need for debriefing and immediate feedback to AT students regarding clinical skills,

and 3) barriers to more authentic real-time patient encounters. Simulation technology (e.g., simulators, task trainers) was often used during simulations, which occurred most frequently during classroom/laboratory sessions rather than during clinical education. Participants reported that simulations allowed for immediate debriefing to provide feedback to athletic training students regarding their performance. This feedback could then be used to improve future performance. Simulations were used more frequently due to barriers that existed preventing the utilization of more authentic real-time patient (i.e., time constraints, injuries not occurring during clinical education) and SP encounters (e.g., cost, drain on faculty time, improper facilities). Real-time patient encounters occurred during clinical education and were preferred but their use was based on opportunity and could not be guaranteed for all students. SPs, when utilized, were to provide standardized guaranteed experiences for demonstration and evaluation of performance. **Conclusions:** Providing students all the necessary patient encounters needed for professional practice during clinical education remains a challenge. Although simulations remain the primary technique for assessing clinical integration proficiencies over those of real-time patient or SP encounters, additional data on how more valid, reliable and standardized approaches can be implemented is still needed.

Learning Objectives:

At the conclusion of the session, participants will be able to:

1. Distinguish between the various approaches to evaluating athletic training student's clinical skills and clinical integration proficiencies.
2. Compose strategies to overcome barriers for utilizing real-time patient encounters.

References:

1. Walker S, Weidner T, Armstrong KJ. Standardized patient encounters and individual case-based simulations improve students' confidence and promote reflection: a preliminary study. Athl Train Educ J. 2015;10(2):130–137.
2. Walker, SE, Weidner TG, Armstrong KJ. Evaluation of athletic training students' clinical proficiencies. J Athl Train. 2008;43(4):386-395.

## Faculty Perceptions of Standardized Patient Use in Athletic Training Education

Hoots KM, Cuchna JW, Van Lunen BL, Walker SE: Old Dominion University, Norfolk, VA, and Ball State University, Muncie, IN

**Context:** The use of standardized patients (SPs) has become commonplace in medical education, however, there is limited research on the use of SPs in athletic training educational programming. **Objective:** To understand how SPs are utilized in professional athletic training programs. **Design:** Qualitative. **Setting:** Individual phone interviews. **Patients of Other Participants:** Ten athletic training faculty (8 program directors, 2 clinical education coordinators, 3 males, 7 females, 39.9 + 5.09 years) participated. **Data Collection and Analysis:** Interviews occurred using a semi-structured interview guide and were audio recorded and were transcribed verbatim. Data were analyzed using a general inductive approach. Trustworthiness of the data was established via member checking, peer debriefing and multiple-analyst triangulation. Data saturation guided the number of participants. **Results:** The value of SP use in the education of students was recognized as a worthwhile investment. SP use aided students in gaining confidence in the clinical skills required for patient care. Three overarching themes were identified regarding use of SPs: 1) utilization, 2) training, and 3) case creation. Participants utilized SPs for up to 6 years to teach students and evaluate their performance. Fifty percent of the participants (n=5) utilized SPs to teach students and evaluate performance, 3 (30%) used them only for teaching purposes and 2 (20%) used them only to evaluate performance. SPs were used for teaching purposes 1 to 10 times per semester and to evaluate performance 1 to 5 times per semester. SPs were most often utilized to teach or evaluate performance during orthopedic, emergency care and general medicine encounters. Some programs were able to compensate SPs for their time (n = 4) while others did not (n = 6). The majority of participants (n = 8) were able to record encounters for feedback. Three participants (30%), who were formally trained in the utilization of SPs trained their SPs, while 2 were using staff from simulation centers on their campus to train their SPs. Training took 30 minutes to a couple weeks with novice SPs taking more time to train. Recruitment of SPs ranged from students from other departments on campus (e.g. theatre, exercise science, pre-majors or other healthcare professional programs), community members, alumni and preceptors. SP cases were created from current conditions seen in the clinical setting and varied from 4 hours or less to develop. Although time and money were consistent challenges to overcome, most program faculty found value in the use of SPs. **Conclusions:** The utilization of SPs was recognized as a valuable teaching strategy in the professional preparation of students' for real patient care. Whether being used for teaching purposes or to evaluate student performance, the time involved in developing cases, training SPs, and implementing into a curriculum needs to be considered by faculty.

Learning Objectives:

1. At the conclusion of this presentation, participants will be able to identify how standardized patients are utilized within athletic training professional programs.
2. At the conclusion of this presentation, participants will recognize the factors related to training standardized patients in athletic training professional programs.
3. At the conclusion of this presentation, participants will be able to identify the factors contributing to the development of cases for standardized patients utilized in athletic training professional programs.

References:

1. Barrows HS. An overview of the uses of standardized patients for teaching and evaluating clinical skills. Acad Med. 1993;68(6):443-451.
2. Walker SE, Weidner TG. The use of standardized patients in athletic training education. J Athl Train. 2010;5(2):87-89.

# Free Communications, Oral Presentations: Running Biomechanics: Fatigue and Injury

Saturday, June 25, 2016, 12:00PM-1:15PM, Room 315; Moderator: Luke Donovan, PhD, ATC

### Pre-Injury Running Mechanics Are Different in Runners With a Running-Related Musculoskeletal Injury Compared to Injury-Free Runners

Beard MQ, Torp DM, Donovan L, Thomas AC, Bazett-Jones DM, Gribble PA: Capital University, Columbus, OH; Eastern Kentucky University, Richmond, KY; University of Toledo, Toledo, OH; University of North Carolina at Charlotte, Charlotte, NC; Carroll University, Waukesha, WI; University of Kentucky, Lexington, KY

**Context:** Abnormal running mechanics in the hip and trunk have been identified in female runners with a running-related musculoskeletal injury (RRMI). Considering the high rate of RRMIs and that altered running mechanics have been identified in runners with a RRMI, it is imperative to investigate prospectively the influence of running mechanics on the development of a RRMI. Specifically, runners with a RRMI demonstrate altered trunk and hip excursion patterns. However, there has been no prospective investigation to determine if trunk and hip movements during running contribute to the onset of RRMIs. This information will be crucial to the development of prevention interventions for RRMIs. **Objective:** Investigate differences in frontal plane hip, pelvis and trunk running mechanics between runners who develop a RRMI and runners that remain injury-free (INJF). **Design:** Prospective cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** Fifty female recreational runners enrolled in a marathon training program volunteered (39.01 ± 9.44 yrs, 165.35 ± 7.43cm, 64.78 ± 11.95kg). **Interventions:** Three-dimensional kinematics (200Hz) and kinetics (1000Hz) were collected bilaterally during six successful trials of over-ground running at a self-selected pace prior to the initiation of marathon training. A RRMI was defined as a running related, lower extremity overuse musculoskeletal injury diagnosed by a clinician and caused 1day of interrupted running. **Main Outcome Measures:** Hip adduction and abduction, pelvis contralateral drop (CPD) and lift, and trunk contralateral and ipsilateral (TIL) lean throughout the stance phase of running were examined. The injured limb of the RRMI group was compared with the average of both limbs from the INJF group. Stance phase of running was normalized to 100 frames, with 1 frame representing 1% of stance phase. Initial contact equals 1%, and toe-off is 100%. For all 100 frames, group means and associated 90% confidence intervals (CIs) were calculated. The entire stance phase was examined for segments in which the CIs did not overlap for three consecutive time points. **Results:** Fifteen runners sustained a RRMI and 35 remained injury-free. The RRMI group demonstrated increased CPD from 16-28% and 48-93% of the stance phase compared to the INJF group (mean group difference: 1.44 ± 0.08° and 1.64 ± 0.12°, respectively). The RRMI group exhibited decreased TIL compared to the INJF group (mean group difference: 1.19 ± 0.07°) from 1-87% of stance phase. There were no differences between the groups for hip frontal plane motion. **Conclusions:** Specific excursion patterns of the trunk and pelvis during running may be related to the development of a RRMI amongst female runners during training. Clinicians and researchers should consider utilizing gait analysis to identify biomechanical alterations in runners, and implement appropriate intervention strategies such as gait reeducation and strengthening to minimize abnormal frontal plane pelvic and trunk motion during running.

### The Impact of Deficits During the Functional Movement Screen on Gait Movement Patterns in Trained Endurance Runners

Freeman JO, Blohm B, Chapman RF, Docherty CL: Indiana University, Bloomington, IN

**Context:** A clinical analysis of movement quality is commonly used in a variety of healthcare settings. While these clinical measures are informative, it is unclear how these findings translate to actual physical performance. **Objective:** To determine if functional movement deficits relate to the gait symmetry in a trained endurance runner. **Design:** Cohort **Setting:** University research laboratory. **Patients or Other Participants:** Forty trained (>30 miles/week) adults (24 males, 16 females, 24.4 ± 4.4 years; 171.0 ± 8.9 cm; 62.6 ± 10.5 kg) were recruited for this study. Participants were placed in groups based on the presence or absence of bilateral variance in four select tests of the Functional Movement Screen (FMS). If subjects had an asymmetry in at least one of the four tests they were included in the asymmetrical group (n=20). If subjects had symmetrical results on all tests they were placed in the symmetrical group (n=20). Subjects were excluded from the study if they have suffered any lower extremity injury preventing them from reaching thirty miles in a week in any of the previous six weeks. **Interventions:** All subjects completed all movements of the FMS, with the Hurdle Step, In-Line Lunge, Active Straight Leg Raise, and Rotary Stability used to assess asymmetry status. Each movement was scored between 0 and 3, based on published scoring criteria. Immediately following the

FMS, subjects participated in three four-minute bouts of treadmill running at increasing speeds (10 (slowest), 12 (intermediate), and 14 (fastest) km/h for women and 12 (slowest), 14 (intermediate), and 16 (fastest) km/h for men) to capture gait symmetry data. Ground contact time(GCT) and flight time(FT) were captured during the last thirty seconds of each bout of running (Optojump system, Microgate Srl, Bolzano, Italy). The data on the left side were subtracted from the data on the right side from each variable, and the absolute value was identified. **Main Outcome Measures:** Average right to left differences for GCT (seconds) and FT (seconds) at each running speed. Separate one-tailed independent t-tests were used to determine differences between the groups (asymmetrical and symmetrical) for GCT and FT right vs. left differences at each speed. The alpha for statistical significance was set at $p < 0.05$. **Results:** Ground contact time was significantly different between the groups at the slowest (mean difference: $0.0025 \pm 0.0014$s, $p = 0.04$) and fastest (mean difference: $0.0031 \pm 0.0012$s, $p = 0.01$) speeds, as well as approaching significance at the intermediate speed (mean difference: $0.0016 \pm 0.0012$s, $p = 0.09$). No significant differences were discovered when FT data were analyzed ($p > 0.05$). **Conclusions:** Trained runners who display one or more asymmetries in the lower limb movements of the FMS are likely to possess an asymmetrical ground contact time as part of their running gait.

## Sagittal Plane Lower Extremity Kinematics Do Not Indicate Onset of Running Related Musculoskeletal Injuries in Female Runners

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**Context:** Runners that utilize a forward trunk lean during running, decrease forces upon the knee, and concurrently increase hip and knee flexion. Runners with a running-related musculoskeletal injury (RRMI) such as patellofemoral pain syndrome demonstrate increased knee and hip flexion over the course of an exhaustive run, possibly as an attempt to reduce forces and pain on the knee. To understand these retrospective movement differences associated with a RRMI, prospective investigation could reveal potential injurious trunk, hip, and knee extension kinematics that predispose runners to a RRMI. Data from this study would contribute to the development of clinical intervention programs targeting the reduction of the RRMI prevalence rates. **Objective:** Compare baseline sagittal plane mechanics at the ankle, knee, hip, and trunk between female runners that sustain a RRMI during training and runners who remain injury-free (INJF). **Design:** Prospective Cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** Fifty healthy female recreational runners (39.01 + 9.44 yrs, 165.35 + 7.43cm, 64.78 + 11.95kg) enrolled in a marathon training program volunteered. **Interventions:** Three-dimensional kinematics (200Hz) were collected during six successful trials at a self-selected pace during over-ground running. At the end of the 16-week program, participants were either placed in the RRMI group or INJF group depending on the occurrence of a RRMI, defined as a musculoskeletal injury of the lower extremity diagnosed by a clinician that occurred as a result of running, creating a modification or removal from running for at least one training day. **Main Outcome Measures:** Sagittal plane ankle (plantar flexion and dorsiflexion), knee (flexion and extension), hip (flexion and extension), and trunk (flexion and extension) were examined throughout the stance phase. Stance phase was converted to 100 time points. For each dependent variable, group means and 90% confidence intervals (CIs) were produced for each time point, and observed for portions in which the CIs did not overlap for at least three successive time points. **Results:** Analysis of the ankle, knee, hip, and trunk in the sagittal plane over the entire stance did not produce any segments in which the 90% CIs did not overlap, indicating kinematic patterns were not dissimilar between groups. **Conclusions:** Baseline sagittal plane mechanics of the trunk and lower extremity appear to be similar amongst runners who sustain a RRMI and whom remain injury free. Altered mechanics observed post-injury might not be detectable during a non-exhaustive state prior to injury onset. Future research should determine when the altered mechanics, perhaps in the transverse or frontal planes, seen in runners with a RRMI begin to develop during training.

## Running Gait Biomechanics of Female Collegiate Track Athletes With Previous Hamstring Strain: An Initial Investigation

Radzak KN, Wiegand K, Bradley SD, Ollano V, Freedman Silvernail J: University of Nevada, Las Vegas, NV

**Context:** Hamstring strains account for 26% of all track-and-field injuries and remain problematic due to re-occurrence rates over 30%[1]. Late swing phase of running gait is often cited as the onset of injury due to the hamstring's eccentric force production and lengthening at this time. Although previous research indicates decreased force production following hamstring injury, the extent to which swing phase running gait biomechanics is effected remains essentially unknown. **Objective:** The current study evaluated swing phase running gait kinematics and kinetics of distance runners who had sustained a diagnosed hamstring strain within the previous competition season to injury-free controls. Bilateral comparisons were also made within the injured group. **Design:** Case-Control. **Setting:** Controlled research laboratory. **Patients or Other Participants:** Ten female collegiate distance (cross-country) runners volunteered to participate. Four runners sustained diagnosed unilateral hamstring strains (R:3,L:1), representing the injured group (Age: 20.75 ± 0.5 yrs; Participation: 3.25 ± 0.50 yrs; Height: 1.66 ± 0.05m; Mass: 54.75 ± 1.55kg). The remaining six runners served as controls (Age: 20.17 ± 0.98 yrs; Participation: 1.67 ± 0.82 yrs; Height: 1.62 ± 0.06m; Mass: 56.28 ± 4.77kg). Participants currently medically limited from training were excluded. **Interventions:** Three-dimensional lower-extremity kinematics (200Hz) were collected for three strides bilaterally while running at 3.5m/s. Previous medical history questionnaires were utilized to identify individuals with or without prior hamstring strains and then confirmed by the team athletic trainer. **Main Outcome Measures:** Variables of interest were hip and knee sagittal plane angles, velocities and moments during swing phase. Independent t-tests were used for statistical analyses to compare the involved limb of the injured group and the right limb of the controls. Paired t-tests were used to compare the involved and uninvolved limbs within the injured group. **Results:** Injured runners had been on the team significantly longer ($p < 0.01$) than controls; all other demographics were not significantly different. Injured runners had significantly greater ($p = 0.02$) flexion at the minimum knee angle (14.14 ± 2.25°) compared to controls (10.17 ± 2.62°). Other knee variables were not significantly different (Maximum flexion; Injured: 108.52 ± 10.48°, Control: 105.67 ± 6.19°, Maximum extension velocity; Injured: 756.33 ± 98.51°/s, Control: 771.20 ± 46.04°/s, Maximum flexion moment; Injured: 46.09 ± 4.36 Nm, Control: 53.88 ± 12.81 Nm; $p > 0.05$). Comparisons at the hip were non-significant (Maximum flexion; Injured: 57.18 ± 8.85°, Control: 58.15 ± 9.96°, Maximum flexion velocity; Injured: 274.20 ± 35.48°/s, Control: 236.63 ± 47.13°/s, Maximum extension moment; Injured: 77.71 ± 8.59 Nm, Control: 89.43 ± 18.32 Nm; $p > 0.05$). The involved limb had significantly decreased maximum hip extension moments compared to the uninvolved limb (Uninvolved: 92.48 ± 4.86 Nm; $p = 0.03$). Maximum hip flexion and knee extension velocities (Uninvolved: Hip: 253.87 ± 36.17°/s, Knee: 737.35 ± 109.18°/s) were increased in the involved limb at levels approaching significance (Hip: $p = 0.07$; $r = 0.75$, Knee: $p = 0.16$; $r = 0.57$). **Conclusions:** Decreased knee ROM during terminal swing may indicate a protection mechanism by avoiding hamstring lengthening. Bilateral differences in hip extension moment and hip and knee velocities potentially indicates decreased ability to decelerate the swing limb following injury, which corresponds to previous findings of decreased eccentric strength [2]. Despite a small sample size, findings indicate that swing phase biomechanics are effected following hamstring strains and further research evaluating biomechanical risk factors for re-injury is necessary.

1. Opar, D.A., M.D. Williams, and A.J. Shield, Hamstring strain injuries: factors that lead to injury and re-injury. Sports Med, 2012. 42(3): p. 209-26.
2. Lee, M.J., et al., Running biomechanics and lower limb strength associated with prior hamstring injury. Med Sci Sports Exerc, 2009. 41(10): p. 1942-51.

### Influence of Prior History of Sport Concussion on Mood State and Depressive Symptoms in Adolescent Athletes

Combs PR, Glaviano NR, Broshek DK, Saliba SA, Resch JE: The University of Virginia, Charlottesville, VA

**Context:** Sport concussions (SC) are a major health concern in young athletes. Common concussion-related symptoms include headache, fatigue, drowsiness and memory deficits as well as mood-related symptoms such as sadness and nervousness. Mood state and depression symptoms are highest in the adolescent age group which can cause ambiguity when evaluating adolescent athletes for a SC. During the past decade retired professional athletes have reported mood state changes and depression as a result of one or more SCs; however it is unknown how adolescent athletes respond to multiple injuries. **Objective:** To investigate the influence of a history of one or more self-reported SCs on mood state and depression symptom levels in adolescent student-athletes. **Design:** Cohort study **Setting:** A single private high school. **Patients or Other Participants:** Participants included 24 healthy student-athletes who were 17.4 ± 1.35 years of age. Participants with a self-reported history of SC (n = 12) were matched with participants having no prior history of SC (n = 12) based on age and grade. Each group consisted of equal numbers of male (n = 7) and female (n = 5) participants. **Interventions:** All participants completed the Profile of Mood States 2nd Edition Youth Short form (POMS 2-Y) and the Patient Health Questionnaire – 9 (PHQ-9) during their baseline (pre-injury) assessment. **Main Outcome Measures:** Independent t-tests were used to examine statistical difference between groups for the POMS 2-Y Short (anger-hostility, confusion-bewilderment, depression- dejection, fatigue-inertia, tension-anxiety, vigor-activity, and total mood disturbance) and PHQ-9 composite scores. Higher POMS 2-Y Short scores indicate greater mood disturbance and the PHQ-9 range from 0-27, where 27 indicates severe depression and 0 indicates no depression. Effect sizes were calculated using Cohen's d with 95% confidence intervals. All analyses were conducted with $\alpha = .05$. **Results:** Participants in the HSC group self-reported a history of 2.5 + 1.31 SCs. No significant differences were observed between groups for any PHQ-9 ($p > .05$) composite scores, POMS-2Y Short ($p > .05$) composite scores, or POMS-2Y Short ($p > .05$) subset scores. The PHQ-9 and POMS 2-Y Short composite scores both had small effect sizes (0.02 and 0.26, respectively). Moderate effect sizes (-0.57 and -0.52) were observed for the POMS 2-Y anger-hostility and fatigue-inertia scores, respectively. Neither score had confidence intervals crossing 0, leaving these results inconclusive. **Conclusions:** Our results suggest a history of one or more SCs does not influence mood state or depression symptoms in adolescent athletes. Future research is needed in a larger, more diverse sample in order to elucidate our findings. Additionally, future research is needed to establish age- and athlete-specific normative values for the POMS 2-Y Short and to investigate mood state and depression symptoms during the acute recovery phase following SC.

### The Psychological Response to Concussion Compared With Musculoskeletal Injuries in Collegiate Athletes

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**Context:** The psychological response to musculoskeletal injuries has been well documented, however, research on the psychological response to concussion is limited. Further, the confounding variables of injury with lost practice/game time is lacking. **Objective:** To compare the psychological responses of collegiate athletes diagnosed with a concussion to those of athletes diagnosed with musculoskeletal injuries with similar recovery duration. **Design:** Prospective longitudinal. **Setting:** Athletic Training facility. **Patients or Other Participants:** Fifteen collegiate athletes who sustained a musculoskeletal injury (Age: 19.9 ± 1.1 years, Gender: 60% Male, Height: 179.57 ± 9.72 cm, Weight: 84.73 ± 20.89 kg) were matched with 15 collegiate athletes who had suffered diagnosed concussions (Age: 19.4 ± 1.5 years, Gender: 53.3% Male, Ht: 172.63 ± 12.46, Wt: 78.42 ± 20.02 kg). **Interventions:** Participants completed the Profile of Mood States (POMS) and the State-Trait Anxiety Inventory (state anxiety only; STAI) at three time points during injury recovery (acute(A), exercise day 1(ED1), and return to play (RTP)) .The POMS (reliability 0.71–0.89) included descriptive words rated on a 5-point Likert scale, with subscales including: tension-anxiety, anger-hostility, fatigue-inertia, depression-dejection,

vigor-activity, and confusion-bewilderment. The items in the state portion of the STAI (reliability 0.80) assessed anxiety at a specific moment and included 20 questions measured on a 4-point Likert Scale. State anxiety was calculated by summing the scores for each item, with a higher score indicating higher anxiety. **Main Outcome Measures:** The main outcome measures were STAI (state anxiety only) and POMS subscale scores. Seven two-way (group x time) ANOVAs compared the scores on each subscale of the POMS and STAI. **Results:** There was a significant main effect of time regardless of group for the following subscales: anger-hostility, showing differences between A (3.07 ± 4.94) and ED1 (.81 ± 1.44, p = .005) and RTP (.30 ± .75, p = .001); fatigue-inertia, showing differences between A (4.55 ± 3.55) and ED1 (1.56 ± 2.49, p < .001) and RTP (1.17 ± 2.25, p < .001), depression-dejection, showing differences between A (2.86 ± 4.49) and ED1 (.63 ± 1.76, p = .004) and RTP (.40 ± .93, p = .001), confusion-bewilderment, showing differences between A (2.41 ± 2.57) and ED1 (.30 ± .99, p < .001) and RTP (.40 ± .86, p < .001) and total mood disturbance, showing differences between A (9.07 ± 19.89) and ED1 (-3.74± 8.59, p < .001) and RTP (-7.00 ± 7.91, p < .001). No significant effects were seen for group or time for tension-anxiety, vigor-activity, and state anxiety. **Conclusions:** Findings indicate that psychological response improved over time, regardless of type of injury. This contradicts previous research whereby athletes with musculoskeletal injuries had more severe psychological responses than athletes with concussion.

## The Psychological Impact of Sport-Related Concussion on Low Socioeconomic Status Adolescent Athletes

Hunt TN, Harris LL, Langdon JL: The Ohio State University, Columbus, OH; Georgia Southern University, Statesboro, GA; Ohio University, Dublin, OH

**Context:** A concussion can have long-term cognitive, behavioral and psychological consequences. Cognitive rest within the treatment protocol requires patients to disengage from academic and social activities; this has the dire side effect of isolating the adolescent from social and physical activities that are necessary to well-being. **Objective:** Describe the common psychological responses and coping strategies during cognitive rest among low SES adolescents who have suffered a concussion **Design:** General Interpretive-Grounded theory **Setting:** Focus groups were conducted in the library of the participants' high school. **Patients or Other Participants:** Eight male football players (mean age 15.87 + 1.65 years old) sampled on the following criteria participated in the study: history of concussion in previous academic year, sustained concussion during sports competition, low SES student athlete, full return to learn and participation. **Data Collection and Analysis:** Semi-structured interviews were conducted during two focus group sessions. The focus groups were audio recorded and transcribed verbatim by one of the researchers. Notes were taken by one of the researchers. The researchers analyzed transcribed notes and evaluated the focus group interviews for themes associated with (1) psychological responses and (2) emotional needs of the adolescent during recovery using content analysis. Credibility and trustworthiness was established through member checks and using the Certified Athletic Trainer as an auditor. Peer debriefing was utilized to evaluate themes independently and then comparing the results. **Results:** The participants were at least 6 months post-injury when the focus groups were conducted. All participants experienced other injuries prior to the concussion and categorized their injuries by severity. Common themes included: 1) frustration as the most common feeling after concussion 2) reliance on sport to enhance their social environment 3) utilization of sports as an anger management tool 4) prescription of cognitive rest interrupted by boredom 5) poor coping strategies, such as peer support, music and video games, following the injury 6) boredom and poor communication leading to other poor outcomes. **Conclusions:** In low SES male football players, removal from sport created feelings of isolation, loneliness, frustration and ultimately anger. Following the concussive injury, the athletes want to heal, however, boredom and poor coping strategies resulted in longer recovery times, increased anger and frustration with poor communication between clinicians and teachers. The current clinical model for cognitive rest and removal from all social support may be detrimental in a population that is socially grounded. The need for social interaction in this population can be amplified with increased stress during injury and/or poor psychosocial coping strategies enacted following head injuries. This research begins to describe the emotions and coping strategies in a low SES population which should lead to socially-oriented interventions to manage concussion recovery in adolescent athletes.

## Concussion as Psychological and Socio-Cultural Phenomenon: Perceptions of Economically Disadvantaged Hispanic Parents and Children

Ferry MD, Romm KE, Caswell AM, Parham C, Ambegaonkar JP, Cortes N, Caswell SV: George Mason University, Manassas, VA

**Context:** Better understanding the perceptions of economically disadvantaged Hispanic parents and children relating to concussion is important to optimize care. Yet, little research exists exploring concussion from a sociological, cultural, and psychological perspective. **Objective:** To explore how concussion is understood by economically disadvantaged Hispanic parents and children from a psychological and socio-cultural vantage point. **Design:** Qualitative study. **Setting:** Semi-structured interviews conducted in large metropolitan school system and free health clinics. **Patients or Other Participants:** Parents (n=10) and children (n=15) identifying as Hispanic. Most (80%) of parents spoke primarily Spanish. Child participants were bilingual. Socioeconomically advantaged Parents (n=9) and children (n=16) who identified as Caucasian. **Data Collection and Analysis:** Interviews were conducted using a semi-structured guide by athletic trainers identifying as Hispanic and fluent in Spanish. Interviews were recorded and transcribed verbatim. Data were analyzed using an analytic induction and constant comparison approach. **Results:** The primary finding of this study was that Hispanic participants expressed knowledge and healthcare disparities with respect to concussion compared with to Caucasian and socio-economically advantaged counterparts. Three themes emerged: 1) low knowledge, 2) confusion regarding roles of school and healthcare personnel, and 3) low utilization of resources. First, concussion was a poorly understood phenomenon among all Hispanic participants, but especially parents. In fact, no word for concussion exists in the Spanish language, (as it is known in Western and biomedical communities). Caucasian and/or socioeconomically advantaged counterparts discussed concussion with greater confidence and understanding. Second, contrasting with published research examining middle class Caucasian participants, Hispanic participants expressed that coaches have the ultimate say regarding return-to-play following concussion. When posed with a potential scenario of a child suffering a concussion, Hispanic parents uniformly indicated they would defer to coaches' advice. This suggests that Hispanic parents may lack understanding and comfort with school health policy reaffirming a well-documented deference for hierarchical authority and respect within wider Hispanic Cultures. Third, three Hispanic children reported having experienced concussion symptoms following head trauma, but indicated never seeking medical care. Two of the children indicated never reporting symptoms. When symptoms were reported one child said his or hers parents simply told them to rest. No Hispanic parent interviewed reported a child ever experiencing concussion symptoms. Interestingly, although 50% of Hispanic participants had health insurance, 75% reported free clinics and emergency rooms as primary access points to healthcare. Convenience and a lack of work flexibility were reasons cited. **Conclusions:** A perceived disconnect among Hispanic participants regarding concussion knowledge and healthcare utilization exist. Concussion is frequently discussed from Western, middle class, Caucasian perspectives. Our findings suggest that concussion education must be culturally competent and mindful of barriers to accessibility. Supported by the Potomac Health Foundation.

# Free Communications, Rapid Fire Oral Presentations: Field-Based Performance Testing

Saturday, June 25, 2016, 2:45PM-4:30PM, Room 315; Moderator: Daniel Clifton, MEd, ATC, CES

### Lower Limb Symmetry Values for Healthy Subjects Performing Functional Performance Tests

Madsen LP, Hall EA, Docherty CL: Indiana University, Bloomington, IN

**Context:** Functional performance tests (FPTs) can be used following lateral ankle sprains to objectively measure improvements in physical function and as a metric for making return to play decisions. When performing FPTs, the patient completes single leg hopping tasks for either distance or speed using both the injured and healthy limbs. The clinician can then compare the results bilaterally to determine if asymmetry exists. Unfortunately, normal lower limb symmetry values (LLSVs) for commonly used FPTs have yet to be determined. **Objective:** To establish LLSVs among healthy physically active adults performing single leg hopping exercises. **Design:** Cross-sectional design. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** Forty six subjects with no history of ankle sprains, displaced fractures, or lower extremity surgeries volunteered. All subjects were physically active, participating in at least 120 minutes of exercise per week at moderate intensity. Two subjects were excluded from the study due to reports of musculoskeletal pain during data collection leaving 44 participants for data analysis (17 men, 27 women; Mean age = 20.02 ± 2.2 years). **Interventions:** Participants completed five functional performance tests: Side hop, 6-meter crossover hop, lateral hop for distance, medial hop for distance, and figure-8 hop. For each test, three trials were completed on each limb. **Main Outcome Measures:** The fastest trial (sec) for side hop, 6-meter crossover hop, and figure-8 hop was used for statistical analysis. For the lateral hop and medial hop the maximum distance (cm) was used for statistical analysis. First, data for the dominant and non-dominant limbs were compared for each test using a paired samples t-test with a priori alpha level set at $p < 0.05$. Then, LLSVs were calculated for any test that showed no significant differences between limbs. LLSVs were calculated using the mean ± 2 standard deviations of the absolute value of the left/right limb differences. **Results:** There was no significant difference in performance between the dominant and non-dominant limbs for any of the five FPTs ($p > .05$). Therefore, final LLSVs were calculated for each test: side hop (<2.9sec), 6-meter crossover hop (<0.6sec), lateral hop for distance (<59.9cm), medial hop for distance (<48.8cm), and figure-8 hop (<1.1sec). **Conclusions:** Clinicians can use LLSVs for all five FPTs to determine if a patient has recovered from an ankle sprain without concern to whether the injury is to the dominant or non-dominant limb. According to the calculated LLSVs, if a patient has limb differences greater than 2.9sec on the side hop test, 0.6sec on the 6-meter crossover hop, 59.9cm on the lateral hop, 48.8cm on the medial hop, or 1.1sec on the figure-8 hop, the patient has an abnormal lower limb symmetry compared to healthy individuals. As such, clinicians should consider additional treatment for these individuals to further improve functional performance.

### Correlation of Lower Extremity Injury History and Functional Movement Screen™ Limb Scores in Collegiate Club Rugby Players

Samson CO, Straw CM, Henry GM, Brown CN: University of Georgia, Athens, GA

**Context:** Athletes with poor Functional Movement Screen (FMS) scores have increased injury risk, but association of previous lower extremity (LE) injury side and FMS total limb scores is unknown and could assist in corrective exercise program design. **Objective:** To determine if previous LE injury to a given limb is related to and affects FMS total limb and composite scores in a right limb dominant collegiate club rugby population. We hypothesized a negative relationship between side of previous LE injury and FMS total limb scores, and decreased FMS composite scores when the dominant limb has a history of injury. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Right limb dominant collegiate club rugby athletes (n = 23; 11 female, 12 male, age = 20.7 ± 1.2 yrs, height = 173.3 ± 8.4cm, weight = 80.6 ± 17.5kg). **Interventions:** Participants underwent screening and FMS total limb and composite scores were obtained by one trained rater. Interviews for previous injuries were completed, defined as a self-reported sprain, fracture, or subluxation/dislocation of the foot, ankle, knee, or hip for which medical attention was sought from any healthcare provider since freshman year of high school. **Main Outcome Measures:** Point-biserial correlations were used to determine the relationship between previous LE injury to a given limb and FMS total right and left limb scores ($\alpha = 0.05$). T-tests were used to determine FMS composite score differences between injured and uninjured groups with respect to each limb ($\alpha = 0.05$). **Results:** Of 23 participants, 14 (61%) reported

previous LE injury history. Three reported bilateral injuries, thus 17 LE injuries were reported (7 right, 10 left). A previous right LE injury was significantly correlated with right FMS total limb scores ($r_{pb}$ = -0.43, $r_{pb}^2$ = 0.18, p = 0.04, Cohen's d = 1.03) and left FMS total limb scores ($r_{pb}$ = -0.53, $r_{pb}^2$ = 0.28, p = 0.01, Cohen's d = 1.35). FMS composite scores for those with a previous right LE injury were significantly lower than those without (12.7 ± 3.9 vs 16.3 ± 1.9, p = 0.006). No significant correlation between previous left LE injury and right or left FMS total limb scores or difference in FMS composite scores (15.0 ± 2.7 vs 15.4 ± 3.4, p = 0.77) existed between groups. **Conclusions:** A moderate negative correlation was observed between previous LE injury to the dominant limb and right and left FMS total limb scores, with lower FMS composite scores if the dominant limb was injured. Previous LE injury to the non-dominant limb and FMS total limb scores were not correlated for either side. History of LE injury to the dominant limb appears to have a negative effect on FMS total limb and composite scores in a right limb dominant collegiate club rugby population. Overall, FMS scores seem to be affected by previous LE injury to the dominant limb but not by previous injury to the non-dominant limb. Clinicians should implement corrective exercises to both limbs, especially when the dominant limb is injured.

## Functional Movement Screen Item Scores as Predictors of Chronic Lower Extremity Injury History in Intercollegiate Athletes

Glass SM, Sugimoto YA, Ross SE: The University of North Carolina at Greensboro, Greensboro, NC

**Context:** The Functional Movement ScreenTM (FMS) is a clinical instrument used for predicting injury risk. Recent factor analyses demonstrate that the composite score is not associated with a unidimensional underlying construct. Individual item scores may therefore offer a richer source of information that circumvents concerns regarding the psychometric validity of the total score. For lower extremity injury risk classification in particular, FMS components which emphasize lower body function are likely the most applicable. **Objective:** To quantify the validity of selected FMS item scores in predicting group membership for chronic lower extremity injury history in intercollegiate athletes. **Design:** Case-control. **Setting:** Research Laboratory. **Patients or Other Participants:** Division I student-athletes with chronic lower extremity injury (19.48 ± 1.05 years, 174.44 ± 11.53 cm, 73.48 ± 14.95kg; 17 females, 8 males) were compared to a set of controls (19.02 ± 1.09 years, 174.32 ± 9.89 cm, 72.07 ± 10.95 kg; 37 females, 20 males). Chronic injury status was based on any of the following: plantar fasciitis, Achilles tendinitis, medial tibial stress syndrome, anterior compartment syndrome, patella bursitis, chronic ankle instability, iliotibial band bursitis, and posterior tibial tendinitis. **Interventions:** Experienced members of the sports medicine research team qualified to conduct the FMS administered it as part of a pre-participation examination. FMS components with specific relevance to lower extremity function—Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), and Active Straight Leg Raise (ASLR)—were used to predict group membership (chronic injury vs. control). The structure of the component score data presents certain challenges because prediction models must accommodate an increased number of explanatory variables and components which are scored on an ordinal scale. These concerns were addressed using a two-step approach that selected a predictor set using group lasso penalization, and then smoothed differences between neighboring levels of item scores with the same empirically-derived penalty parameter. Post-hoc analyses were performed with logistic regression and Mann-Whitney U tests. The significance threshold was α=0.05. **Main Outcome Measures:** Ordinally ranked FMS item scores and dummy coded injury group assignment (0 = control, 1 = chronic injury). **Results:** No FMS items were retained in the group lasso solution and item score coefficients did not differ from zero even after smoothing. Logistic regression with all variables entered confirmed non-significance of the penalized model ($X^2$ for null-residual deviance = 4.12(4), P = 0.39) and predictors (all P > .05). Mann-Whitney U tests verified a lack of group differences (U(DS) = 740.5, P = .36; U(HS) = 768.5, P = .23; U(IL) = 640.5, P = .80; U(ASLR) = 603.5, P = .90) on FMS item scores (DS: chronic injury = 1.92 ± 0.50, control = 1.96 ± 0.50; HS: chronic injury = 2.16 ± 0.47, control = 2.24 ± 0.47; IL: chronic injury = 2.44 ± 0.51, control = 2.32 ± 0.57; ASLR: chronic injury = 2.68 ± 0.47, control = 2.47 ± 0.63). **Conclusions:** We found no evidence to support the conclusion that the selected FMS item scores are sensitive to chronic lower extremity injury history. Future work should investigate their validity as prospective predictors of acute lower extremity injury.

## Landing Error Scoring System Scores Are Associated With Field-Based Measures of Athletic Performance

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**Context:** It is well-established that aberrant landing biomechanics, which can be quantified through error-scoring assessments such as the Landing Error Scoring System (LESS), are prospective risk factors for lower extremity injury in the physically active population. However, the link between landing biomechanics and objective, field-based measures of athletic performance remains unknown. **Objective:** Determine the association between LESS errors and objective measures of athletic performance: agility, speed, single-leg power production, and core power. **Design:** Cross-sectional descriptive study. **Setting:** Field laboratory. **Patients or Other Participants:** 25 healthy, female NCAA Division I athletes (n = 4 soccer, n = 2 volleyball, n = 3 field hockey, n = 6 lacrosse, n = 7 tennis, n = 3 basketball; age = 20.6 ± 1 yrs; height = 168.7 ± 14.0 cm; mass = 75.8 ± 25.5 kg) participated in this study. **Interventions:** Participants performed 3 jump-landings from a 30-cm high box at a distance half of each individual's height to a white line marked on the ground in front of the box. Participants were instructed to jump from the box, land in front of the line, then immediately jump for maximum height. A Microsoft Kinect v2.0 sensor using validated Physimax® LESS software recorded and autonomously scored the landing errors for each participant. In a randomized, counter-balanced order, participants completed 3 trials for each of the following performance tasks: agility ('T'-test), speed (40-yard sprint), right side single-leg power (triple-hop for distance), and core power (rotational med-ball toss). **Main Outcome Measures:** Pearson product-moment correlation coefficients (r) between LESS scores (number of errors) and 'T'-test and 40-yard sprint times (seconds), and LESS scores and medicine ball toss and triple-hop distances (meters) were calculated to evaluate the relationships between landing biomechanics and athletic performance variables. **Results:** There were moderate, negative associations between LESS score (4.9 ± 2.0 errors) and single-leg triple-hop (16.85 ± 1.62 meters) (r = -0.419, P = 0.025) and med ball toss (22.16 ± 2.74 meters) (r = -0.467, P = 0.021) distances. There was a moderate, positive association between LESS score and 'T'-test time (10.45 ± 0.57 seconds) (r = 0.491, P = 0.025). No significant association between LESS score and 40-yard sprint time (5.74 ± 0.39 seconds) (r = 0.366, P = 0.027) was observed. **Conclusions:** Dynamic movement quality, assessed using the LESS, is associated with lower extremity agility ('T'-test), lower extremity power (single-leg triple hop), and lumbo-pelvic-hip (core) power (medicine ball toss), but not linear speed in NCAA Division I female athletes. Aberrant landing biomechanics are associated with an elevated injury risk and may also limit athletic performance. Our results suggest that clinicians can now confidently inform athletes and coaches that biomechanics associated with injury are linked to deficits in athletic performance. Clinicians deploying corrective exercise programs aimed at improving an individual's biomechanics may also enhance an athlete's athletic performance during sport participation. Future research should explore causal associations between biomechanics and objective measures of athletic performance.

## Title: Relationship Between 2D and 3D Video Analyses of a Single Leg Squat in a Healthy Population

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Context: Knee injuries have remarkable economic, social, and emotional impact. It is important to identify potential risk factors in order to prescribe individualized corrective exercise programs to prevent future injuries. Although 3D motion capture is the "gold standard" for recording and analyzing functional tasks, 2D motion capture can be considered a more reasonable, inexpensive, and portable option for assessment and analysis in large pre-participation screenings. Limited studies compare 2D quantitative measurements to the 3D gold standard during functional tasks. Objective: To compare kinematic measurements in the frontal and sagittal planes between 2D and 3D analyses during a single leg squat. Design: Descriptive laboratory study Setting: Laboratory Patients or Other Participants: 26 healthy, recreationally active adults (22.26 ± 2.99 y, 1.70 ± 0.12m, 67.43 ± 14.24kg) participated. Interventions: Participants performed 3 trials of the single leg squat task, which were recorded simultaneously by 2D video cameras and a 3D motion capture system. 3D joint kinematics were integrated with Motion Monitor software. 2D videos processed with Kinovea software. Main Outcome Measures: Dependent variables were joint displacement at the trunk, hip, knee, and ankle in the frontal and sagittal planes. Bland-Altman plots with 95% limits of agreement (LOA) were used to evaluate agreement between 2D and 3D measurements for each dependent variable. Pearson correlation coefficients were utilized to assess relationships between mean 2D and 3D displacement measures at the trunk, hip, knee, and ankle in the frontal and sagittal planes. Results: Bland-Altman plots

revealed agreement in the average mean difference (AMD) between 2D and 3D in the sagittal plane at the trunk (1.68°; LOA -54.45 to 57.81), hip (2.60°; LOA -15.48 to 20.68), knee (0.74°; LOA -9.70 to 11.19), and ankle (3.03°; LOA -8.89 to 15.14). Agreement in the frontal plane at the trunk (7.92°; LOA -6.65 to 22.50), hip (-6.72; LOA -21.90 to 4.45), knee (-6.62; LOA -29.83 to 16.59), and ankle (3.03°; LOA -7.96 to 14.02) was not as strong. Dependent variables at the trunk, hip, knee, and ankle were all significantly correlated between the two measures in the sagittal plane ($r^2$ = 0.51-0.93), and and at the knee in the frontal plane ($r^2$ = 0.31) at $p < 0.05$. Conclusions: A close relationship exists between quantitative measurements of joint displacement between 2D and 3D analyses in the sagittal plane, and at the knee joint in the frontal plane. The AMD between the two measures was less than 4 degrees at each joint in the sagittal plane, and less than 7 degrees in the frontal plane. We did notice quite wide LOA at the trunk, which could be the result of transverse plane motion. While 2D measurements are not as precise as an electromagnetic tracking system and cannot determine rotation, they may provide a more clinically applicable method of evaluating joint displacement.

### Relationship Between Single Leg Squat Scoring System and Lower Extremity Kinematics

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**Context:** The ability to assess abnormal movement patterns during a functional assessment has become increasingly important when screening for lower extremity injury risk. The single leg squat (SLS) is a foundational task that has been used to identify faulty lower extremity mechanics, however an observational scoring system is needed for clinical implementation. **Objective:** To evaluate the reliability and validity of an objective scoring system for the single leg squat. **Design:** Descriptive laboratory study **Setting:** Laboratory **Patients or Other Participants:** Nineteen healthy and recreationally active volunteers (22.6 ± 6.6 y, 1.7 ± 0.1m, 66.4 ± 9.5 kg). Thirty-eight knees were independently analyzed. **Interventions:** Three trials of a SLS task were performed bilaterally and recorded simultaneously by 2-dimesional (2D) standard video cameras (one positioned in the frontal plane, one positioned in the sagittal plane) and a 3-dimensional (3D) motion capture system. 2D videos were subsequently scored with 10 objective criteria by two raters, who were blinded from each other's scores. Rater 1 scored a subgroup of randomly selected videos (10) during a second session, and was blinded from the scores assigned during session one. 3D joint kinematics were integrated with Motion Monitor software. **Main Outcome Measures:** Dependent kinematic variables analyzed were peak joint angles at the trunk, hip, knee, and ankle in the frontal and sagittal planes, in addition to joint displacement. Subjects were divided into quartiles based on SLS performance. A one-way ANOVA was performed for each dependent variable, with group as the between-subject factor. To evaluate the intrarater and interrater reliability, intraclass coefficient (ICC) and standard error of measurement (SEM) values were calculated, using the ICC formula 2,1 and 2,k respectively. All analyses were performed with $\alpha = .05$ a priori. **Results:** The overall mean (SD) SLS score was 3.76 (1.20). Subjects who scored a total of 5 or more errors, showed significantly higher trunk flexion displacement (19.12 ± 8.87 vs. 11.49 ± 6.58 deg; $p < .05$), knee valgus displacement (11.21 ± 4.61 vs. 5.46 ± 3.24 deg; $p < .05$), and peak knee valgus angle (10.92 ± 4.50 vs. 3.32 ± 2.17 deg; $p < .01$) than those who scored 5 errors or less. No other significant differences were observed between groups. Intrarater reliability was excellent in both the sagittal (ICC2,1 = 0.96, 95% CI: 0.85 TO 0.99) and frontal (ICC2,1 = 0.93, 95% CI: 0.75 TO 0.98) plane scoring, and SEM values were 0.09 and 0.18 respectively. Interrater reliability was excellent in the sagittal plane scoring (ICC2,K =0.97, 95% CI: 0.85 TO 0.99), and strong in the frontal plane scoring (ICC2,1 = 0.86, 95% CI: 0.49 TO 0.97), and SEM values were 0.11 in both planes. **Conclusions:** This single leg squat scoring system may be appropriate in observing errors in those who display gross faulty movement patterns (i.e. ≥ 5 errors). This scoring system indicates that an increase in errors corresponds with poor lower extremity biomechanics. Further analysis is warranted to investigate whether differences exist between sexes.

## Ground Reaction Forces Are Predicted With Functional and Clinical Tests in a Healthy Collegiate Population

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**Context:** Injuries to the Anterior Cruciate Ligament (ACL) are common, costly and debilitating. Increased vertical and posterior ground reaction forces are associated with ACL injury. Without sophisticated laboratory measures, it is not possible to accurately predict these ground reaction forces. If a practical means to predict ground reaction forces existed, ACL injury risk could be identified and thus attenuated. **Objective:** This study aimed to generate models predicting ground reaction forces, an established predictor of ACL injury incidence, from practical functional and clinical tests. **Design:** Descriptive design. **Setting:** University motion analysis laboratory. **Patients or Other Participants:** Forty-two healthy, active college age individuals (21 females, 20.667 ± 1.461 years; 70.702 ± 2.363cm; 82.202 ± 7.606kg; 21 males, 21.571 ± 1.28 years; 65.524 ± 1.874cm; 64.190 ± 9.059kg) participated. **Interventions:** After assuring all participants met inclusion criteria and provided consent, lower extremity dominance was determined with drop landings. Individuals then had Fat Free Mass [FFM] determined from skinfolds and ankle joint dorsiflexion passive range of motion taken with a standard goniometer [DPROM]. Quality of lower extremity movement was evaluated using the overhead deep squat test [ODS]. Participants then performed the following tests in a counterbalanced order: Margaria-Kalamen [MK], Single Leg Triple Hop [SLTH], and isometric peak force for lateral hip rotation [HipLR], knee flexion and knee extension. The knee flexion and extension peak force data was used to calculate a flexion:extension peak force ratio [H:Q]. Stepwise linear regression models to predict the ground reaction forces were calculated using FFM, DPROM, ODS, MK, SLTH, HipLR, H:Q and sex as the predictors. Alpha levels for all analyses were set a-priori at P< .05. **Main Outcome Measures:** Peak vertical (GRFz) and posterior (GRFy) ground reaction forces were obtained from five, signal-averaged LE drop landings from 35cm height onto a forceplate. These forces were then normalized to the participant's Fat Free Mass [nGRFz and nGRFy]. **Results:** Step-wise linear regression analysis indicated that a significant nGRFz model occurred utilizing all independent variables (P= .048), but was most parsimonious with only SLTH and DPROM as predictor variables (Adjusted R2 = .274; P =.001). Use of all eight-predictor variables for nGRFy also resulted in a statistically significant result (P = .001) but the most parsimonious model occurred with only H:Q, FFM and DPROM (Adjusted R2 = .476; P < .001). **Conclusions:** Two models significantly predicted ground reaction forces from practical clinical measures and functional tests. One model predicted nGRFz from SLTH and DPROM, while one model predicted nGRFy from H:Q, FFM and DPROM. If validated, a practical method of predicting ground reaction forces would be available to identify those at elevated ACL injury risk.

## Is There a Relationship Between Single Leg Squat Performance and Y-Balance Test Anterior Reach Distance?

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Context: Y-Balance Test (YBT) anterior reach deficits have been associated with lower extremity injury. However, wide-scale implementation of the YBT is time intensive requiring leg length assessment, practice trials and three reaches per limb. Single leg squat (SLS) is a common clinical movement screen that utilizes simple performance categorization as excellent, average or poor, and requires only 90 seconds testing time. Both YBT and SLS require balance, ankle flexibility and high levels of neuromuscular control at the knee and hip. Understanding the relationship between the SLS and YBT could provide clinicians with information for selecting time-efficient screening tests. **Objective:** To examine group mean differences in YBT anterior reach distance by SLS performance group. **Design:** Cross-sectional Study. **Setting:** Military Entrance Processing Station (MEPS). **Patients or Other Participants:** U.S. Military Applicants (Male = 819, Female = 147). **Interventions:** U.S. Military Applicants (N = 966: Male = 819, 20.9 ± 3.1 yrs., 176.3 ± 7.1 cm, 75.7 ± 11.4 kg; Female = 147, 20.8 ± 3.0 yrs., 162.7 ± 6.9 cm, 60.7 ± 7.9 kg) from the Baltimore MEPS performed the SLS and YBT prior to entering military basic training. SLS performance was rated as Excellent, Average, or Poor based on rater's overall impression. YBT anterior reach distance (YBT-ant) was used for analysis. Separate sex-specific ANOVA and Tukey HSD post-hoc tests identified YBT-ant mean reach differences between SLS performance groups. Cohen's d was calculated to determine the magnitude of significant mean differences between groups. **Main Outcome Measures:** SLS overall impression; YBT-ant reach

(cm); performance group mean reach±-standard deviations; Cohen's d and 95% Confidence Intervals. **Results:** For males, SLS performance was rated as Excellent in 18.3% (n = 150), Average in 56.7% (n = 464), and Poor in 25.0% (n = 205) of applicants. Excellent, Average, and Poor performance for females was 7.5% (n = 11), 59.9% (n = 88), and 32.7% (n = 48), respectively. Mean YBT-ant reach was 57.5 ± 6.4cm for males and 53.7 ± 5.6cm for females. ANOVA revealed a significant group by YBT distance interaction for males ($F_{2,816} = 26.0$, $p < 0.001$), and a trend for females ($F_{2,144} = 2.9$, $p = 0.06$). Post-hoc testing for males showed significant mean reach differences between Excellent and Poor groups (59.4 ± 5.9cm v. 54.9 ± 6.5cm, $p < 0.001$; Effect Size/ES 0.72, 95% CI 0.50-0.94), and Average and Poor groups (58.0 ± 6.2cm v. 54.9 ± 6.5cm, $p < 0.001$; ES 0.49, 95% CI 0.33-0.66); while not significant, Excellent and Average group means trended towards significance (59.4 ± 5.9cm v. 58.0 ± 6.2cm, $p = 0.05$). **Conclusions:** Males rated as Excellent or Average on the SLS displayed significantly higher YBT-ant reach distances than applicants rated as Poor. Females displayed no mean YBT-ant reach differences between SLS groups, possibly due to the lower number of Excellent female performers - 92.5% displayed Average or Poor performance. Overall SLS categorization appears to be a reasonable surrogate for YBT reach distance for males, but not for females. More research is necessary to determine task similarities between these movements and whether the SLS could efficiently predict injury for mass settings.

## Functional and Psychological Benefits of Active Video Gaming in Chronic Ankle Instability


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**Context:** Active Video Games (AVGs) can offer variability to rehabilitation protocols. Existing research has found number of functional and psychological benefits (e.g., increased adherence, confidence, and mood) of using AVG's during rehabilitation. However little research has investigated the physical and psychological outcomes of AVG aided rehabilitation in young, active individuals. Similarly, no AVG rehabilitation studies have investigated its effectiveness in chronic ankle instability (CAI) rehabilitation. **Objective:** The purpose of this study was to examine functional and psychological outcomes of AVG aided balance rehabilitation for individuals with CAI. **Design:** Cohort **Setting:** Collegiate athletic training clinic. **Patients or Other Participants:** Twenty recreationally active individuals (9 Female, 11 Male; 22.7 ± 3.35 yrs; 172.5 ± 10.4cm; 81.5 ± 26.4kg) with CAI (score of >27 on the Cumberland Ankle Instability Index) were included. Exclusion criteria were concurrent lower extremity injury, pregnancy, or any condition affecting the vestibular system. **Interventions:** Participants were randomly assigned to the AVG or traditional (TRAD) balance training protocols for 4-weeks. The AVG group played selected games of varying difficulty on the Xbox Kinect™, all required single-leg balance. The TRAD group completed standard-of-care balance exercises. In each group, the ATC supervised the exercises 3-5 times per week **Main Outcome Measures:** Measures were completed at baseline, week-2, and at week-4. Functional measures included the Balance Error Scoring System (BESS), Star Excursion Balance Test (SEBT), and patient reported Foot and Ankle Ability Measure(FAAM) and its sport subscale (FAAM-S). Psychological measures were the Rehabilitation Adherence Measure for Athletic Training. Psychological Readiness to Return to Sports-scale, and the Brunel Mood-scale(completed every other day). Repeated measures ANOVA compared all dependent variables (except mood states) between the independent variables of group (AVG vs TRAD) and time (baseline vs week-4). The emergent changes in mood states throughout the rehabilitation were visually analyzed **Results:** All participants significantly improved BESS (Pre:11.6 ± 7.4; Post: 9.8 ± 5.8; $F_{1,17} = 5.427$, $p = .032$), SEBT posterior-medial (Pre: 79.1 ± 11.2; Post: 85.2 ± 10.9; $F_{1,18} = 14.834$, $p = .001$) and posterio-lateral (Pre: 70.4 ± 13.9; Post: 77.9 ± 11.9; $F_{1,18} = 17.943$, $p < .001$) , and FAAM-S (Pre:69.2 ± 18.7, Post: 85.2 ± 18.1; $F_{1,17} = 15.922$, $p = .001$). All participants' significantly increased their adherence to rehabilitation (Pre: 45.6 ± 4.1, Post: 51.9 ± 5.2; $F_{1,17} = 17.159$, $p = .001$) and confidence to return to play (Pre: 43.5 ± 8.5; Post: 49.8 ± 7.7; $F_{1,18} = 16.285$, $p = .001$) Adherence and confidence appeared to increase more in the AVG group, though it did not reach significance. No discernible changes in mood were seen over the course of the intervention between the groups. **Conclusions:** The AVG balance rehabilitation protocol produced comparable functional outcomes to traditional balance protocol. This information helps clinicians make informed decisions about novel rehabilitation strategies. The increased adherence and confidence to return to play results and in the AVG group warrants further study with a larger sample size and longer follow-up.


## Physicians' Perceptions on the Scope of Practice and Knowledge of Athletic Trainers


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**Context:** Athletic training is continually evolving as a health care profession. The relationship between athletic trainers (ATs) and physicians is not only a legal obligation but also a growing collaboration to improve patient care in a variety of athletic training settings. **Objective:** To determine if physicians understand the educational preparation, legal obligations, and scope of practice for ATs and to determine whether previous relationships and experience with ATs or athletics influences interprofessional perceptions. **Design:** Cross-sectional. **Setting:** Web-based survey. **Patients or Other Participants:** We recruited physician (MD, DO) participants (n = 169) via social media (3.0%, 5/169), professional organizations (4.1%, 7/169), and personal emails (92.9%, 157/169) to ATs and physicians. Respondents were typically male Medical Doctors (male=111/169, 65.7%, female 58/169, 34.3%; MD = 133/169, 78.7%, DO = 36/169, 21%). **Interventions:** We asked participants about their previous/current experiences working with an AT, and previous athletics experience. We used this data to categorize participants for comparison. **Main Measure Outcomes:** We asked participants about their degrees held, medical specialty, years practicing, primary state of practice, and gender. We then asked about the educational preparation, legal obligations, and scope of practice of an AT in their respective states (7 items). Finally, we asked participants about their interprofessional relationships with ATs using

a validated interprofessional collaboration (IPC) scale. We compared the knowledge scores between those with previous, current, or no previous experience and previous experience or no experience as an athlete with separate one-way analysis of variance. Significance was set at $p < 0.05$ a-priori. **Results:** Experience working with an AT significantly improved knowledge scores ($F2,162 = 17.401$, $p < 0.001$) where those currently working with an AT scored higher ($5.4 \pm 1.7$) than those who previously worked with an AT ($4.2 \pm 2.0$, $p = 0.034$) and those who had never worked with an AT ($3.3 \pm 2.2$, $p < 0.001$). Previous experience as an athlete and exposure to an AT also significantly improved knowledge scores ($F1,152 = 6.846$, $p < .010$) where those who had access to an AT while participating in athletics scored higher ($5.3 \pm 1.8$) than those who never had access to an AT participating in athletics ($4.4 \pm 2.1$). Those currently working with an AT also demonstrated more positive perceptions of interprofessional collaborations, particularly regarding understanding each other's responsibilities ($\chi^2 = 22.213$, $df = 6$, $p = 0.001$), sharing similar patient care approaches ($\chi^2 = 16.818$, $df = 6$, $p = 0.010$), consultation ($\chi^2 = 24.982$, $df = 6$, $p < 0.001$), cooperation ($\chi^2 = 36.361$, $df = 6$, $p < 0.001$), anticipating the need for one another ($\chi^2 = 33.600$, $df = 6$, $p < 0.001$), and sharing information ($\chi^2 = 30.762$, $df = 6$, $p < 0.001$). **Conclusions:** Physicians who have a current working relationship with an AT and those who had access to an AT as an athlete demonstrated significantly more knowledge about an AT's academic preparation, legal obligations, and scope of practice. Moreover, physicians currently working with ATs report more positive interprofessional collaborations. Therefore, exposure to an AT increases physicians' knowledge of athletic training.

## Current Practices of Certified Athletic Trainers Concerning Post Practice Fluid Intervention Strategies

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**Context:** Athletes' hydration habits during practice and research-developed educational interventions have been examined in previous literature. However, athletic trainers' (AT) clinical decision making and interventions to address hypohydration post practice have not been determined. **Objective:** Describe AT's current clinical decisions and fluid intervention strategies for hypohydrated athletes post practice. **Design:** Mixed-methods, survey design. **Setting:** NCAA Division I, II, and III, NAIA, and high school (HS). **Patients or Other Participants:** 354 ATs (male = 162, female = 175) responded. One thousand NATA members, meeting clinical setting requirements, were initially recruited (response rate = 250/1000, 25%). An additional 104 ATs were recruited via social media to diversify clinical settings. **Interventions:** A 7-question survey via Survey Monkey was utilized. The survey included questions on specific policies and management for hypohydrated athletes. The survey was developed by 3 content experts and 1 graduate student. The survey was piloted twice with local clinical ATs. ATs were emailed 3 times during the 6-week collection period. Frequency statistics (respondent number/354) were calculated for each question. **Main Outcome Measures:** After demographics, questions focused on the clinical decision process for fluid interventions, referral, currently used treatment interventions for hypohydrated athletes, and the existence of institutional hydration policies. **Results:** ATs represented all clinical settings, with 44% DI, 12% DII, 1% DIII, 33% HS, & less than 1% NAIA. ATs use either absolute (41.9%) or percent (49.5%) body mass changes to clinically decide if an intervention is warranted. Of the AT's who use body mass changes, 8.6% did not use a value to determine if an intervention was needed. Of those who use percent change in body mass, 31.9% use -3 to -4% and 4% use greater than a -5% change to decide if an intervention is needed. The majority (83.5%) indicate they share hypohydration levels, but do not refer, non-emergency hypohydration (84.9%) with sports medicine team members. The majority of ATs (56%) indicate they have written institutional policies in place for when an athlete is deemed hypohydrated. An overwhelming majority of ATs (97%) intervene with verbal education about rehydration, whereas only one-third (37%) provide specific amounts of fluids based on body mass changes. When fluids were provided for hypohydrated athletes, water and sports drinks were the two most common choices (97% and 92%, respectively). **Conclusions:** Currently, ATs commonly use -3% body mass change as a clinical decision basis for intervention. A majority of AT's indicated institutional policies are in place for hypohydrated athletes; they use easily accessible fluids (water and sports drinks), and verbal education as a fluid intervention. Two-thirds of AT's did not provide specific fluid amounts to hypohydrated athletes. ATs should use body mass calculations to make athlete-specific clinical decisions for fluid interventions.

## The Effect of Static Stretching and Joint Mobilizations on Clinician-Oriented Measures in Those With Chronic Ankle Instability

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**Context:** Joint mobilizations are used to restore arthokinematic motion, dorsiflexion range of motion (DFROM), and dynamic balance in those with chronic ankle instability (CAI). Stretching of the gastroc-soleus complex is also believed to improve several of these impairments. However, there is no evidence regarding the summative effects of combining these interventions to further enhance clinical outcomes for people with CAI. **Objective:** Determine the effect of a combined joint mobilization and static stretching intervention on talocrural arthrokinematics, DFROM, and dynamic balance in individuals with CAI. **Design:** Single-blinded, pretest-posttest design. **Setting:** Laboratory. **Patients or Other Participants:** Ten adults (5 male; age = 24.4 ± 4.7 years; height = 172.1 ± 11.3cm; weight = 76.2 ± 17.1kg) with self-reported CAI participated. Inclusion criteria consisted of a history of >1 ankle sprain, >2 episodes of giving way in the past three months, answering "yes" to >4 questions of Ankle Instability Instrument, scoring <24 on the Cumberland Ankle Instability Tool, and scoring >24 on the Godin Leisure-Time Exercise Questionnaire. **Interventions:** All subjects participated in a 4-week intervention in which they completed static stretching and joint mobilizations. The stretching intervention was completed daily at home and included two static stretches targeting the gastroc-soleus complex. Stretches were held for 30 seconds and repeated three times each. Six treatment sessions of joint mobilizations were completed in which participants received one minute of talocrural traction followed by four sets of Maitland Grade III anterior-to-posterior (AP) joint mobilizations which were two minutes each. DFROM was measured using the weight-bearing lunge test (WBLT) and dynamic balance was assessed with the anterior reach direction of the Star Excursion Balance Test which was normalized to leg length (SEBT-AR). Talocrural arthrokinematics were measured using an instrumented ankle arthrometer to assess anterior and posterior ankle displacement. For each measure, three pre-intervention and post-intervention trials were averaged for analysis. **Main Outcome Measures:** The independent variable was time (pre-intervention, post-intervention). The dependent variables were scores on the WBLT (cm), SEBT-AR (%), and anterior and posterior ankle displacement (mm). Pre-intervention and post-intervention differences for each dependent variable were examined with t-tests and Hedge's g effect sizes (ES). Alpha set a-prior at $p < 0.05$. **Results:** Significantly improvements were identified in the WBLT post-intervention (Pre = 9.8 ± 3.60cm, Post = 11.2 ± 3.05cm, ES = 0.41, p = 0.007). However, no significant differences were identified for the SEBT-AR (Pre = 73.06 ± 7.72%, Post = 75.09 ± 6.53%, ES = 0.27, p = 0.081), anterior ankle displacement (Pre = 8.63 ± 2.01mm, Post = 9.35 ± 2.49mm, ES = 0.30, p = 0.459), or posterior ankle displacement (Pre = 8.34 ± 2.13mm, Post = 8.54 ± 2.42mm, ES = 0.09, p = 0.808). **Conclusions:** A 4-week joint mobilization and static stretching intervention resulted in DFROM improvements in individuals with CAI. These results suggest that joint mobilization and stretching could be applied to patients with CAI to help restore mechanical deficits. However, the combined intervention did not produce changes in the postural control or ankle arthrokinematics.

### Investigation of Provisional Medical Care in the Public Secondary School Setting


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**Context:** Employment of full and part-time athletic trainers (ATs) in public secondary schools has risen to approximately 70%, however employment of other caregivers presents a barrier to continued growth. **Objective:** Determine who is providing medical care for public secondary school athletes during practices and games in schools where an athletic trainer (AT) is not employed. **Design:** Mixed methods design. **Setting:** Phone and email survey of all 14,951 public secondary schools, which include grades 9-12 in the US during September 2011 - December 2013. **Patients or Other Participants:** Athletic directors (ADs) or principals were contacted up to 4 times to describe the medical coverage at home athletic events in lieu of an AT. **Data Collection and Analysis:** Interventions: Semi-scripted phone interviews, or emails upon request, were delivered to administrators nationwide, which included questions about the types of medical caregivers employed for athletic coverage by schools which reported no employment of ATs. Answers were categorized by type of employed medical caregiver, and quotes were used to describe each category. Descriptive statistics were used to analyze the categories, and quotes were reviewed for major themes. **Main Outcome Measures:** Categories included: no caregiver (which included coaches and other uncertified/volunteer medical care), emergency medical services (EMS), physician, first responder (FR), nurse, physical therapist, physician assistant, and chiropractor. **Results:** 26% (n = 2,180/8,509) of schools reported no employment of an AT. Of those schools, 25.3% (n = 552/2,180) reported no caregiver hired for athletic events. All volunteer medical care was categorized as no caregiver, as they have limited responsibility and liability. In reference to a volunteer AT, an AD from South Dakota stated, "Why would we employ one if they volunteer?" Of schools, which employed a caregiver (n = 1,628/2,180), EMS coverage was more common than all other types of caregiver (80.4%, n = 1,309/1,628). Physician (16.7%, n = 272/1,628), FR (9.6%, n = 156/1,628), physical therapist (3.3%, n = 53/1,628), and nurse (2.9%, n = 48/1,628) represented a small proportion of the caregivers. PA (0.7%, n = 11/1,628) and chiropractor (1%, n = 16/1,628) coverage were the least common of all types of caregivers. More than one type of caregiver was employed at 13.7% (n = 223/1,628) of schools. Ads overall misunderstood the role of an AT, exemplified by one from Washington who stated, "Coaches have the training so we don't need an official AT." **Conclusions:** Coverage by EMS provided the majority of medical care for secondary school athletes in lieu of an AT, followed by physician and FR. While ATs provide care specifically for the physically active, other caregivers maybe less versed the needs of athletes. It appears that administrators are naïve to the role of ATs, and thus hire alternative medical care. These results provide us with context as we continue to educate ADs and other administrators on athletic training and appropriate care for secondary school athletes.

### Temporal Neuromuscular Quadriceps Dysfunction Occurs Bilaterally in Patients Following Unilateral Anterior Cruciate Ligament Reconstruction


Gabler CM, Pietrosimone BG, Johnson DL, Mattacola CG: University of Kentucky, Lexington, KY, and University of North Carolina at Chapel Hill, Chapel Hill, NC


**Context:** Persistent quadriceps weakness and inhibition are two of the most prominent deficits observed in the involved limbs of patients after ACL reconstruction (ACLR). Therefore, the majority of attention is placed on that limb during rehabilitation. However, compiling evidence suggests that these deficits also reside in the uninvolved limbs, making them vulnerable to injury upon returning to sport. **Objective:** To examine the extent and progression of bilateral quadriceps weakness and inhibition in patients before and after ACLR. **Design:** Prospective cohort. **Setting:** Musculoskeletal laboratory. **Patients or Other Participants:** 13 patients (3 males, 10 females; age = 18.4 ± 3.9 years; height = 167.4 ± 11.7 cm; mass = 66.2 ± 9.8 kg) diagnosed with ACL injuries and scheduled to undergo unilateral ACLR volunteered to participate in this study. **Interventions:** Laboratory assessment of neuromuscular quadriceps function were performed on both limbs (LIMB) of patients before ACLR, and at 3 and 6 months (TIME) post-ACLR. **Main Outcome Measures:** Peak isometric knee extension torque (PKET) and voluntary quadriceps activation (VQA) were the main outcome measures of neuromuscular quadriceps function. Bilateral torque and activation measurements were performed on an isokinetic dynamometer with patients' knees fixed at 90° of flexion. PKET was captured during each patient's maximal voluntary isometric contraction (MVIC), and

then normalized to their bodyweight (Nm/kg). A superimposed burst (SIB) technique was used to assess VQA by superimposing a train of electrical stimuli once the patient reached PKET during MVIC. A central activation ratio (CAR) was then used to quantify VQA [CAR = (SIB torque /MVIC torque) 100] as a percentage. CAR less than 95% has previously been used to classify patients with quadriceps inhibition. Two-way repeated measures ANOVAs (LIMB x TIME) were employed to assess differences in the outcome measures ($P<0.05$). **Results:** PKET was significantly lower in the involved versus uninvolved limbs of patients before ACLR ($2.7 \pm 0.7$ vs. $3.3 \pm 0.5$ Nm/kg, $p < 0.01$), and at 3 ($1.5 \pm 0.7$ vs. $3.1 \pm 0.4$ Nm/kg, $p < 0.001$) and 6 months post-ACLR ($1.8 \pm 0.7$ vs. $2.8 \pm 0.5$ Nm/kg, $p < 0.001$). PKET significantly decreased at each time point in the involved limb ($p < 0.02$), and in the uninvolved limb between pre-ACLR and 6 months post-ACLR ($p < 0.01$), and between 3 months and 6 months post-ACLR ($p < 0.05$). CAR was not significantly different between involved and uninvolved limbs before ACLR ($90.6 \pm 8.7$ vs. $88.1 \pm 8.6\%$, $p < 0.05$) or at 6 months post-ACLR ($90.2 \pm 11.2$ vs. $88.5 \pm 9.3\%$, $p < 0.05$), but it was significantly higher in the involved versus uninvolved limb at 3 months post-ACLR ($94.5 \pm 6.2$ vs. $88.1 \pm 6.9\%$, $p < 0.02$). Quadriceps inhibition was present in both limbs of patients (CAR < 95%) at each time point, but there were no significantly changes observed over time ($p > 0.05$). **Conclusions:** Quadriceps weakness and inhibition are known to persist in the involved limbs of patients following ACLR, but our findings further demonstrate that these deficits are present in the uninvolved limb. Therefore, the importance of high intensity quadriceps exercise should be emphasized on both limbs during rehabilitation.

### The Impact of Osteoarthritis Following Knee Surgery on Knee Function in Former Collegiate Athletes

Simon JE, Grooms DR, Docherty CL: Ohio University, Athens, OH, and Indiana University, Bloomington, IN

**Context:** A major knee injury may not only lead to an interrupted athletic career, but also to the development of knee osteoarthritis (OA) and limited function later in life. **Objective:** Identify the consequences of knee surgery in a cohort of former collegiate athletes. **Design:** Cross-sectional **Setting:** Athletic training laboratory **Patients or Other Participants:** One hundred individuals met the following inclusion criteria: between the ages of 40-65 and participated in an NCAA Division I sport (60 Males, 40 Females, $53.13 \pm 7.42$years). Individuals were split initially into two groups: no history of knee injury requiring surgery (33 Males, 24 Females, $54.53 \pm 5.95$ years), and history of knee injury requiring surgery in college (n = 43). The history of knee injury requiring surgery in college was further broken into two groups: history of knee surgery in college with no diagnosis of OA later in life (n = 10/43; 4 Males, 6 Females, $51.26 \pm 7.29$ years), and history of knee surgery in college with physician diagnosed OA later in life (n = 33/43; 23 Males, 10 Females, $54.21 \pm 7.64$ years). **Interventions:** All individuals completed the Knee injury Osteoarthritis Outcome Score (KOOS), and the SF-36v2 to evaluate their current global and knee HRQL. The mean follow up time after the index injury was 27 years (range 19-42years). The KOOS measures knee function and health, and has five subscales (KOOS-Pain, KOOS-Symptom, KOOS-ADL, KOOS-Sport/Recreation, and KOOS-QOL). The SF36v2 is a patient-reported survey of general HRQL, and has two summary scores: physical (PCS) and mental (MCS). Lower scores for the SF36v2 and KOOS indicate more disability (range 0-100). A MANOVA was conducted for the dependent variables: PCS, MCS, and five KOOS scales with the independent variable group (healthy knee, surgical knee, and surgical knee/OA). Follow-up univariate analysis of variance and pairwise comparisons were conducted on any significant findings. The alpha level was set at $p<0.05$ for all analyses. **Main Outcome Measures:** PCS, MCS, KOOS-Pain, KOOS-Symptom, KOOS-ADL, KOOS-Sport/Recreation, and KOOS-QOL scores. **Results:** Self-reported knee disability was significantly worse in the surgical knee/OA group, compared to the healthy knee group, and the surgical knee group ($F(7,91) = 12.96$, $p = 0.001$, Wilk's $\lambda = 0.43$). There were no significant differences on any of the scales between the healthy knee group and surgical knee group ($p > 0.05$). The largest differences were on the KOOS scales between the healthy knee and surgical knee/OA groups; with the surgical knee/OA group scoring worse on the scales. Specifically, the KOOS-QOL, KOOS-Sport/Recreation, and KOOS-Symptom with a mean difference of 52.75, 43.68, and 30.43, respectively. **Conclusions:** A majority of individuals who had a knee surgery in college did develop OA. Functional limitations were observed in individuals who sustained a knee injury requiring surgery and developed OA. These findings support increased efforts toward prevention and better treatment and outcomes of knee injury.

## Influence of Psychological State Including History of Anxiety and Depression on Collegiate Student-Athletes' Baseline Concussion Assessment Tools

Weber ML, Hoffman NL, Miller EH, Schmidt JD: The University of Georgia, Athens, GA

**Context:** A small, but clinically important, percentage of student-athletes suffer from diagnosed anxiety and depression. Presence of anxiety and/or depression and a student-athlete's psychological state at the time of assessment may influence baseline concussion assessment performance. **Objective:** 1) To determine whether baseline concussion assessments differ between individuals with and without a history of anxiety or depression. 2) To determine whether baseline concussion assessments correlate with psychological state assessment. **Design:** Cross-sectional. **Setting:** Clinical Research Laboratory. **Patients or Other Participants:** A total of 340 Division I collegiate student-athletes (males = 162, females = 173, unreported = 6; height = 183.1 ± 98.3 cm, mass = 77.6 ± 19.8 kg, age = 19.9 ± 1.3 years). **Interventions:** Participants completed a demographic form, a psychological state assessment (Brief Symptom Inventory-18 – BSI-18), and the following baseline concussion assessments: the Balance Error Scoring System (BESS), symptom evaluation (from SCAT3), the Standardized Assessment of Concussion (SAC), and a neurocognitive assessment (CNS Vital Signs, CNSVS). **Main Outcome Measures:** Baseline concussion measures included the BESS total error score, the total symptom severity score, the SAC total score, and the following CNSVS standard scores: verbal memory, visual memory, psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, and executive function. Participants that reported anxiety (n = 9) and depression (n = 20) were matched to control participants based on gender, age, and concussion history. Participants (n = 6) with both anxiety and depression were included in each group analysis. Baseline concussion assessment scores were compared between individuals with a history of anxiety, and then depression using a one-way ANOVA ($\alpha = 0.05$). Pearson's correlations were used to assess the relationship between the psychological state assessment subscores of anxiety, depression, and somatization and baseline concussion measures ($\alpha = 0.05$). **Results:** We did not observe any significant differences in baseline concussion assessments between individuals with and without anxiety or depression. Individuals with a history of anxiety displayed higher BSI-18 subscores (depression: 7.0 ± 7.5; anxiety: 6.6 ± 7.6; somatization: 3.0 ± 2.8) compared to individuals without a history of anxiety (depression: 0.4 ± 0.7, $p = 0.019$; anxiety: 0.3 ± 0.7, $p = 0.026$; somatization: 0.5 ± 1.1, $p = 0.024$). Individuals with a history of depression displayed a trend towards higher BSI-18 subscores (depression: 3.3 ± 4.9, anxiety: 3.4 ± 1.4, somatization: 2.5 ± 2.8) compared to individuals without a history of depression (depression: 1.1 ± 1.9, $p = 0.065$; anxiety: 1.4 ± 1.9, $p = 0.063$; somatization: 1.4 ± 2.2, $p = 0.145$). We observed a moderate positive relationship with all BSI-18 subscores and total symptom score (depression: $r = 0.39$, $p < 0.001$; anxiety: $r = 0.44$, $p < 0.001$; somatization: $r = 0.40$, $p < 0.001$) and a weak positive relationship between somatization and BESS total errors ($r = 0.12$, $p = 0.03$). No significant relationship was observed between the BSI-18 subscores and SAC total score or CNSVS domains. **Conclusions:** The BSI-18 may be useful for assessing psychological state among collegiate athletes with history of anxiety and depression. Although the BSI-18 and symptom evaluations are different measures, similar information is gained from each. Higher reported somatization may weakly relate to poorer balance performance.

### Clinical Education Supports Transition to Practice in Professional Master's Athletic Training Programs

Bowman TG, Mazerolle SM, Barrett JL: Lynchburg College, Lynchburg, VA, and University of Connecticut, Storrs, CT

**Context:** A critical component to the future of the profession is the ability of students to transition into professional practice. There is a paucity of research on professional master's (PM) students' transition to practice and readiness to provide autonomous care. This information is critical, as it can help programs as they begin to evaluate their new curriculums and delivery of educational experiences to incorporate specific mechanisms as a means to support transition to practice. **Objective:** Examine how PM Athletic Training Programs (ATPs) help prepare students to transition to practice as entry-level clinicians. **Design:** Qualitative study. **Setting:** Professional master's athletic training programs. **Patients or Other Participants:** 16 PM students, 8 program directors and 5 PM athletic training faculty members allowed for data saturation. Students averaged 25 ± 3 years of age, while program directors and faculty members were 45 ± 9 years old. The faculty and program directors reported 22 ± 8 years of experience as athletic trainers and 12 ± 7 years of experience in ATPs. **Data Collection and Analysis:** We used an online questionnaire via Qualtrics for data collection and analyzed the data using an inductive technique. Participants responded to a series of open-ended questions related to the structure and curricular offerings of the PM ATPs. Questions reflected the role the participant played in the ATP. A small pilot study was conducted prior to data collection. We secured trustworthiness through data source triangulation, multiple analyst triangulation and peer review. **Results:** We found that students and faculty identified clinical education as the major facilitator in the socialization process used to help prepare students to transition into clinical practice. Clinical education was viewed as the foundation for growth and role understanding. From this major finding, three subthemes emerged. Both stakeholder groups felt that students gain experience through comprehensive clinical education experiences and mentorship from preceptors that allow students to develop confidence and feel prepared to enter the profession. That is, diverse experiences in the clinical education component allowed for role understanding, which can facilitate transition into careers as athletic trainers. Mentorship provided within the clinical education experience also allowed for skill development, which is critical for transition to autonomous practice. Finally, students were able to develop confidence and feel prepared to enter clinical practice due to the opportunities provided by their ATPs to gain experience during clinical education. **Conclusions:** Professional master's programs provide clinical education experiences that are designed to help students gain the skills and confidence necessary to become autonomous practitioners. Diversity and mentorship founded these clinical education experiences, which facilitated confidence and preparedness. Our findings illustrate that students need the chance to engage in their future roles and require mentoring to succeed in the future, which can be accomplished in PM ATPs.

### Newly Credentialed Athletic Trainers Transition During the First Nine Months of Clinical Practice: A Six-Month Follow Up Interview

Walker SE, Mazerolle SM, Thrasher AB: Ball State University, Muncie, IN; University of Connecticut, Storrs, CT; Arkansas State University, Jonesboro, AR

**Context:** Transition-to-practice is a process of professional growth as one adapts to a new role and typically lasts throughout the first year or longer of clinical practice. Research has yet to explore the experiences as newly credentialed athletic trainers move through the first year of this transition. Understanding this transition could lead to initiatives employers could implement to enhance this process. **Objective:** Explore the transition to practice of newly credentialed athletic trainers approximately nine months into clinical practice. **Design:** General inductive qualitative. **Setting:** NATA employment settings. **Patients or Other Participants:** 13 athletic trainers certified between January and September 2013 participated (8 female, 5 male; aged 23.85 ± 2.64 years; work settings included college, high school, clinic, and other). Participants initially completed a phone interview during the first 3-5 months of certification, and then completed follow-up interviews 6 months later. Data saturation guided the number of participants. **Data Collection and Analysis:** Phone interviews were conducted using a semi-structured interview guide and were audio recorded and transcribed verbatim. Data were analyzed using the general inductive approach, with data coded for common themes and subthemes. Credibility was established via member checks, peer review, and intercoder reliability. **Results:** Two major themes emerged regarding our participants transition: building relationships with constituents

and development of self-efficacy. Participants described developing relationships with coaches, peers, parents and patients over these first few months at their setting. Participants developed trust from constituents by showing dedication to their patients, which in turn garnered trust from patients, parents, and coaches. While these relationships developed, participants gained an understanding of diverse personal characteristics and communication styles (e.g., texting vs. email vs. in person conversations) needed to successfully interact with constituents. Over time, participants felt more comfortable and supported due to these relationships. As participants provided the appropriate care and learned to communicate effectively with coaches, parents, and patients, they developed self-efficacy. Participants also developed self-efficacy by making correct decisions and trusting themselves as clinicians as they transitioned. That is, through being actively engaged as an autonomous practitioner they developed competence and confidence. Additionally, receiving feedback and the trust from previously identified constituents, mentors, and peers regarding their decision-making resulted in increased confidence. **Conclusions:** As newly credentialed athletic trainers transition into clinical practice, they should begin to develop relationships with various individuals at their setting. Not all individuals prefer the same mode of communication (e.g., texting, email, phone) and determining proper communication methods for patients, parents, and coaches will assist with building relationships as well as enhancing comfort in their role. Showing dedication and commitment to patients will also help develop relationships. Feedback from legitimizing agents such as peers and mentors also proved to help our participants gain the confidence for clinical practice.

## Examining Support Received During the Transition to Practice for the Secondary School Athletic Trainer

Kirby JL, Walker SE, Mazerolle SM: Ball State University, Muncie, IN, and University of Connecticut, Storrs, CT

**Context:** Transitioning into clinical practice can be stressful for the newly credentialed athletic trainer (AT). The support provided by mentors, peers, and athletic training faculty can increase the confidence of the AT. The perspective of those in the secondary school setting is needed to create specific initiatives for a smoother transition. **Objective:** Examine the transition-to-practice and mentorship of newly credentialed ATs providing medical care in the secondary school setting. **Design:** General inductive qualitative. **Setting:** Secondary school setting. **Patients or Other Participants:** 17 (2 males, 15 females, age 23.0 ± 2.0 years) ATs participated in our study. Participants were employed in the secondary school setting through graduate assistantships (14) or full-time employment (3), had been credentialed less than one year, and completed professional bachelors' degree programs. **Data Collection and Analysis:** We completed 17 semi-structured phone interviews. Interviews were recorded and transcribed verbatim. Two researchers independently following the stepwise progression of a general inductive approach completed data analysis. Trustworthiness was established through multiple analysis triangulation, peer review, and member checks. Data saturation was confirmed at 17 interviews. **Results:** Two major themes emerged regarding the support received by our participants: past mentors and current networks of professionals. Past mentors, which was comprised of two sub-themes, refers to those preceptors who mentored our participants during their professional education. These past mentors provided autonomous learning opportunities during clinical education and now serve as a resource for guidance and advice. Participants also reported the ATs they interacted with while in high school clinical education experiences now provide guidance and support as they transitioned into the high school setting. Current networks of professionals was defined by 3 subthemes and refers to individuals such as graduate athletic training faculty, peer graduate students, and the community members within the secondary school setting (i.e. athletic director, coaches, parents). These individuals served as mentors and provided support as participants transitioned into clinical practice. Some participants said they considered building relationships with athletes, coaches, administrators, and parents as enjoyable, and others described building those relationships as successes. **Conclusions:** Our results highlight the importance of mentoring during transition to practice and the support it can provide to the newly credentialed AT. Former preceptors and faculty provide resources and support to facilitate transition and help develop confidence. Preceptors should allow for increased independence as a means to help their students develop as clinicians. The development of networks within the community, that is, the secondary school itself, is also critical in the transition as it provides the AT with role legitimation.

## An Exploratory Analysis of Transition-to-Practice Support Provided by Employers of Newly Credentialed Athletic Trainers in the College/University Setting

Henning JM, Pike AM, Walker SE: High Point University, High Point, NC, and Ball State University, Muncie, IN

**Context:** Newly credentialed athletic trainers (ATs) often transition from student to practicing clinician through the role of a graduate assistant (GA) or intern. This transition-to-practice phase is common; however, little is known about how GAs/interns are supported by employers during this role transition. **Objective:** To describe characteristics of GA/intern positions, describe the types of on-the-job training/orientation provided; and identify employers' expectations for mentoring GAs/interns. **Design:** Cross sectional online survey. **Setting:** College/university setting. **Patients or Other Participants:** 144 participants were identified as the contact person for a GA or internship posted on the NATA Career Center between February - August 2013. 44 (31%) ATs responded (30 males, 14 females; 16.01 ± 8.57 years certified). **Interventions:** Participants completed an online survey of 11 employer/supervisor demographic questions (e.g., years of experience), 10 items describing the advertised position(s) (e.g., sport assignment, type of on-the-job training/orientation), and14 items regarding how often (1 = never, 5= very frequently) they anticipated providing formal mentoring for clinical situations (e.g., head injury evaluation). Content validity was established by a panel of experts. **Main Outcome Measures:** Descriptive statistics (frequencies, percentages, means, standard deviations) were calculated on each survey item. An independent samples t-test compared NCAA division groups and frequency of mentoring. Alpha level was set at $P < 0.05$. **Results:** Not all participants answered every question. Participants represented institutions (21 NCAA Division I institutions and 20 non-NCAA Division I) that offered 156 positions (113 GAs, 3.65 ± 2.42 per institution, 43 internships, 2.87 ± 1.45 per institution). 24 (55%) participants reported that salaries offered were < $10,000 and the most common employment benefits were professional membership dues (n = 25, 54%) and professional licensure fees (n = 21, 46%). The most frequent sports assigned were: men's/women's cross country/track and field (n = 72), women's volleyball (n = 27), softball (n = 27), and football (n = 23). The most common forms of formal on-the-job training/orientation focused on athletic training policies and procedures (n = 39, 89%), availability of supervisor (n = 36, 82%), institutional policies and procedures (n = 35, 80%), and the least common were conducting chart reviews of patient progress (n = 15, 34%) and participating in grand rounds (n = 3, 7%). Participants perceived that 32.72% ± 19.06 of their job was spent mentoring GAs/interns and 31 (70%) reported providing informal mentoring. Participants anticipated having to provide formal mentoring in clinical situations only on an occasional basis (2.59 ± .81-3.20 ± .98) with the greatest expectation during clinical examination of a head injury (3.20 ± .98) and determining when referral to another healthcare provider is appropriate (3.20 ± .95). Participants anticipated mentoring less frequently for the skills of evaluating and managing emergent injuries/condition (2.82 ± 0.92) and applying equipment, taping/wrapping, or other devices (2.59 ± 1.06).There were no significant differences in mentoring expectations between NCAA division groups. **Conclusions:** While supervisors expect to provide guidance on an occasional basis, they are committing one third of their time mentoring newly credentialed ATs.

# Free Communications, Oral Presentations: The Role of the Organization on Professional Issues

Thursday, June 23, 2016, 11:45AM-1:15PM, Room 316; Moderator: R. Mark Laursen, MS, ATC

### Variation in Sports Medicine Staffing Across NCAA Power 5 Schools

Baugh CM, Kroshus E, Lanser BL, Lindley TR, Meehan WP III: Micheli Center for Sports Injury Prevention, Division of Sports Medicine, Boston Children's Hospital, Boston, MA; Interfaculty Initiative in Health Policy, Harvard University, Cambridge, MA; Department of Pediatrics, University of Washington, Seattle, WA; Seattle Children's Research Institute, Center for Child Health, Behavior and Development, Seattle, WA; Harborview Injury Prevention and Research Center, Seattle, WA; Department of Kinesiology-Athletic Training, University of Wisconsin-Madison, Madison, WI; Intercollegiate Sports Medicine, Northwestern University, Evanston, IL

**Context:** Previous research suggests insufficient staffing is associated with poor clinician job satisfaction and suboptimal implementation of concussion management protocols. Little is known about the staffing levels of college sports medicine groups. **Objective:** To examine the ratio of athletes per sports medicine clinician and determine whether staffing varies by number of athletes, athletics department revenues, and athletic conference. **Design:** Cross-sectional. **Setting:** Telephone, internet. **Patients or Other Participants:** Sports medicine departments at the 64 universities of NCAA Division I Power 5 conferences: Atlantic Coast, Big Ten, Big 12, Pacific-12, and Southeastern. Electronic data were gathered for all schools in the NCAA Power 5 (n = 64); telephone surveys were completed for 41 (64%) schools. **Interventions:** A telephone survey queried both the presence and full-time equivalence (FTE) of a variety of sports medicine clinicians providing care to athletes at each institution. Number of staff athletic trainers and athletic department revenues were gathered from publicly available online sources. All data was gathered between July and September 2015. Linear regression was used to examine the relationship between the number of athletic trainers and 1) the number of athletes, 2) the athletic department revenues, and 3) athletic conference. **Main Outcome Measures:** Ratio of athletes per staff athletic trainer; ratio of athletes per staff, graduate assistant, or certified intern athletic trainer. **Results:** The number of staff athletic trainers ranged from 7 to 20 across schools. Based on the telephone survey, all schools' sports medicine teams had staff athletic trainers, under half included certified intern athletic trainers (40.1%), and nearly three-quarters included graduate assistant athletic trainers (70.7%). Nearly all schools had physicians on the sports medicine staff, and all had one or more physicians available for on-site athlete care. The majority of schools included additional clinicians on their sports medicine team, with more than half employing a nutritionist or dietician, clinical psychologist, or chiropractor. The ratio of athletes per staff athletic trainer ranged from 21 to 114. When graduate assistants and certified interns were included in the denominator, the ratio ranged from 20 to 54 athletes per athletic trainer. The number of staff athletic trainers was significantly associated with the number of athletes ($p < 0.001$) and athletic department revenues ($p < 0.001$). Controlling for these two factors, schools within the Big Ten conference had significantly more staff athletic trainers, on average, than schools within any other Power 5 conference ($p < 0.001$). **Conclusions:** There was significant variability in clinician staffing across schools. More research is needed to quantify whether/how staffing patterns affect athlete injury outcomes or clinician job satisfaction. Research examining clinician staffing patterns outside NCAA's Division I Power 5 conferences is warranted.

### An Examination of Organizational-Professional Conflict in Athletic Training Practice Settings

Pitney WA, Mazerolle SM, Parsons J , Martinez J: Northern Illinois University, DeKalb, IL; National Collegiate Athletic Association, Indianapolis, IN; University of Connecticut, Storrs, CT

**Context:** Organizational-professional conflict (OPC) occurs when the organization's values and practices run counter to the values and practice standards held by professionals working in the organization. Recent media reports related to early return to play following concussion indicate that OPC can exist. **Objective:** To examine OPC in AT practice settings and the factors that contribute to its occurrence. **Design:** Cross sectional online survey. **Setting:** Collegiate and secondary school. **Patients or Other Participants:** 630 certified athletic trainers (325 (51.6%) female; 296 (47%) male; 9 (1.4%) undisclosed) with 13 ± 10 years of experience. A total of 4970 invitations to participate were delivered; response rate = 12.7%. **Interventions:** The OPC in AT Settings (OPCATS) scale was used to examine OPC. The OPCATS was adapted from a previously validated, 3 item scale (Cronbach's $\alpha = .77$). We added two additional AT medical-decision conflict items. Content validity was established with a panel of experts. The Cronbach's α, was .77. Demographics were collected along with individual's direct supervisor to determine the sports medicine practice model at the setting. For example, if a respondent was supervised by an athletic director or coach he/she was classified in a Sport Model (SM); if supervised by a medical director he/she was classified in a Medical Model (MM); if supervised by a department chair he/she was classified in an

Academic Model (AM). Main Outcome Measures: The OPCATS consisted of 5 items and responses of 1-trongly disagree to 7-strongly agree. The OPC score is a sum of the responses, thus scores can range from 5 (low score)-35 (high score). An ANOVA was used to examine differences in OPC score by practice model and practice setting. A correlation was performed to determine the relationship between years of experience and OPC. Our a priori α was <.05 for all analyses. **Results:** The Mean OPC score was 15.28 ± 6.25 indicating low-moderate OPC; the range, however, was 5-35. There was no difference in OPC by practice setting ($F_6 = .70$, $P = .65$). There was a significant difference between practice models ($F_7 = 2.46$, $P = .02$)—The LSD post hoc test revealed differences between the SM and MM, ($P = .03$); the AM and SM, ($P = .01$); and Combined SM/AM model, ($P = .02$). The M ± SD scores for the models were: SM = 14.32 ± 6.3; MM = 15.64 ± 6.1; AM = 16.95 ± 7.2; SM/AM = 17.43 ± 8.2; SM/MM = 14.96 ± 5.41. There was a weak, but significant negative correlation between years of experience and OPC $r = -.12$ ($P = .002$). **Conclusions:** Low to moderate levels of OPC were discovered in these practice settings with the SM having the lowest OPC mean score. Less OPC occurred as years of experience increased. Perhaps an increase in medical professionals' involvement in decision making may lead to an increase in OPC, or perhaps ATs not reporting to coaches and Athletic Directors do not identify as much with the sport culture and, thus, experience more conflict.

### Women Athletic Trainers in the Role of the Head Athletic Trainer in the Non-Division I Collegiate Setting

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

**Context:** Research suggests that women do not pursue leadership positions in athletic training due to a variety of reasons including family challenges, organizational constraints, and a reluctance to hold the position. Although the Division I collegiate level appears to create a barrier for women, the non-Division I setting seems to attract a greater number of women as head athletic trainers. However, literature is only focused on the Division I setting, limiting full understanding. **Objective:** Examine the experiences of women athletic trainers (ATs) currently employed as head athletic trainer and retroactively explore their path towards their current leadership position. **Design:** Qualitative study **Setting:** National Collegiate Athletic Association Division II, III settings. **Patients or Other Participants:** 77 women ATs employed as a head AT in the Division II or III levels participated in our study. Our participants were 38 ± 9 (range 24 to 57) years old and had an average of 14 ± 8 (range 1 to 33) years of athletic training experience. **Data Collection and Analysis:** We conducted online interviews (Qualtrics) with all participants. Participants journaled their reflections to a series of open-ended questions pertaining to their experiences as head ATs. The interview framework was previously used which provided credibility to the instrument. Data was analyzed following a general inductive approach. Credibility was secured by peer review and researcher triangulation. **Results:** We were able to identify three barriers and three facilitators regarding the experiences of women ATs in the role of the head AT in the non Division I setting. Three themes materialized to explain barriers to the role of head AT: sex, lack of women mentors, and motherhood were discussed as potential barriers and obstacles to assuming the role of head AT. Workplace atmosphere of the non Division I setting, having role models and mentors, and personal attributes were shared as facilitators to assuming the role of the head AT. **Conclusions:** Women ATs working in the Division II and III settings experience similar barriers and facilitators to assuming the role of the head AT as those working in the Division I setting. Being able to identify a career mentor and having certain individual skills were helpful in navigating their leadership role. Stereotyping still exists within college athletics, which may limit the number of women in higher ranking positions. Additionally, a lack of desire to hold a leadership position as well as the desire to have a balance between work and home inhibit some women from moving up. The non-Division I setting was viewed as less formidable for the women wanting to be in the role of the head AT because it was viewed as more manageable due to a reduction in the win-at-all cost mentality.

## Personality Characteristics, Burnout, and Job Satisfaction of Athletic Trainers

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**Context:** Identifying the personality profile of athletic trainers can help those in the field better understand each other and educate prospective students about the characteristics of individuals in their profession. Personality information is also useful for understanding differences within the profession in terms of job satisfaction and feelings of burnout. **Objective:** The goal was to determine the Big Five personality profile of athletic trainers, and to evaluate personality correlates of job satisfaction and burnout. **Design:** Cross-sectional study. **Setting:** Web-based survey. **Patients or Other Participants:** A total of 308 certified athletic trainers (age = 29.4 ± 9.6 years, 59% female) participated. The majority of participants had earned a master's degree (67%, n = 201) and the most common place of employment was the college/university setting (37%, n = 114). **Interventions:** Participants completed a 5-10 minute online survey that included demographic questions and the 44-item Big Five inventory used to assess broad personality characteristics. Short measures of job satisfaction and burnout were also completed. Subject recruitment occurred via email and social media distribution. **Main Outcome Measures:** The personality variables were Neuroticism, Extraversion, Openness to experience, Agreeableness, and Conscientiousness. Levels of job satisfaction and burnout were also included. Descriptive, correlation, and regression statistics were completed with an alpha level set aprior at .05. **Results:** The sample had a mean score of 4.17 ± .44 out of five points for Conscientiousness, followed by Agreeableness 3.98 ± .47, Openness 3.60 ± .48, Extraversion 3.51 ± .69, and Neuroticism 2.49 ± .60. Burnout and Job Satisfaction were negatively correlated (rho = -.37, $p < .001$). Conscientiousness (rho = -.25, $p < .001$) and Extraversion (rho = -.15, $p < .001$) were negatively with burnout whereas Neuroticism (rho = .25, $p < .001$) was positively correlated with burnout. Multiple regression analyses that found that Conscientiousness ($R2 = -.18$, $p < .001$) and Neuroticism ($R2 = .16$, $p < .001$) were significant independent predictors of burnout controlling for age and sex. Conscientiousness (rho = .23, $p < .001$), Agreeableness (rho = .21, $p < .001$), Extraversion (rho = .20, $p < .001$) were all positively correlated to job satisfaction, while Neuroticism (rho = -.19, $p < .001$) was negatively correlated. Multiple regression analyses found that Extraversion ($R^2 = .18$, $p < .001$) and Agreeableness ($R^2 = .16$, $p < .001$) were significant predictors of job burnout controlling for age and sex. **Conclusions:** Athletic trainers have a personality profile that is characterized by high Conscientiousness, low Neuroticism, and moderate levels of Extraversion, Openness to experience, Agreeableness compared to population norms. Conscientiousness and Neuroticism were the most significant correlates of burnout for athletic trainers, but these associations are small to moderate. Agreeableness and Extraversion were the most closely related personality traits to job enjoyment for athletic trainers. The findings may be useful for those who are considering athletic training as their future profession as it provides a better understanding of the personality profiles of athletic trainers. Individuals contemplating athletic training as a career might consider high Conscientiousness and low Neuroticism as important aspects of the personality profile of athletic trainers.

## Organizational Infrastructure in the Collegiate Athletic Training Setting: Benefits, Barriers, and Commonalities Among the Academic, Athletics, and Medical Models

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**Context:** Collegiate athletic training staffs are housed under three different organizational models: Academic, athletics, and medical. Anecdotal evidence suggests organizational infrastructure may impact the quality of life of athletic trainers (ATs). However, little is known about ATs' perceptions of the models, particularly as they relate to organizational hierarchy. **Objective:** Explore the perceived benefits, barriers, and commonalities among organizational models in the collegiate athletic training setting. **Design:** Mixed-methods study utilizing survey and qualitative methods. **Setting:** Full-time ATs employed in the collegiate setting. **Patients or Other Participants:** A criterion sample of 59 ATs (academic = 14, athletics = 25, medical = 20) age 36.3 ± 9.5, with 13 ± 9 years of experience completed our survey. Twenty-four (15 males, 9 females) ATs, 8 from each model, age 35 ± 10, with 13 ± 10 years of experience completed personal interviews with a researcher. **Data Collection and Analysis:** Quantitative data were collected via an online instrument containing 5-point Likert-scale and open-ended items measuring role strain, work-life balance, job satisfaction, and intent to stay. We analyzed this data using descriptives and a Kruskal-Wallis test. Qualitative data were collected via semi-structured interviews, and evaluated using a general inductive approach. Multiple analyst and data source triangulation, and peer review established credibility. **Results:** Participants in the athletics model worked more hours (69.6 ± 11.8; $p = 0.001$), were less satisfied with their pay (2.68 ± 1.07, $p = 0.021$), felt less support from

administrators (3.12 ± 1.13, p = 0.009), and had less intent to stay (3.2 ± 1.20, p = 0.028). Participants in the academic model felt less support from co-workers (3.71 ± 0.91, p = 0.033) and immediate supervisors (3.43 ± 0.94, p = 0.050). In the academic model, role congruence emerged as a benefit, while role strain and work-life conflict were barriers. Role conflict and role ambiguity for new employees were subthemes within role strain. Athletic trainers in the academic model expressed inter-sender role conflict with coaches/administration and inter-role conflict with fulfilling multiple, overlapping roles. In the athletics model, benefits were role identity, and role congruence via relationship building and supervisor/physician support. Barriers were role strain, staffing, and work-life conflict. Role strain emerged as role incongruity within the athletics department and inter-sender role conflict with coaches/administration. In the medical model, role congruence and work-life balance emerged as benefits, while role conflict, specifically inter-sender role conflict with coaches, was a barrier. Three commonalities, communication, social support, and time management and work-life balance strategies emerged. **Conclusions:** Our findings suggest organizational structure does impact the collegiate AT's role in patient care and mediates varying sources of strain. The benefit of role congruence, and the barrier of role conflict with coaches/administration were expressed by ATs in all three models. Academic and athletics ATs expressed work-life conflict and multiple sources of role strain. Regardless of infrastructure, ATs needs to have time management skills, be effective communicators, and develop multiple support networks.

### Comparison of Athletic Trainer Stress and Job Satisfaction With Different Models of Care Delivery

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**Context:** Collegiate institutions have long held the "traditional" athletic training program model (TM-AT) in which athletic directors serve as the supervisor of the athletic training staff, with the ability to hire and fire, change assignments, and determine budgets. Recently a "medical" model of athletic training (MM-AT) service delivery has been introduced where athletic training services are an extension of university/college student health services. This model may provide a better work-life balance, limit conflicts of interest, elevate athletic trainer (AT) compensation and increase quality of patient care. **Objective:** The purpose of this study was to determine if differences exist in self-reported AT stress and job satisfaction between athletic trainers working in a TM-AT and a MM-AT for delivery of athletic training services. **Design:** A 1-time electronic survey administered via the Research Electronic Data Capture system (RedCap™). **Setting:** 8 NCAA DI institutions with comparable athletic programs. **Patients or Other Participants:** Full-time AT staff at those DI institutions: 76% (44/58) responded. **Interventions:** Respondents completed the self-administered, online, Institute for Collegiate Sports Medicine's (ICSM) College and University Athletic Trainer Stress Survey consisting of a 25-item survey. Each item had a 5-level response. A high score (0-100 scale) is associated with high stress and/or low job satisfaction. **Main Outcome Measures:** The responses were categorized according to type of model employed by the participant's institution and analyzed to identify differences in AT stress and job satisfaction between models. Independent t-tests were performed to compare scores. $\chi 2$ tests were performed to analyze responses between models for individual items. The results were also compared to pre-established reported responses to the same survey posted by ICSM (n = 114). **Results:** The mean TM-AT stress score (43.65) was significantly greater than the mean MM-AT score (32.43); $t(42) = 2.96$; $P = 0.005$. It was 7X more likely for a TM-AT to have a stress score ≥ 39 than an MM-AT, TM-AT 74% (17/23), MM-AT 29% (6/21). ICSM reports an even greater average stress score of 47.79 at comparable institutions without model specification. Response values for 5 survey items (too little pay, rapid program changes, denied breaks/lunch/sick leave/vacation, angry clients/disrespectful supervisors, and feeling underappreciated/used) demonstrated significant difference in professional satisfaction. A greater proportion of TM-AT reported job dissatisfaction compared to MM-AT. **Conclusions:** ATs who work in the TM setting are more likely to report greater work-related stress, and less likely to report job satisfaction than ATs who work in the MM setting. Survey responses suggest greater professional respect and more desirable work-life balance among MM-ATs. The results of this study strongly support a transition from TM to MM for improved job satisfaction, decreased working hours, and improved patient care.

### Visual Feedback Contribution to Postural Control

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**Context:** Maintaining postural control requires the processing of constantly changing visual feedback. Stroboscopic Vison (SV), intermittent obstruction of vision, employed in physical training has been shown to improve perceptual-cognitive performance and reaction time, but the effects of SV on postural control is unknown. **Objective:** To determine the effects of SV on postural control in unipedal stance. **Design:** Crossover. **Setting:** Laboratory. **Patients or Other Participants:** Eighteen healthy subjects without vision or balance disorders or lower extremity injury history (9 males, 9 females; age = 22.1 ± 2.1 years; height = 169.8 ± 8.5cm; mass = 66.5 ± 10.6kg) participated. **Interventions:** Subjects performed 3 trials of unipedal stance on their dominant limbs for 10 seconds with eyes open (EO) and closed (EC), and with SV that was completed with specialized eyewear that intermittently cycled between opaque and transparent for 100 milliseconds at a time. Balance tasks were conducted on both firm and foam surfaces, and the order of testing was randomized. **Main Outcome Measures:** Main outcomes were center of pressure excursion used to compute mediolateral (ML) and anterior-posterior (AP) velocity. Two repeated measures ANOVAs were conducted to compare ML and AP velocity respectively, between EO, EC, and SV conditions. Fisher's LSD tests were performed for post-hoc comparisons. The alpha level was set at <.05. **Results:** For both AP and ML velocity measures there were significant differences between the 3 visual conditions on both firm (ML:$F(2,34) = 37.72$, $p < .001$; AP:$F(2,34) = 26.80$, $p < .001$) and foam (ML:$F(2,18) = 24.08$, $p < .001$; AP:$F(2,18) = 22.92$, $p < .001$) surfaces. ML velocity was significantly greater with SV(1.34 ± .38sec) than EO(.78 ± .20sec), but less than EC(1.85 ± .74sec) on the firm surface. However, on the form surface, the ML velocity with SV(2.35 ± .82sec) did not differ from EC(2.52 ± .64sec) while they were both significantly greater than EO(1.13 ± .29sec). These same results were also found in the AP measures with SV(1.12 ± .45sec) greater than EO(.71 ± .16sec), but EC(1.69 ± .80sec) greater than both for the firm surface and SV(2.17 ± .76 sec) and EC(2.72 ± .87sec) not different, but greater than EO(.98 ± .23sec) for the foam surface. **Conclusions:** SV was found to disrupt postural control on both surfaces. On the firm surface, the effects of SV was significant but not to the extent as EC, however on the foam surface SV caused similar effects as EC. Direct visual disruption with SV may have the potential to be an adjunctive tool to balance training.

### Differences in Plantar Pressure During an Unplanned Transition Task in Individuals With Chronic Ankle Instability

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**Context:** Individuals with chronic ankle instability (CAI) have altered postural control and motor control strategies. However, most of the published studies evaluate postural control in a single static position or during a planned dynamic task. Little is known about the motor control strategies of those with CAI have during an unplanned task. **Objective:** The purpose of this study was to determine evaluate peak plantar pressure between those with CAI compared to controls during an unplanned transition task from a double-limb stance to a single-limb stance. **Design:** Cohort. **Setting:** Controlled laboratory. **Patients or Other Participants:** Eight individuals with self-reported CAI (5 males, 3 females, age = 20.38 ± 2.50 years, height = 165.26 ± 9.84 cm, mass = 79.69 ± 21.744 kg, previous sprains= 3.38 ± 2.92, Identification of Functional Ankle Instability (IdFAI) = 19.00 ± 4.92, FAAM Sport = 80.47 ± 10.22%) and 10 controls (4 males, 6 females, age = 21.80 ± 4.49 years, height = 168.15 ± 8.34 cm, mass = 67.95 ± 12.08 kg, previous sprains = 0.00 ± 0.00, IdFAI = .90 ± 1.91, FAAM Sport = 100 ± 0.0) volunteered. **Interventions:** Plantar pressure data were collected using an in-shoe pressure system. Subjects stood in a double-limb stance facing a screen. At a random time an arrow appeared on the screen indicating which limb the subject should transition onto. Subjects would transition to a single-limb stance and balance for 10-seconds following transition. Subjects performed the transition task on both a firm surface and a foam surface. **Main Outcome Measures:** Three successful trials in which subjects transitioned onto their involved limb were analyzed. Plantar

pressure was divided into 9 regions. For each region, peak plantar pressure from time of transition to 500ms post-transition was analyzed. The data from three successful trials were averaged. Trials on firm surface were analyzed separately. For each region and the entire foot, independent t-tests were conducted to determine differences between groups. Alpha was set a priori at $P < .05$. **Results:** On the firm surface, subjects with CAI had significantly higher peak plantar pressure in the middle forefoot (CAI = 123.2 ± 69.90 KPa; controls = 104.98 ± 28.38 KPa; p = .024) and significantly lower peak plantar pressure in the medial forefoot (CAI = 74.22 ± 16.11 KPa; controls = 201.75 ± 108.65 KPa; p = .042) regions compared to controls. On the foam surface, subjects with CAI had significantly higher peak pressure in the middle forefoot compared controls (CAI = 142.52 ± 88.93 KPa; controls = 86.79 ± 20.41 KPa; p = .015). No other regions for firm or foam surfaces were different between groups. **Conclusions:** During an unplanned movement, individuals with CAI tend to have increased lateral plantar pressure compared to controls. This indicates that those with CAI utilize different movement patterns compared to controls during an unplanned task.

## Visual Motor Control of Drop Landing Following Anterior Cruciate Ligament Reconstruction

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**Context:** Visual feedback is a crucial component to human motor control. When vision is obstructed, alterations in landing neuromuscular control are exhibited that may increase injury risk. However, due to limitations in visual obstruction technology, only simple movements without environmental interaction have been investigated, which lack generalizability and sport specificity. The development of stroboscopic glasses that disrupt vision without removing it allows visual-motor assessment during dynamic movements with target acquisition. No known research has considered the effect of stroboscopic visual feedback disruption (SVFD) on knee landing mechanics. **Objective:** To investigate SVFD effects on drop vertical jump landing with an in air target, and if injury history or gender influences these effects. We hypothesize that SVFD will alter landing kinematics and injury history will increase the SVFD effect. **Design:** Cohort study. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** 15 anterior cruciate ligament reconstructed (ACLR) individuals (7 males, 8 females, 21.41.5 ± 2.60 years, 1.72 ± 0.09 m, 69.24 ± 15.24 kg, Tegner activity level 7.30 ± 1.30, 36.18 ± 26.50 months post-surgery) and 15 matched healthy controls (7 males, 8 females, 23.15 ± 3.48 years, 1.73 ± 0.09 m, 69.98 ± 14.83 kg, Tegner activity level 6.77 ± 1.48) participated. **Interventions:** A three-dimensional passive optical motion capture system (Vicon, Los Angeles, CA) and two 40 x 60cm force plates (Bertec, Columbus OH) were used to capture kinematics and kinetics of all subjects. Participants performed a warm-up with the stroboscopic glasses and then 5 practice trials of a drop vertical jump. The drop vertical jump involved each participant falling forward from a 30cm box, then immediately performing a vertical jump, raising both arms to a target set at 90% of their maximum jump height (Vertec, Power Systems, Knoxville, TN). Three landing trials were then performed under normal and SVFD conditions. **Main Outcome Measures:** Peak knee flexion, abduction angles, moments and vertical ground reaction forces were calculated during the landing phase and compared across gender, ACLR, and side, with a repeated measures ANOVA a priori $p < .05$. **Results:** The change scores from full vision to stroboscopic for knee flexion (4.04 ± 2.20º, p = 0.048) and abduction angle (1.99 ± 1.53º, p = 0.001) were higher than previously reported within session error (3.2º flexion and 0.9º abduction). Kinetic and joint moment change scores from full vision to the stroboscopic condition were not greater than within session error. There was an effect for ACLR only for knee flexion angle (ACL: 3.12 ± 3.76º, CON: -0.84 ± 4.45º, p = 0.001). There was no effect of side or gender. **Conclusions:** SVFD alters sagittal and frontal plane landing knee kinematics, but not kinetics. ACLR may induce alterations in sagittal plane visual-motor control of the knee. The SVFD effect is comparable to effects brought about by an in-flight perturbation, motor learning feedback intervention, or a season long plyometric training program, indicating visual-motor ability may contribute to knee neuromuscular control on a clinically significant level.

### Balance Training Does Not Impact on Sensory Reweighing in Individuals With Chronic Ankle Instability: Systematic Review with Meta-Analysis

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**Context:** Individuals with chronic ankle instability (CAI) have known balance impairments. Recent research suggests these CAI associated balance impairments might be due to an inability to appropriately reweight sensory and/or somatosensory information. Indeed, individuals with CAI have been shown to place a greater emphasis on visual information while balancing than uninjured controls. Balance training has been shown to be an effective intervention at improving postural control and self-reported function in those with CAI. However, the effect of balance training on sensory reweighting remains unknown. **Objective:** To determine if balance training alters sensory reweighting, by reducing the emphasis on visual information, during the maintenance of postural control in those with CAI. **Data Sources:** We searched PubMed, CINAHL, SPORTDiscus, and Scopus databases from origin to October 2015 using the combination of key words including: neuromuscular training, balance training, coordination training, ankle instability, postural control. **Study Selection:** To be eligible, a study had to investigate the effects of balance training on instrumented (i.e. force plate) single limb stance with both eyes open (EO) and closed (EC) in those with CAI. **Data Extraction:** A total of 3 articles, with a total sample size of 53 participants, were identified. For each investigation, sample sizes, means, and standard deviation (SD) of time-to-boundary (TTB) outcomes for EO and EC stance before and after the balance training intervention were extracted. **Data Synthesis:** The pooled EC to EO TTB outcomes were compared between pre- and post-balance training using standardized mean differences (SMD) and 95% confidence intervals (CI) as well as paired sample t-tests. Larger negative effect size point estimates indicate less emphasis on visual information. Paired sample t-tests revealed no significant differences ($p > 0.05$) between pre and post balance training assessments. The 95% CI of the mediolateral (ML) TTB mean (Pre: -2.20 (-2.68 to -1.72); Post: (-2.55 (-5.18 to 0.00)), ML TTB SD (Pre: -1.61 (-2.05 to -1.17); Post: (-1.52 (-2.86 to -0.18)), anterioposterior (AP) TTB mean (Pre: -2.56 (-3.07 to -2.05); Post: (-2.01 (-2.81 to -1.20)), and AP TTB SD (Pre: -2.46 (-2.96 to -1.95); Post: (-1.54 (-2.06 to -1.02)) outcomes overlapped, indicating no significant change in the weighting of visual information after balance training and confirming the results of the paired sample t-tests. **Conclusions:** All three of the included studies reported postural control improvements, as traditionally measured, after their respective balance training interventions. However, the current results illustrate that balance training does not significantly alter the reweighting of sensory information. Therefore, the observed balance improvements may be due to improving the participant's ability to visually process information. Additional interventions may be needed to augment balance training interventions and reduce the emphasis placed on visual information by CAI participants.

### Triceps Surae Stretching Enhances Sensory-Reweighting in Those with Chronic Ankle Instability

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**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 sensory-reweighting in these patients. **Objective:** To evaluate the effects of 2 weeks of sensory-targeted rehabilitation strategies (STARS) on the eyes closed to eyes open ratio on single limb stance center of pressure (COP) variability in those with CAI. **Design:** Randomized Controlled Trial. **Setting:** Research Laboratory. **Patients or Other Participants:** 38 patients with self-reported CAI (15 males, 23 females; age: 22.6 ± 3.7 yrs; height: 170.6 ± 10.2cm; mass: 72.7 ± 15.7kg) 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 open and eyes closed single limb stance on a force plate standing on the self-reported CAI limb. After baseline testing, patients were randomly allocated to either a triceps surae stretching (STARS-TS) or control (CON). Each patient in the STARS-TS group received 6, 5-minute treatments of a stretching protocol over 2 weeks. All subjects were reassessed on eyes open and closed single limb balance after the 2 week treatment window. **Main Outcome Measures:** For each trial, the standard deviation (SD) of the COP in the anteroposterior (AP) and mediolateral (ML) directions were calculated. The SD-COP represents the variability in the spatial profile of postural control. A larger the SD indicates poorer the postural control. The 3 trial mean for each variable was used for

further analysis. The sensory-reweighting ratio was calculated by dividing the eyes closed SD-COP by the eyes open SD-COP. Change scores (Δ) on the sensory-reweighting ratio from 2-weeks post- to pre-STARS were generated. Change scores were compared between groups using independent sample t-tests and Hedge's g effect sizes (ES) with 95% confidence intervals (CI). **Results:** STARS-TS (Δ:-0.3 ± 0.5cm; ES:0.7 (0.2 to 1.3)) resulted in improved SD-COPML sensory-reweighing ratio ($p = 0.02$) with a moderate ES and a CI that did not cross zero compared to the CON (Δ:0.1 ± 0.5cm). As well, the SD-COPAP ratio significantly reduced in the STARS-TS group ((Δ:-0.4 ± 0.6cm; ES:1.0 (0.4 to 1.5) compared to the control group ((Δ:0.3 ± 0.7cm) with a large effect size and a CI that did not cross zero. **Conclusions:** STARS-TS substantially reduced the sensory-reweighting ratio in both the ML and AP directions. The sensory-reweighting ratio provides an indication of the shift in postural control between eyes open and closed. A larger ratio indicates a greater decline in postural control with the removal of vision. Our findings suggest that targeting the sensory information from the triceps surae for 2 weeks appears to positively influence sensory-reweighting during single limb stance for those with CAI.

### Emergency Preparedness of Secondary School Athletic Programs


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**Context:** The social, emotional, and health benefits of secondary school athletic programs are well established. Death and disability associated with athletic participation is often due to cardiac arrest, heat illness, and head injury. Schools that sponsor athletic programs have an obligation to provide a safe sporting environment that includes appropriate policies and available equipment to address emergencies. **Objective:** To describe the emergency preparedness of secondary schools in Arizona, specific to emergency action plans, cardiac issues, concussion, and heat illness. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** Athletic directors from 143 Arizona secondary schools (response rate = 54%). **Interventions:** Participants were solicited via email by the state interscholastic athletic association to complete an online survey developed by the sports medicine advisory committee and validated for content validity by sports medicine experts and athletic directors. The survey consisted of 5 sections that included questions related to athletic trainer (AT) access, emergency action plans (EAPs), automated external defibrillators (AEDs), concussion and heat illness. **Main Outcome Measures:** Descriptive statistics (percentages, frequencies) were reported. **Results:** Most respondents (81%, n = 116) indicated their school has access to a licensed AT, with 80% (n = 91) being employed full-time. Ninety-five percent (n = 125) of respondents reported their school has a written EAP and 71% (n = 89) noted the school has venue-specific EAPs. Only 27% (n = 29) of schools indicated that the EAP is signed off by a physician. Reviews of the EAP were reported to occur each season (15%,n-21), annually (63%, n = 85), biannually (1%, n = 1) or the frequency of review was unknown (21%, n = 29). Only 32% (n = 38) of respondents (n = 82) indicted that the EAP is practiced annually at each venue with the critical personnel relative to the venue. AEDs were available at most (93%, n = 121) schools, with 44% (n = 41) having two, 19% (n = 18) having three, and 16% (n = 15) having one. AEDs were noted to be within 3-5 minutes of 92.9 ± 13.9% of venues. All respondents (100%, n = 128) were familiar with the state interscholastic concussion policy and 98% (n = 123) indicated they had a school-specific concussion policy. The majority (71%, n = 71) noted that the concussion policy had school board approval. Almost all respondents (99%, n = 121) reported they were familiar with the state heat illness policy, with 45% (n = 51) indicating that their school/district has additional heat-related polices. Environmental measures are taken prior to practices at 48% (n = 60) of schools and 84% (n = 94) have a treatment plan for managing heat illness, with 70% (n = 82) reporting that their school has access to a cold water immersion tub. **Conclusions:** While the majority of schools reported access to an AT, not all schools have adequate polices and equipment in place to ensure a safe sporting environment. Schools would benefit from additional educational opportunities regarding best practices and policy development to improve emergency preparedness.


### County Economic Well-Being Rating is Excellent Predictor of Full-time Utilization of Licensed Athletic Trainers in North Carolina Public High Schools


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**Context:** Economic factors weigh heavily in health care access and utilization, but little is known about the influence of county economies and students' household income on the hiring practices of licensed athletic trainers (LAT). North Carolina state policy requires the presence of a LAT or a first responder at all football practices and games and wrestling matches. **Objective:** To examine the utilization of full-time LAT's and predictors of their employment at North Carolina High School Athletic Association (NCHSAA) member public high schools. **Design:** Enumeration Study **Setting:** Phone interviews were conducted with a representative from NCHSAA member public high schools **Patients or Other Participants:** The research team surveyed the entire population of NCHSAA member public high schools and was able to gather information from all but one school (99.7%). **Interventions:** Data collected was demographic in nature. A group of seven researchers and research assistants read a script and recorded the answers provided by the high school representative. All data were aggregated by a single investigator. **Main Outcome Measures:** The presence or absence of a full-time LAT in each NCHSAA member public schools was used as the categorical dependent variable. A full-time LAT was defined as one that provided care for multiple teams over multiple seasons and had presence on campus more than two days per week. One independent variable included the North Carolina

Department of Commerce (NCDOC) County Tier Designation, which annually subdivides North Carolina's 100 counties into three categories according to economic well-being. The other independent variable was the school's percentage of low-income students, according to the 2013 federal Title I report. A logistic regression analysis was conducted using County Tier Designation and percentage of low-income students as predictors of utilization of a full-time LAT. **Results:** Of the 396 high schools contacted, 244 (62%) utilize the full-time services of a LAT for care of their athletes, 150 (38%) utilize solely first responders, and 6 reported utilizing neither. A test of the full model was statistically significant, indicating that the predictors as a set reliably distinguished between having a full-time AT and not (chi square = 67.438, $p < .001$ with df = 2). The Wald criterion indicated that only County Tier Designation made a significant contribution to prediction of utilization of full-time services of an athletic trainer ($p < .001$). The percentage of low-income students was not a significant predictor of the use of a full-time LAT ($p = .343$). **Conclusions:** Prior to our data collection, there was no official account of LAT utilization in NCHSAA high schools. Access to the services of a full-time LAT aligns with the economic health of the county. For high school athletes to gain access to athletic training services, we must understand the variables that influence the utilization of an athletic trainer.

## Low Socio-Economic Status Limits High School Athletes' Access to Quality Athletic Training Services

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**Context:** An estimated 70% of high schools in the United States have access to athletic training services. Although the percentage of secondary schools with athletic trainer (AT) coverage has increased dramatically over the past decade there still remains a discrepancy in coverage and access to ATs. To date, there is limited data on the affect the common measure of socio-economic status (SES) has on the amount of access to an AT. **Objective:** To determine how the SES of a school impacts the availability of AT services **Design:** Cross-sectional survey. **Setting:** High schools in Wisconsin. **Patients or Other Participants:** High School Athletic Directors and ATs thought to be providing high school services for each school in the state of Wisconsin (N = 492) were solicited via email to complete an electronic (UW-Qualtrics) survey. Non-respondents were contacted by mail and phone and given the opportunity to complete a paper form of the survey. **Interventions:** Respondents provided information regarding the number of hours they have an AT onsite. The SES of each school was stratified into thirds based on economic data (% students with free or reduced lunch [%Free] and county median household income [MHI]) provided by the Wisconsin Department of Public Instruction. Schools were classified as Low SES (highest %Free and lowest MHI), Medium SES schools (mid-level of %Free and mid-level MHI) or High SES (lowest %Free and highest MHI). **Main Outcome Measures:** The main outcome measure was the number of hours (Mean±SD: 95%CI) an AT was onsite at the school each week. **Results:** Usable data were collected on N = 401 (82%) schools with n = 382 (95%) reporting having AT coverage at their school. There was considerable variability in the hours of AT availability (12.7 ± 7.1, range: 0.5-48) across the schools. The respondent schools' mean %Free was 42+17% (range: 7.6%-91%) while MHI was $52,176 + 8,629 (range: $33,330-$75,850). Schools with the highest %Free had significantly fewer ($p < 0.001$) hours of onsite AT access (10.3: 8.1,12.2) than schools in the mid %Free (11.4: 9.6,13.2) and lowest %Free (17.1: 15.3,18.9). Schools in counties with the lowest MHI had significantly fewer ($p < 0.001$) hours of onsite AT access (8.8: 7.2,10.4) than schools in the mid MHI (11.6: 10.1,13.1) and highest MHI (17.4: 15.5,19.3). **Conclusions:** This study demonstrated that high school athletes at schools with higher measures of poverty (lower SES) is associated with less access to an onsite AT than athletes at schools with higher SES. Although overall AT coverage has increased, it can be argued that lower SES schools have limited access to quality healthcare due to less hours ATs spend onsite.

## Athletic Training Diversity Initiative at Large Urban High School

Mendez JM, Breitbach AP: Saint Louis University, St. Louis, MO

**Context:** The purpose of this study is to develop an educational athletic training program for high school students from underrepresented ethnic groups interested in the profession. The current makeup of the Athletic Training (AT) profession is only 10% ethnic minorities and with a growing demand for cultural competence in healthcare, the promotion of the AT profession to minority high school students needs to be a priority. **Objective:** The main objective of this preliminary pilot study is to measure the effectiveness that a multi-workshop program has on the education and interest in the AT profession among high school students from underrepresented ethnic minorities. **Design:** Survey measuring the change in participants' perceptions. Students were administered an eight question survey that measured their perceptions about the profession of AT prior to the program and after participation. **Setting:** Public high school in large urban area that has a student enrollment of 1079 and a demographic breakdown of 90.5% ethnic minorities **Patients or Other Participants:** 21 high school students ranging in ages 15-18 years old from an underrepresented ethnic minority group. Interventions: Each student participated in an AT Club with four learning sessions conducted by college student mentors majoring in AT. **Main Outcome Measures:** Effectiveness of the program was measured by comparing the participants' pre-program and post-program responses based on a Likert scale to help the participants define their experience. These comparisons were also used to understand how to improve the program for future expansion and research **Results:** Paired t-tests were performed to analyze the response data. Significant ($p < 0.05$) changes occurred in 4 items regarding the following: (1) understanding of the education needed for an AT, (2) understanding of the role of the AT on the sports medicine team, (3) understanding of the math and science preparation needed in high school to study AT, and (4) understanding of the human anatomy preparation needed in high school to study AT. **Conclusions:** These data indicates that, in a pilot survey, participation in the AT Club improved the students' knowledge of the AT profession and the preparation required to be an AT. Many of the participants have expressed that their experience in the AT Club has increased their interest in AT as a career path after high school. More research is needed to explore if the development and implementation of educational programs like the AT Club may be a reliable method of educating and recruiting students of underrepresented ethnic minorities into the profession of AT. Additionally more research is needed to study the AT Club's mentors to assess a change in cultural competence based on this experience.

## Private Secondary Schools Use Various Individuals When Providing Medical Coverage

Pike AM, Pryor RR, Vandermark LW, Mazerolle SM, Casa DJ: Korey Stringer Institute, University of Connecticut, Storrs, CT, and California State University, Fresno, CA

**Context:** The percentage of athletic trainers (ATs) employed in secondary schools is rising, with approximately 58% of schools in the private sector having some extent of athletic training services. However, many schools do not have ATs to provide medical care, and utilize services of less qualified medical providers and/or unqualified individuals. **Objective:** Examine who provides medical care to private secondary school student-athletes at schools that do not employ an AT. **Design:** Concurrent mixed-methods. **Setting:** Private secondary schools in the United States (US). **Patients or Other Participants:** Six hundred sixty-eight private secondary schools without an AT participated in the survey, with representation from all regions of US (North 21.4%, n = 143; South 32.2%, n = 215; Midwest 25.1%, n = 168; Southwest 13.5%, n = 90; Northwest 7.8%, n = 52). **Interventions:** Athletic directors (ADs) or principals from private schools were identified by the US Department of Education website. They were contacted up to four times via phone or email from December 2013 to June 2014 to complete a survey assessing who is providing medical care to student-athletes. Questions included whether schools have or use an AT and if not, who is providing medical care during practices and home competitions. **Main Outcome Measures:** Descriptive statistics assessed frequency and percent of coverage types in schools without an AT. These include emergency medical technician (EMT),

physician, first responder, nurse, physical therapist (PT), physician's assistant (PA), and chiropractor employed in full or part time positions. Parent, coach, AD, or any other volunteer/uncertified caregiver was defined as "no medical coverage." For qualitative data, participants responses were recorded for content analysis, categorization, and coding. **Results:** Of those schools that did not employ an AT, 63.5% reported having "no medical coverage." For the 244 schools with coverage other than an AT, the most frequently reported caregivers were EMT (49.2%, n = 120). Other types included nurse (21.7%, n = 53), physician (20.9%, n = 51), first responder (17.6%, n = 43), PT (4.1%, n = 10), PA (1.2%, n = 3), and chiropractor (0.4%, n = 1). Qualitative data confirm coverage type reported. Participants responses included, "EMS for football," "…we have a chiropractor there that will look at injured athletes," and reliance on "…parents who are doctors in the stands." **Conclusions:** For those schools that do not employ an AT, the medical coverage provided is most commonly an EMT, who are less qualified to prevent, recognize, and treat athletic injuries appropriately. Education and advocating for the services of the AT are needed at the secondary school level, particularly with parents, coaches, athletic directors and school boards.

## Developing Novice Athletic Training Faculty Members: The Mentoring Relationship From the Perspective of the Mentor


Mazerolle SM, Nottingham S, Barrett J: University of Connecticut, Storrs, CT, and Chapman University, Orange, CA


**Context:** An important component for success in higher education for a faculty member is competence and success as a researcher. Although doctoral education provides ample opportunities for skill development in this area, transitioning into an autonomous researcher may still require further support and guidance. Moreover, due to the complexity of the role of the faculty member additional guidance may be needed during the transition. Mentorship is often the mechanism whereby continued encouragement is provided. The National Athletic Trainers' Association (NATA) has developed a formal mentoring initiative to help support the novice faculty member who is transitioning into this role. **Objective:** Perspectives on mentorship are often garnered from the mentee, thus our purpose was to understand the mentoring relationship from those who have served as a mentor to a novice faculty member. **Design:** Phenomenological qualitative study. **Setting:** Higher education institutions with CAATE accredited programs. **Patients or Other Participants:** 14 mentors completed our study (years certified: 21 ± 4, years experience in AT education: 15 ± 5). 7 participated in the NATA Research and Education Foundation's (REF) Research Mentor program (2 females, 5 males) as research mentors and 7 (2 females, 5 males) who identified as mentors but had not formally participated in the NATA REF program. **Data Collection and Analysis:** We completed semi-structured phone interviews following an interview script. The interview framework allowed for discourse while maintaining consistency. Interviews were transcribed and saturation was obtained. Analysis was grounded by the phenomenonlogical approach. Peer review and researcher triagulation were completed for trustworthiness. We also used data source triangulation to verify our findings through the use of those who have mentored outside of the NATA mentor program. **Results:** Our findings suggest mentoring can help faciliate role transiton into higher education, as it was perceived that doctoral preparation can be incomplete. Mentoring was viewed as a means to faciliate professional development for the mentee, and served as a tool for skill advancement for the mentor. Mentoring relationships must include clear communication regarding expectations and needs for the relationship as well as continual feedback for growth professionally. Mentors rely on their previous mentoring relationships, whereby they were mentored, to develop their current mentoring strategies. Additionally, those who served as NATA mentors noted their relationships were more formal than those who have not participated in the program. **Conclusions:** Our results substantiate previous work suggesting mentoring can promote role transition particularly where doctoral education is unable to provide comprehensive experiences, related to administration and service. Mentors find the relationship beneficial not only to their own careers, but also to support the growth of promising new investigators. Mentors believe that communicating with their mentees about expectations and providing feedback regarding their performance can facilitate a successful relationship.

## Novice Faculty Members' Perspectives of Mentorship During the Transition From Doctoral Student to Tenure-Track Faculty


Nottingham S, Mazerolle SM, Barrett J: Chapman University, Orange, CA; University of Connecticut, Storrs, CT


**Context:** Previous research suggests there may be an incongruity between doctoral preparation and the actual responsibilities of athletic training faculty members. While mentorship has been identified as an important component of education, little is known about the role of mentorship during the transition from student to faculty member during the first several years in academia. The National Athletic Trainers' Association (NATA) has developed a program designed to provide mentorship of novice faculty members, particularly in the area of research. **Objective:** Obtain novice faculty members' perspectives on mentorship as it relates to their experiences as a tenure-track faculty member. **Design:** Qualitative, phenomenological research. **Setting:** Higher education institutions with CAATE accredited programs. **Patients or Other Participants:** 14 participants were distributed among 2 groups: 7 (5 females, 2 males) participated in the NATA Foundation's Research Mentor program as mentees, while 7 (6 females, 1 male) were identified as novice faculty members who had not participated in the NATA Foundation's program. The mentees' average age was 34 ± 3, they had an average of 8 ± 3 years of experience as a faculty member and researcher. **Data Collection and Analysis:** We developed and piloted an interview guide designed to gain participants' perspectives on doctoral preparation and mentorship in relation to their faculty roles and responsibilities. Semi-structured telephone interviews were completed with each individual and transcribed

verbatim. Data were analyzed using a phenomenological approach and saturation was obtained. Trustworthiness was established with the use of member checking, researcher triangulation, and data source triangulation. **Results:** Regardless of participation in the research mentor program, novice faculty members believed that mentors helped them navigate institutional expectations and guidelines, the professional landscape, and their faculty responsibilities. Mentors provided support and guidance, particularly when mentees believed there was a misalliance between their doctoral preparation and their expectations as a faculty member – usually in the areas of service and administration. Participants believed that effective mentoring relationships are grounded in a willingness to engage in the relationship, effective communication, and similar interests and goals. While all participants described having informal mentoring relationships with more experienced faculty members in their institutions, participants in the NATA mentor program identified their formally assigned mentor as one who provided additional mentoring in the areas of research and professional networking. **Conclusions:** Our results support previous findings regarding characteristics of effective mentoring relationships, suggesting mentorship is an important mechanism for support during socialization into a new role such as a tenure-track faculty position. Mentorship appears to be particularly valuable when there is a perceived lack of preparation for one aspect of a faculty position. Most novice faculty members seek out mentors within their institution, and connecting with mentors beyond their university may provide additional support for research and professional networking.

### The Development of Athletic Training Educators' Teaching Practices

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

**Context:** Little research is available on how athletic training educators develop their instructional styles over the course of their careers and what influences their teaching practices. Understanding the development of athletic training educators' teaching practices may help promote effective teaching in athletic training programs and help guide professional development. **Objective:** Gain an understanding of how athletic trainers have developed as educators and how over time their teaching practices have changed. **Design:** Phenomenological qualitative. **Setting:** Higher education institutions. **Patients or Other Participants:** : Eleven athletic trainers teaching in undergraduate professional athletic training programs participated (4 men, 7 women; age range 34-55 years; 14-32 years as an athletic trainer; 10-28 years as an educator). Participants were purposefully selected based on inclusion criteria: 1) currently teaching at least one undergraduate athletic training class, 2) a terminal degree (e.g., EdD or PhD) in athletic training or related field, and 3) a minimum of 8 years of experience teaching as a means to ensure role continuance. Data saturation was satisfied. **Data Collection and Analysis:** Curriculum vita, course syllabi, and a videotaped teaching lesson were obtained and reviewed prior to each phone interview. Data gained from these artifacts were used to triangulate data collected during the interviews, as well as collect background information about our participants. All interviews were recorded and transcribed verbatim. Data were analyzed using a phenomenological approach. Trustworthiness was established through member checking, data source triangulation, multiple analyst triangulation, and peer review. **Results:** Two main themes emerged from the data: 1) professional development, and 2) teaching for student learning. Participants discussed how their teaching evolved from focusing on students memorizing every detail and fact to emphasizing to students the importance of larger concepts that were applicable to clinical practice. The participants reported on how they valued their previous (and sometimes current) clinical practice. Their clinical practice helped inform and focus the content taught. To promote student-learning, participants sought to improve their students' critical thinking and clinical decision-making skills. By promoting the decision-making process educators challenged students to transfer the knowledge learned into clinical practice. Participants valued and encouraged these skills for students to utilize during clinical practice. **Conclusions:** Informal processes were a critical aspect to our participants' development as educators, suggesting that growth was stimulated because of self-reflection and role engagement. Clinical practice provided the platform for delivery of materials for our participants, as it allowed for student learning through a sense of realism in content. Our participants also demonstrated growth in expectations and goals for their students, suggesting maturation in their role as an educator. Continued research using the socialization paradigm is necessary to understand how novice educators develop into more experienced ones.

# Free Communications, Oral Presentations: Appropriate Management of Infectious Conditions and Rare Sequelae

Friday, June 24, 2016, 5:00PM-6:15PM, Room 316; Moderator: CPT Shane Larson, MD

### Community Associated Methicillin Resistant Staphylococcus Aureus (CA-MRSA) Infection Incidence and Management Within Northeastern High Schools and Intercollegiate Athletic Programs

Braun T, Kahanov L, Dannelly HK, Lauber CA: Rocky Mountain University of Health Professions, Provo, UT; Idaho State University, Pocatello, ID; Misericordia University, Dallas, PA; Indiana State University, Terre Haute, IN; University of Indianapolis, Indianapolis, IN

**Context:** Community Associated Methicillin Resistant Staphylococcus aureus (CA-MRSA) strains are increasingly the cause of soft tissue and skin infections within the athletic population. The sports medicine research focus on MRSA over the past two decades primarily includes retrospective outbreak reports and environmental investigations rather than quantifying the overall extent of the problem. Although position statements and recommendations offer many effective solutions in controlling and managing infections, few studies have established the infection incidence rates, management protocols, and interprofessional practices of high school and intercollegiate athletic programs. **Objective:** The objective of this study was to assess the yearly incidence rates of CA-MRSA infections, sport risk, management protocol, and interprofessional practices within in high school and intercollegiate athletic programs during the 2012-2013 competitive academic school 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:** 156 certified athletic trainers (ATs) responded from National Athletic Trainers Association (NATA) District Two. ATs provided care for 67,678 student athletes. **Interventions:** This descriptive study elicited participation via email from high school and intercollegiate athletic programs in the Northeastern United States. Respondents answered a one-time survey. This survey consisted of 11 questions within three content areas: (1) Demographic information, (2) CA-MRSA infection rates, (3) Management of CA-MRSA infections and suspicious bacterial lesions. The internal consistency of the selected items was considered high (Cronbach's alpha = .913). **Main Outcome Measures:** Frequencies, ANOVA, prevalence and relative risk were calculated to determine differences between settings and sports for CA-MRSA infections. **Results:** The overall infection incidence was 15.5 per 10,000 athletes (95% CI, 13-19). The incidence and relative risk were significantly higher in wrestling (90.2 per 10,000, 95%CI, 62-132: RR = 7.8, 95% CI, 5.0-12.2) and football (42.3, 95% CI, 31-59: RR=3.9, 95% CI, 2.6- 5.9) compared to the general athletic population. The majority of interprofessional practice included referral to general or primary physicians (60.5%, n = 133). Dermatologists and infectious disease specialists only contributed to 12.5% (n = 28) of interprofessional practice referrals. Emergency room personnel (9.1%, n = 20) and midlevel providers (8.6%, n = 19) were the other represented members of interprofessional treatment teams. ATs made 526 selections of steps employed in their interprofessional treatment approaches to CA-MRSA. The majority of protocol steps selected (58.1%, n = 306) indicated coordinated decisions to isolate the athlete and setting decontamination. Approximately half the respondents indicated that all suspicious bacterial lesions are presumptively treated as CA-MRSA (49%, n = 71). **Conclusions:** Despite recommendations and position statements, athletes, particularly contact athletes, remain a high risk population for contracting CA-MRSA infections. With a wide range of referral and management protocols, it is critical that ATs continue to assess the current standard of care and work in interprofessional teams to better treat and advocate for student-athletes.

### Idiopathic Rash and Joint Pain in a Division I Soccer Player

Stepchuk B, Joseph C: University of Central Florida, Orlando, FL

**Background:** A 22 year old female, division 1 soccer player presented with a rash on her anterior and posterior lower leg that was painful to the touch, and deep, achy pain in her left knee, after a soccer game. Over the next 24 hours, she reported the rash spread to the ulnar sides of her forearms, and began showing nodules causing increased pain. Her joint pain spread to the right knee, however, ibuprofen seemed to control her symptoms. She has a previous medical history of asthma, ADHD, Gastroesophageal Reflux Disease (GERD), suffered from an episode of mononucleosis seven months prior, and is taking an oral contraceptive. **Differential Diagnosis:** Erythema Nodosom (EN), Rheumatoid Arthritis, Lupus, Acute Rheumatic Fever (ARF), Streptococcus, Post-Streptococcal Reactive Arthritis (PSRA), Lyme disease, Hepatitis, Chlamydia, and Parvovirus **Treatment:** She saw the team physician 48 hours after her symptoms presented, and was diagnosed with EN or a delayed allergic reaction to her asthma, oral contraceptive, or GERD medication. She was prescribed penicillin for 10 days and a Complete Blood Count, Comprehensive Metabolic Panel (CMP), Antistreptolysin O (ASO) Titer, and chest x-ray were ordered. She was removed from activity at this time. The x-ray showed no significant findings. The lab results demonstrated an increased ASO Titer, proving she had a subclinical episode of streptococcal infection causing EN. She completed the dose of penicillin and her symptoms resolved for 3 weeks. At this point, she experienced increased joint pain, affecting 9 joints in the upper and lower extremity. As a result, the physician ordered a follow up CMP, ASO and Anti-Nuclear Antibody Test, prescribed

prednisone, and a low dose injection of penicillin for the next 6 months to prevent another streptococcal infection. Prednisone relieved her symptoms within 24 hours, allowing her to begin cardiovascular training as tolerated. The lab results showed increased Globulin levels, further elevated ASO levels, and elevated sedimentation levels, causing the physician to believe she had a possible PSRA and/or ARF. She was referred to rheumatology and cardiology for further evaluation. An echocardiogram demonstrated normal findings, ruling out mitral valve regurgitation, a sign of ARF. The rheumatologist determined the initial rash presentation was not consistent with ARF, but she probably suffered from PSRA. The rheumatologist prescribed diclofenac, twice daily, for joint pain. She will continue with monthly penicillin injections to prevent any further streptococcal infections, the underlying cause in this case. She will return to play as tolerated. **Uniqueness:** The findings of this case are rare since the athlete showed no signs of streptococcus prior to her initial symptoms. PSRA is present in 24% of streptococcal cases. The annual occurrence of EN is approximately 1 to 5/100,000 people, usually seen because of a sexually transmitted infection or a reaction from a medication, and rarely spreads to the upper body. Sedimentation levels in lab work remain normal in 15-40% of EN patients, but in this case they were elevated, a sign of ARF. Finally, she never presented with a fever, a key symptom for ARF. These symptoms overlap clinical diagnoses of ARF and PSRA making this case unique because she did not fit either criterion fully, therefore, she was never given an official diagnosis. **Conclusions:** This case demonstrates that a simple rash can have a significant underlying cause. As athletic trainers, we need to be aware of our athletes and their symptoms in order to prevent any long term negative effects as a result of something that at first may seem minor.

## Erythema Multiforme Minor in a Collegiate Football Player With Diabetes

Karpoff KM, Manspeaker SA, Herr AR: Duquesne University, Pittsburgh, PA

**Background:** A 19-year-old male, Division I, collegiate football player presented to the athletic training clinic with erythematous, papular, umbilicated lesions across his chest, back, bilateral arms, and mouth that had been present for 36 hours. He stated that these lesions were itchy and bothersome during activities of daily life and football participation. He reported no changes in detergents, soaps, medications, or other allergen sources. He has a known previous history of Varicella zoster, Herpes Simplex I (HSV I), and Type I Diabetes which, is currently controlled by Lispro (Humalog) insulin injections via pump. **Differential Diagnosis:** Urticaria, vasculitis, hypersensitivity reaction, figurate erythema, Varicella zoster, HSV I outbreak, drug eruption, syphilis, methicillin-resistant Staphylococcus aureus (MRSA), tinea corporis, lupus erythematosus, EM minor, EM major, toxic epidermal necrolysis, and Stevens-Johnsons Syndrome. **Treatment:** Diagnostic evaluation included dermatological assessment in the athletic training clinic, emergency room, and dermatologist office. Blood tests for creatinine and uric nitrogen levels were conducted. These evaluations led to a diagnosis of EM minor (unspecified) within 72 hours of presentation of signs/symptoms. The patient was prescribed Prednisone (6 week taper, decreased to 10 mg weekly from 60 mg), to decrease inflammation of the lesions, and Valacyclovir (500 mg) as a precaution to prevent the worsening or recurrence of an HSV outbreak. He was prohibited from physical activity for four weeks including practice, competition, workouts, lifting, and rehabilitation for injuries. He was due for follow-up evaluation four weeks after diagnosis, however, at three weeks post-diagnosis, on his own volition, he was seen by his personal physician who determined the lesions had scarred and healed and was subsequently cleared for physical activity. He was then cleared for full return to football activity by the team physician 20 days post-diagnosis with monitoring by the athletic trainer. **Uniqueness:** This case proved difficult to diagnose as EM is a rare condition affecting less than one percent of the population and there were issues in treating due to the pre-existing condition of diabetes. EM minor causes a reaction of the skin and mucous membranes, in rash form, that appears symmetrical in fashion, spreads toward the center of the body, and may have episodes of recurrence. Although this condition may be caused by bacterial, viral, or fungal agents, the most common occurrence results from a reaction to HSV infection, though it is not a typical sequelae of HSV. Pharmacological intervention was complicated by the comorbidity of diabetes; two physicians were willing to give the patient Prednisone whereas the third was reluctant to place the patient on a corticosteroid treatment due to potential effects on insulin levels and immunosuppressive effects. The athlete was ultimately given Prednisone however, he experienced side effects in the form of fluctuating glucose levels that were difficult to control. Additionally, current evidence suggests Prednisone is not the only course of treatment and it is appropriate to consider intravenous Cytoxan, pooled gamma globulin, or oral Cyclosporin as well. **Conclusions:** Dermatological disorders present in varied forms. Athletic trainers must be familiar with not only common conditions, but also be aware that conditions may present differently or progress into more rare conditions. This case highlights the importance of understanding dermatology, pharmacological treatment options, comorbidities, and gaining a thorough past medical history for all athletes.

## Pyoderma Gangrenosum in a Male Collegiate Coach

Long MD, Bhojani RA: Air Force Academy, Colorado Springs, CO; Lamar CISD, Rosenberg, TX; Memorial Hermann Sports Medicine, Sugarland, TX

**Background:** A 27 year-old male collegiate basketball coach presented with a small pimple inside his left ear. He initially popped the lesion and removed an oily, purulent substance and subsequently noted that the area became swollen and painful. The following day, the athletic trainer evaluation showed that the swelling had spread to the entire outer ear canal and tragus. The area was cleaned and a cool compress was applied to help stop the swelling and pain and he was referred for physician evaluation. The urgent care physician diagnosed cellulitis; at that time, the anterior aspect of the tragus was lanced without drainage, packed with sterile gauze, and started on Augmentin. Two days later, the pain and swelling worsened. The team ENT evaluated the patient and recommended a CT scan for possible sebaceous gland abscess, which came back negative. He was admitted to the hospital to begin IV Vancomycin for Methicillin-resistant Staphylococcus aureus. **Differential Diagnosis:** Cellulitis, Necrotizing Fasciitis, Subcutaneous Necrotizing Fasciitis, Sebaceous gland abscess, Methicillin-resistant Staphylococcus aureus (MRSA). **Treatment:** After one day in the hospital, the ENT reported to the athletic trainer that the infection seemed to be coming to a head anterior and inferior to the left ear. An incision was made in the area and about 20cc's of sebaceous fluid was drained off of the area. IV Daptomycin was then started to augment the Vancomycin. The next morning, the affected area showed tissue necrosis with purple/red discoloration along with small pustules under the skin around the incised area. Surgical intervention by the team ENT to remove the dead tissue was done, and the ENT reported that the skin just "wiped away like raw ground beef". The diagnosis of necrotizing fasciitis was made and an infectious disease consult was obtained. IV Clindamycin was then started. On the third day of hospitalization, the infection continued to spread and another surgery was performed to cut in front of the necrotized tissues and into healthy tissue in order to remove any possible infection. The ear lobe and tragus were also removed. During surgery, it was found that the infection was under the skin, but was not damaging the muscle tissue. The infectious disease doctor changed the diagnosis to subcutaneous necrotizing fasciitis. During this time, a team physician and the athletic trainer determined that a dermatologist should be consulted. The team dermatologist visited the hospital on day 5 and reviewed the chart and pictures and revealed that this was a classic case of pyoderma gangrenosum. Due to the auto-immune nature of this disease, antibiotics were not effective; however, Prednisone therapy was able to stop the progress. Three days later, the coach was sent home with a tapered steroid regimen and wound care products. The wound took approximately 6 months to heal completely. **Uniqueness:** Pyoderma Gangrenosum is an uncommon disease that often affects people with a poor immune system. It has also been strongly correlated with gastrointestinal dysfunction. It is not commonly seen in the collegiate setting and there are no documented cases of pyoderma gangrenosum on the face in the United States. **Conclusions:** This case presented as a possible staph infection but resulted in a more serious diagnosis. Staphylococcus aureus and MRSA are skin diseases that are common in athletics. However, it is important for the athletic trainer to be aware of other skin diseases that can present in a similar fashion and know when to refer for further evaluation by physicians and specialists.

## Pediatric Autoimmune Neuropsychiatric Disorder Associated With Streptococcal Infection in an Adolescent Football Athlete

Heath M, Powers ME, Gildard M: Marist College, Poughkeepsie, NY

**Background:** A 16 year-old male football athlete reported to the athletic trainer complaining of involuntary sudden, rapid and repetitive movement of his head consistent with simple motor tics. During these episodes his head would rotate unilaterally to the right. He stated that the symptoms began the previous day however he had been feeling better since the initial episode. The patient reported the symptoms after having to leave football practice as a result of the repeated involuntary head movements. He also complained of a headache and back pain, but did not report any chills, nausea, vomiting or dizziness. His personal medical history included a bout of pneumonia and a concussion he suffered two years prior. The patient denied any alcohol, supplement or recreational or performance enhancing drug use. His father stated that he has never acted like this before and has no previous history of psychological disorders. Upon assessment, the patient appeared fidgety and could not remain still while he was symptomatic. There were no remarkable findings during assessment other than the obvious tics that were observed. The patient was referred to the emergency department due to the continued involuntary movements. **Differential Diagnosis:** Stress related disorder, Lyme disease, Tourrette's syndrome, Sydenham chorea, allergic reaction, reflex sympathetic dystrophy, focal seizure. **Treatment:** At the emergency department, cardiovascular, respiratory, neurological, gastrointestinal, genitourinary, musculoskeletal, and pain assessments were all negative. Plain film radiographs and computed tomography without contrast were negative. Elevated leukocyte levels were noted following urinalysis and elevated plasma levels of potassium

and creatinine were observed. A drug screen was also performed and found to be negative. The patient was diagnosed with a tic disorder and prescribed .5-mg of Xanax. He was cleared to return to sports even though the tic was still consistent. The athletic training staff used heat and manual therapy on the upper trapezius and sternocleidomastoid in an attempt to relax the muscles and diminish the tics. They also performed passive static stretching on the same muscles. When the patient relaxed, the tic would diminish for the duration of the therapy. The athletic training staff decided that it would be safer to wait and return to the patient to participation once the tics had completely resolved. At the suggestion of another parent, the patient was referred to his pediatrician who identified a high strep level following an overnight strep test. The pediatrician diagnosed the patient with pediatric autoimmune neuropsychiatric disorder associated with streptococcal infection (PANDAS) and prescribed amoxicillin. The tics cease within a few days and he returned to full participation without complication. **Uniqueness:** Although PANDAS commonly affects younger children, it also can occur in the older teenage population. It has a variety of signs and symptoms associated with it and is easily missed or confused with other diseases, as it was with this particular case. It would be very easy and useful to add a strep test to the variety of tests done when an adolescent presents with symptoms with an unknown cause or etiology. **Conclusions:** Sudden onset of obsessive compulsive disorder (OCD) or a tic should raise suspicion for PANDAS and the need for referral. More research is needed to discover the true etiology of this condition. A child may be diagnosed with PANDAS when OCD and/or tic disorders suddenly appear following a strep infection or if the symptoms of OCD or tic symptoms suddenly become worse following a strep infection.

# Free Communications, Oral Presentations: It's More Than a Sprain: Acute Lateral Ankle Sprain Recovery

Saturday, June 25, 2016, 7:00AM-7:45AM, Room 316; Moderator: Scott Ross, PhD, ATC

### The Effects of Immobilization and Physical Activity Following Acute Ankle Sprain on Corticospinal Excitability to the Lower Leg

Stirling AM, Felpel Z, Needle AR: Appalachian State University, Boone, NC

**Context:** Neuromechanical changes present after an acute ankle sprain can lead to adaptations or maladaptations subsequently affecting joint stability. It is unclear how immobilization and physical activity during the first week following injury can affect neurological function throughout the healing process. **Objective:** The objective of this investigation was to quantify cortical and reflexive excitability and their relationship to immobilization and physical activity levels following an acute ankle sprain. **Design:** Pilot Cohort Study. **Setting:** University Laboratory. **Patients or Other Participants:** A pilot cohort of 6 male subjects (20.8 ± 0.8 yrs, 180.3 ± 3.5 cm, 84 ± 9.8 kg) reporting within a week of a lateral ankle sprain volunteered for this investigation. **Interventions:** Subjects were tested 1, 2, 4 and 8 weeks following an acute lateral ankle sprain. During each session, physical activity level and time immobilized were recorded via questionnaires. Cortical and reflexive excitability were also assessed bilaterally with Transcranial Magnetic Stimulation (TMS) and peripheral nerve stimulation to evoke the Hoffmann reflex, respectively. Electromyography sensors were placed on the tibialis anterior (TA), peroneus longus (PL) and soleus (SOL). **Main Outcome Measures:** Time immobilized (hrs) was quantified with a self-reported questionnaire and time walking (hrs) with the International Physical Activity Questionnaire. Cortical excitability was determined by using maximum motor evoked potential (MEPmax, %Mmax) from TMS stimuli to the primary motor cortex. Reflexive excitability was determined from the ratio of maximum reflexive to direct muscle response (Hmax:Mmax). Analyses included descriptive statistics and Spearman's rank correlation coefficients between time immobilized, time walking, and neurological variables across all time points. **Results:** During week 1, participants spent 27.05 ± 30.72 hrs immobilized and 1.97 ± 1.36 hrs walking. Increased immobilization in the first week of injury raised the excitability of the SOL at 2 (0.047 ± 0.03; $\rho = 0.900$, $P = 0.037$) and 4-weeks (0.046 ± 0.047; $\rho = 0.800$, $P = 0.05$) post-injury. Similarly, increased physical activity (walking) in the first week raised SOL reflexive excitability (0.63 ± 0.05; $\rho = 0.900$, $P = 0.037$) and the PL MEPmax (0.54 ± 0.35; $\rho = 0.900$, $P = 0.037$). **Conclusions:** The results of this preliminary dataset reveal that immobilization during the acute phases of a lateral ankle sprain may raise increase cortical connections to the plantarflexors, while physical activity may increase SOL reflexive excitability and cortical excitability to PL. Despite a small cohort, it is possible that immediate immobilization may have the capacity to offset the decreased excitability observed in chronic ankle instability models. Further investigation is needed to determine the long term effects of immobilization and physical activity (walking) on acute ankle sprain recovery.

### Recovery of Star Excursion Balance Test Scores Following a First Time Acute Lateral Ankle Sprain

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**Context:** Lateral Ankle sprains (LAS) remain the most common musculoskeletal injury sustained during physical activity. Further, 1 out of 3 individuals who sustains a LAS will go on to develop residual symptoms often defined as chronic ankle instability. The prevalence of chronic ankle instability suggests that current treatment techniques for acute LAS are not sufficient. Unfortunately, information regarding the long-term recovery process of objective clinician-oriented outcomes after acute LAS remains limited. **Objective:** To examine the 12-month recovery of Star Excursion Balance Test (SEBT) scores following acute LAS. **Design:** Longitudinal study. **Setting:** Research Laboratory. **Patients or Other Participants:** Twelve college students (6 males and 6 females, age = 21.7 ± 2.7 yr., mass = 79.4 ± 20.4 kg, height = 174.2 ± 11.5 cm) with first time acute LAS volunteered to participate. Eight patients were diagnosed with mild LAS while 2 were diagnosed with moderate, and two were diagnosed as severe LAS. All participants were recreationally active and otherwise healthy prior to sustaining the acute LAS. **Interventions:** Subjects with an acute LAS were enrolled within three days of injury. When able to bear weight, the SEBT was completed in the anterior (Ant), posteriomedial (PM), and posteriolateral (PL) directions on the involved limb. Patients completed an SEBT assessment 3-days, 1-week, 2-weeks, 4-weeks, 6-weeks, 8-weeks, 12-weeks, 16-weeks, and 1-year post

injury. For all assessments, patients practiced each reach direction 4 times before completing 3 test trials in each direction. **Main Outcome Measures:** Normalized SEBT reach distance (% of ipsilateral leg length [ASIS to middle of medial malleolus]) in the Ant, PM, PL directions. Reach distances were compared over time using repeated measures ANOVAs with an a priori alpha level set at 0.05. Missing data was replaced using a linear interpolation technique. **Results:** The Ant reach distance was significantly lower ($p = 0.006$) 3-days post-injury (56.94 ± 6.93%) relative to the 2-week (62.97 ± 8.78%), 4-week (64.72 ± 6.68%), 6-week (65.99 ± 7.48%), 8-week (67.74 ± 6.96%), 12-week (67.61 ± 7.65%), 16-week (71.51 ± 7.51%), and 1-year (68.61 ± 6.84%) assessments. Ant reach at 1-year was significantly longer than the 3-day post-injury assessment ($p < 0.001$). The normalized PM reach distance was significantly reduced ($p = 0.032$) at the 3-day (75.68 ± 12.47%), 2-week (80.83 ± 8.52%), 4-week (81.96 ± 9.62%), and 6-week (83.59 ± 6.79%) assessments compared to the 1-year post-injury (92.25 ± 9.91%) assessment. The PL reach distance was significantly reduced ($p = 0.048$) at the 3-day (70.17 ± 12.31%), 1-week (72.71 ± 13.43%), and 2-week (74.52 ± 9.38%) time points relative to the 1-year post-injury (92.25 ± 9.91%) assessment. However, PL reach distance was also reduced, although not significantly, at the 4-week (76.25 ± 9.19%, $p = 0.079$), 6-week (78.23 ± 7.61%, $p = 0.073$), and 12-week (79.24 ± 7.54%, $p = 0.057$) time points relative to the 1-year post injury assessment. **Conclusions:** Following LAS, normalized SEBT reach direction scores appear to recover at different post-injury time points. More specifically, Ant reach distance recovers at 1-week post injury, PM at 6-weeks post injury, and PL at 2-weeks post injury. However, a trend for continued PL deficits was noted at 12-weeks post injury.

## Ankle Laxity is Still Present One Year After an Acute Lateral Ankle Sprain

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**Context:** Ankle sprains remain one of the most common orthopedic injuries. Most concerning are the numbers of patients that develop long term ankle instability and have decreased subjective function and activity levels. Despite these problems there are limited long term studies examining changes after an acute lateral ankle sprain (LAS). **Objective:** To examine ankle laxity one year after a LAS. **Design:** Longitudinal study. **Setting:** Research Laboratory. **Patients or Other Participants:** Twelve college students (6 males and 6 females, age = 21.7 ± 2.7 yr., mass = 79.4 ± 20.4 kg, ht = 174.2 ± 11.5cm) with an acute LAS participated in the study. **Interventions:** Subjects with an acute LAS reported to the lab within three days of injury. A certified athletic trainer assessed the injury and ensured patients met inclusion criteria. Ankle laxity was measured with a LOGIQ Book (GE Healthcare, Waukesha, WI) diagnostic ultrasound. The ankle was positioned in 0° of dorsiflexion/plantar flexion. The examiner orientated the probe to view the cross sectional view of the lateral malleolus and the lateral talar articular surface cartilage and the neck of the talus. Once those landmarks and the anterior talar fibular ligament (ATFL) were located, images were saved. Measurements of ATFL length were made using ImageJ software (National Institutes of Health, Bethesda, MD). We measured the distance from the anterolateral aspect of the lateral malleolus, to the most anterior aspect of the lateral talar articular surface cartilage. These are the respective landmarks for the origin and insertion of the ATFL. **Main Outcome Measures:** The length of the ATFL (mm) in a neutral non-stressed position at 3 days post LAS and 1 year post LAS. **Results:** There was a significant difference between the involved LAS ankle and the uninvolved ankle in ATFL length 3 days after injury ($p = 0.02$). The LAS had an average ATFL length of 19.5 + 1.4mm compared to the healthy limb of 17.4 + 1.7mm. There was no significant difference in ATFL length in the involved ankle between 3 days after injury and 1 year after injury ($p = 0.10$). One year after injury the involved ATFL length average was 18.9 + 1.4 mm. **Conclusions:** One year after a LAS subjects still had ankle laxity as measured by length of the ATFL ligament. This lack of significant ligament healing is a concern and may explain the high percentage of patients that develop CAI. Rehabilitation and immediate management needs to better protect and facilitate ligament healing after a LAS to restore mechanical stability after injury.

## Ankle Evidence-Based Forum: Movement Strategies Following Ankle Injury

Satuday, June 25, 2016, 8:00AM-9:00AM, Room 316; Moderator: Patrick McKeon, PhD, ATC
Discussants: J. Ty Hopkins, PhD, ATC, FACSM, FNATA; Erik Wikstrom, PhD, ATC, FACSM

### Knee Flexion Excursion Predicts Magnitude of Loading During Walking Gait in Individuals Following Anterior Cruciate Ligament Reconstruction


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**Context:** Anterior cruciate ligament reconstructed (ACLR) individuals are five times more likely to develop knee osteoarthritis, potentially due to excessive loading of articular cartilage associated with aberrant gait biomechanics. Alterations in knee joint biomechanics have been demonstrated to persist for years following ACLR. More specifically, the overall magnitude (peak vertical ground reaction force [vGRF]) and rate of loading (vGRF_LR) during gait adversely affect cartilage health. Knee kinematics (i.e. knee flexion angle) influence vGRF during dynamic activities such as landing, suggesting that feedback interventions cueing a change in knee flexion angle may be successful in reducing the aberrant loading. It remains unknown however, if knee kinematics during walking gait associate with knee loading following ACLR. **Objective:** To determine if knee kinematics are associated with peak vGRF and vGRF_LR in the injured limb during walking gait in individuals with ACLR. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Forty-one participants with unilateral ACLR (29 Females, age = 22.8 ± 3.2 years, height = 169.5 ± 11.1cm, mass = 74.4 ± 19.2kg, 43.5 ± 37.7 months post ACLR). **Interventions:** Three-dimensional kinematics and kinetics were captured during five trials of walking gait at a self-selected speed. **Main Outcome Measures:** Loading variables, which included peak vGRF and vGRF_LR, as well as knee kinematic variables, which included knee flexion angle at initial contact (flex_IC), peak knee flexion angle (flex_PEAK), and knee flexion angle excursion (flex_EXCURSION) were calculated during the first 50% of the stance phase of walking gait. First, bivariate partial correlations were used to determine associations between kinematic variables and loading variables while accounting for gait speed. If a kinematic variable significantly associated ($P < 0.05$) with one of the loading variables we conducted a hierarchical linear regression analysis to determine the amount of variance that the kinematic variable of interest predicted after accounting for gait speed and the other kinematic variables. We then determined the change in R2 for the kinematic variable of interest after gait speed and the other kinematic variables were imputed into the regression analysis. **Results:** None of the kinematic variables individually associated with vGRF_LR (r = -0.106 to -0.164, $P > 0.05$). Flex_EXCURSION was the only kinematic variable that significantly associated with peak vGRF (r = 0.524, P = 0.001). After accounting for gait speed and flex_IC, flex_EXCURSION predicted 16% of the variance in peak vGRF (change in R2 = 0.16, P = 0.001). After accounting for gait speed and flex_PEAK, flex_EXCURSION predicted 11% of the variance in peak vGRF (change in R2 = 0.11, P = 0.004). **Conclusions:** During load acceptance phase of walking gait, knee flexion excursion independently predicted the magnitude of peak vGRF in the ACLR limb, regardless of how flexed the knee was at initial contact or during the maximal flexion value. Implementing feedback interventions, which specifically cue a change in knee flexion excursion, may subsequently reduce the overall magnitude of knee loading during walking gait.

### Quadriceps Active Motor Threshold Does Not Associate With Kinetic Asymmetries During Walking Gait in Individuals With Anterior Cruciate Ligament Reconstruction


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**Context:** Kinetic asymmetries during walking gait are common following anterior cruciate ligament reconstruction (ACLR) and may contribute to the development of osteoarthritis. Increased magnitude and loading rate of the vertical ground reaction force (vGRF) have been observed following ACLR, and are surrogate measures of knee joint loading during gait which may adversely affect the cartilage. Lower internal knee extension moments (KEM) during gait are common in individuals with ACLR and may indicate an inability of the quadriceps to eccentrically control the knee during loading. Inability to regain quadriceps function following ACLR is due in part to persistent deficits in quadriceps corticomotor excitability. Establishing the association between quadriceps corticomotor excitability and kinetic asymmetries may aid in the development of treatments that restore optimal loading symmetry following ACLR. **Objective:** To determine the association between quadriceps corticomotor excitability and limb symmetry index (LSI) for vGRF magnitude and loading rate, and KEM during walking gait. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty participants with unilateral ACLR (24 Females, age = 22.1 ± 3.6 years, height = 167.3 ± 9.6cm, mass = 70.1 ± 13.2kg, 47.7 ± 40.2 months post ACLR). **Interventions:** Transcranial magnetic stimulation (TMS) was used to assess quadriceps

active motor threshold (AMT), a measure of corticomotor excitability. TMS testing was performed at 90° of knee flexion during an active contraction of 5% maximal voluntary isometric contraction. Three-dimensional kinetics and kinematics were collected during five gait trials at a self-selected walking speed. **Main Outcome Measures:** Quadriceps AMT was determined as the lowest TMS intensity that elicited measurable motor evoked potentials (>100μV) in at least 5 out of 10 consecutive trials. Peak vGRF, vGRF linear loading rate (vGRF_LR), and peak KEM were calculated bilaterally. LSI (Injured Limb/Uninjured Limb) was calculated for each loading variable, with a LSI>1 indicating a greater value on the ACLR limb compared to the uninjured. Pearson product-moment correlations (r) and Spearman rank-order correlations (ρ) were used to determine associations between AMT and the LSI for each normally and non-normally distributed loading variable, respectively ($\alpha = 0.05$). **Results:** AMT was not significantly associated with any of the loading variables during gait (vGRF_LSI [$r = 0.17$, $p = 0.38$], vGRF_LR_LSI [$\rho = -0.08$, $p = 0.66$], and KEM_LSI [$\rho = .08$, $p = 0.67$]). **Conclusions:** The weak, non-significant associations between AMT and kinetic LSI's may be due to steady state gait being primarily controlled by central pattern generators, while tasks utilizing more cortical involvement (i.e. gait initiation, termination, or navigation) may rely more on higher corticomotor excitability. Additionally, AMT may be more strongly associated with timing outcome measures during gait (i.e. EMG onset times) rather than the magnitude measures used in this study.

## A Meta-Analysis of the Progression of Walking Kinematics and Kinetics Following ACL Reconstruction

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**Context:** ACL injury and subsequent reconstruction alter lower extremity gait kinematics and kinetics, however the progression of gait mechanics from time of injury through long-term follow-up after ACL reconstruction remains unclear. **Objective:** To compare 3D hip and knee kinematics and kinetics during walking gait between ACL deficient (ACLD), ACL reconstructed (ACLR), and healthy individuals. **Data Sources:** A search of PubMed and Web of Science databases for articles from 1980-2014 using the following key words: ("ACL reconstruction" OR "anterior cruciate ligament reconstruction" OR "ACL injury" OR "ACL deficiency" OR "ACL insufficiency") AND ("gait" OR "walking"). **Study Selection:** 511 studies were initially identified, 46 were eligible for inclusion, and subsequently 20 studies were excluded due to the inclusion of non-walking tasks, lack of mean and estimates of variability, or inconsistent normalization of kinetic variables. **Data Extraction:** Studies reporting peak kinematics and kinetics for knee and hip during the stance phase of walking gait were retained for analysis. Methodological quality for included studies was assessed using the PEDro scale. **Data Synthesis:** Data were organized by group (ACLR, ACLD, healthy) and limb (involved, contralateral). Weighted means and 95% confidence intervals (CI) were calculated for healthy, ACLD, and ACLR groups at each reported time since surgery (Range = 3-64 months). The magnitude of difference between the ACLR involved and contralateral limbs and healthy control group was estimated using Cohen's d effect sizes. Individuals with ACLD demonstrated reductions in knee flexion angle (d = -0.60), knee flexion moment (d = -0.97), and knee adduction moment (d = -0.60) compared to the healthy group. Individuals with ACLR demonstrated reductions in knee flexion angle (Range d = -0.56, -1.59), knee flexion moment (Range d = -0.67, -1.03) and knee extension moment (Range d = -1.00, -2.42) within 12 months after ACLR compared to healthy and contralateral limb. Between 12-24 months after ACLR, individuals demonstrated reductions in knee flexion angle (Range d = -1.01, -1.24), knee flexion moment (Range d = -0.43, -0.44), knee extension moment (Range d = -0.60, -1.49), and knee adduction moment (d = -0.81) compared to healthy and contralateral limb. Greater than 24 months after ACLR, individuals demonstrated reduced knee flexion angle (Range d = -0.56, -1.06), knee flexion moment (Range d = -0.43, -0.44), and knee adduction moment (Range d = -0.80, -1.23) compared to healthy and contralateral limb. **Conclusions:** The results indicate that individuals with ACLD and ACLR demonstrate persistent reductions in peak knee flexion angle, knee flexion moment, extension moment and adduction moments, which have been associated with knee joint cartilage degeneration and development of osteoarthritis.

## Gait Mechanics Depend Upon Quadriceps Central Activation Ratio in an Anterior Knee Pain Cohort

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**Context:** Quadriceps deficits are often present in an anterior knee pain (AKP) population. However, common self-reported classification tools including Visual Analog Scale (VAS), Kujala Anterior Knee Pain (KAKP), Tampa Scale for Kinesiophobia (TSK), Tegner Activity Level (TAL) scores, and/or other subject inclusion criteria may not be sensitive enough to identify specific movement characteristics in patients with AKP. Quadriceps central activation ratio (CAR) may help to discriminate movement characteristics in patients with AKP. **Objective:** To examine gait mechanics between two subdivisions of AKP patients, separated by quadriceps function (CAR < 0.95 and CAR > 0.95). AKP patients were defined by VAS, KAKP, TSK, and TAL scores. **Design:** Cohort. **Setting:** Controlled laboratory. **Patients or Other Participants:** 30 (M = 16, F = 14; 22.3 ± 3 yrs, 175 ± 9 cm, 72.5 ± 14 kg) AKP patients participated: 15 Quadriceps Deficit (QD: CAR = 0.91 ± 0.04, VAS = 3.87 ± 1.3, KAKP = 82.9 ± 6.6, TSK = 37.9 ± 4.7, TAL = 6.3 ± 1.2) and 15 Quadriceps Functional (QF: CAR = 0.97 ± 0.01, VAS = 3.93 ± 0.7, KAKP = 79.3 ± 7.9, TSK = 36.9 ± 5.2, TAL = 6.8 ± 1.4). **Interventions:** Subjects performed three quadriceps maximum voluntary contractions (MVC) for 3 sec on a Biodex dynamometer (100 Hz). When MVC torque plateaued 1.5-2 sec later, a superimposed burst was transmitted to two electrodes placed on their quadriceps to measure CAR. Two successful trials were averaged for data analysis. Subjects performed five gait trials at a self-selected walking speed. Gait data were collected using high-speed video (240 Hz) and a force plate (1200 Hz). A functional analysis was used to detect mean between-group differences in gait mechanics during the entire stance phase (0-17% = loading response, 18-50% = mid-stance, 51-83% = terminal stance, and 84-100% = pre-swing). This analysis allowed us to compare variables as polynomial functions rather than discrete values. If 95% confidence intervals did not overlap zero, significant differences existed between groups ($p < 0.05$). **Main Outcome Measures:** Sagittal-plane knee joint angle (°), internal knee joint torque (Nm), and vertical ground reaction force (VGRF; N/kg). **Results:** Relative to QF patients, QD patients demonstrated (i) decreased knee flexion angle at 4-90% of stance, (ii) reduced internal knee extension torque at 14-32% of stance, and (iii) reduced VGRF at 19-37% of stance and increased VGRF at 46-70% of stance ($p < 0.05$). **Conclusions:** The present data suggest that relative to QF patients, QD patients adopt quadriceps weakness gait mechanics that have been reported in individuals with knee osteoarthritis, ACL reconstruction, and effused knee joints. These alterations may create long-term compensatory gait patterns at the knee and adjacent ankle and hip joints, which may lead to mechanical and biological changes in knee articular cartilage. Future research is needed to examine a potential relationship between these gait alterations and articular cartilage health over the long-term.

## Characteristics Between Osteoarthritis and No-Osteoarthritis After Anterior Cruciate Ligament Injury: A Systematic Review and Meta-Analysis

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**Context:** The incidence of knee osteoarthritis (OA) increase after anterior cruciate ligament reconstruction (ACLR), with reports of nearly 50% of ACLR patients who had developed mild to moderate OA after 6 years following diagnosis of ACLR. However, the reasons for developing OA after ACL injury and ACLR are unclear. **Objective:** The purpose of this systematic review was to identify characteristics of knee OA followed by acute ACL injury. **Data Sources:** Three databases were used to collect papers (PubMed, CINAHL, and Scopus) until October 2015 using the search terms "anterior cruciate ligament", "reconstruction or injury" and "osteoarthritis". **Study Selection:** Studies were included if it met the following criteria: (1) Subjects with ACLR or ACL insufficiency after ACL injury, (2) Subjects with OA or no-OA, (3) written in English, and (4) mean, standard deviation, and sample size of each group had to be reported. All sources were cross-referenced to identify additional relevant studies. **Data Extraction:** Three investigators graded each study on the Physiotherapy Evidence Database (PEDro) scale. Nine studies that met the inclusion criteria yielded an average PEDro score of 4/10. Means and standard deviation were extracted from each study to compare characteristics in patients with OA and no-OA individuals after ACLR. **Data Synthesis:** Cohen's d effect size (ES) with 95% confidence intervals (CI) were calculated for each outcome to compare between groups. Meta-analysis was conducted if studies were homogenous. Six studies reported that patients with OA after ACL injury had an increased BMI (ES = 0.48; CI:

0.33-0.63). A moderate positive effect size was found in VAS activity scale (ES = 0.49; CI: 0.15-0.82). The gait patterns in OA after ACL injury was characterised by decreased pelvis obliquity angle (ES = -3.07; CI: -3.88,-2.15), a decrease in knee internal rotation peak angle (pooled ES = -0.57; CI: -0.87, -0.27), an increased pelvis anterior-posterior tilt angle (ES = 0.08; CI: 0.07, 1.30), increased hip flexion angle (ES = 0.97; CI: 0.32, 1.58), and an increased knee varus peak angle (pooled ES = 1.58; CI: 1.19, 1.97). In addition, OA after ACL demonstrated a decreased knee adduction moment (pooled ES = -2.36; CI: -2.78, -1.91), an increased knee internal rotation moment (pooled ES = 1.85; CI: 1.45, 2.26), and an increased ankle dorsiflexion moment (ES = 0.69; CI: 0.06, 1.29). **Conclusions:** The Strength of recommendation for this study is A with inconsistent results since there is a limited amount of studies to examine consistency. However, decreased pelvic obliquity, internal rotation, increased pelvic anterior tilt, hip flexion, and knee varus during gait should be monitored after ACL injury to prevent further development of OA. In addition, strengthening and neuromuscular control training of muscles that are associated with knee joint motions should be guaranteed to prevent OA.

### Changes in Self-Report of Impairments, Function and Disability Following Sport-Related Knee Injuries: A Report From the Athletic Training Practice-Based Research Network

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**Context:** Knee injuries commonly occur during physical activities. Evidence suggests that patients may experience long-term deficits in health status (ie, impairments, functional limitations, disabilities) following a knee injury, but little is known about short-term changes. **Objective:** To determine changes in self-reported health status, as measured by the International Knee Documentation Committee Form (IKDC), during the first two weeks of treatment post sport-related knee injury. **Design:** Cohort. **Setting:** Athletic training clinics within the Athletic Training Practice-Based Research Network. **Patients or Other Participants:** One hundred and two patients representing fourteen sports were diagnosed with a knee injury by an athletic trainer and grouped by injury severity based upon sport participation status at intake. At intake, 75 patients (male = 56, female = 19; age = 19.4 ± 8.2 years, height = 173.5 ± 11.2 cm, mass = 75.7 ± 15.4 kg) were restricted from participation and assigned to the severe knee injury (SKI) group, and 27 patients (male = 11, female = 16; age = 19.9 ± 8.2 years, height = 169.5 ± 13.9 cm, mass = 75.0 ± 19.7 kg) were cleared for participation and assigned to the mild knee injury (MKI) group. **Interventions:** The independent variables were injury severity and time. Patients received usual care from an athletic trainer and completed the IKDC during treatment sessions at Time 1 [(T1); range = 0-7 days post-intake] and Time 2 [(T2); range = 10-19 days post-intake]. The IKDC is a valid, reliable, and responsive (minimal important change [MIC] = 13 points) patient-reported outcome instrument that assesses impairments, function, and disability. The IKDC total score (TS-IKDC) ranges from 0-100, with higher scores indicating better health status. **Main Outcome Measures:** The dependent variable was TS-IKDC. Descriptive statistics (mean ± SD) were reported, and a generalized estimating equation was used to evaluate interaction and main effects of injury severity and time. Bonferroni-adjusted comparison evaluated pairwise differences ($P < .05$, two-tailed). **Results:** Patients completed the IKDC 12 days apart (SKI = 12.0 ± 2.6 days, MKI = 11.7 ± 2.7 days). A significant interaction ($P = 0.001$) was reported between injury severity and time, with the SKI group reporting greater improvement in TS-IKDC between T1 and T2 (14.1 ± 12.8 points) than the MKI group (8.8 ± 10.8 points). Significant improvements in TS-IKDC were reported for the SKI ($P = 0.001$; T1: 43.6 ± 19.1 [range 8-96], T2: 57.7 ± 18.9 [range = 18-100]) and MKI ($P = 0.001$; T1: 61.1 ± 15.3 [range 32-91] and 69.9 ± 15.4 [range = 39-98]) groups between T1 and T2. Individually, 54.7% (41/75) of the SKI group and 37.0% (10/27) of the MKI group exceeded the MIC value between T1 and T2. **Conclusions:** Patients suffering knee injuries report statistically significant changes in health status during the first two weeks of treatment. Patients with SKI generally report greater improvements during this time than patients with MKI. However, based on the MIC, a relatively small percentage of patients experienced a perceived meaningful change in health status during this time period. Future research should identify effective interventions that optimize patient outcomes on a short- and long-term basis following sport-related knee injuries.

### The Epidemiology of Severe Injuries Within NCAA Sex-Comparable Sports Between 2009/10−2014/15

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**Context:** Collegiate student-athletes frequently sustain injuries as a result of high intensity training and prolonged exposure to sport participation. Despite the known effect injuries can have on individuals physically, emotionally, and financially, there is limited evidence describing sex-comparable differences of severe injuries sustained by collegiate athletes. **Objective:** To describe the epidemiology of severe injuries within the NCAA's sex-comparable sports between the 2009/10-2014/15 academic years. **Design:** Descriptive epidemiology. **Setting:** Aggregate injury and exposure data from collegiate sports. **Patients or Other Participants:** Collegiate student-athletes within 7 sex-comparable sports: soccer, basketball, baseball/softball, cross country, track and field, tennis, and swimming and diving. **Interventions:** Injury data from the NCAA Injury Surveillance Program (ISP) during the 2009/10-2014/15 academic years were analyzed. A severe injury must (1) occur during a sanctioned competition or practice, (2) require medical attention by an athletic trainer or physician, and (3) result in time loss from sport activity of at least 21 days or not return for that sport season. **Main Outcome Measures:** Injury rates per 10000 athletic-exposures (AE), injury rate ratios (RR), injury proportions by body site and diagnosis, and injury proportion ratios (IPR) were reported with 95% confidence intervals (CI). **Results:** A total of 448 and 648

severe injuries were reported by men and women, respectively. The severe injury rate was higher in women than men (0.50/10000AE vs. 0.37/1000AE; RR = 1.36, 95%CI: 1.20-1.53). The number (men: n = 296, 66.1%; women: n = 475, 75.6%) and proportion (75.6% vs. 66.1%; IPR = 1.14, 95%CI: 1.06-1.24) of severe injuries that occurred to the lower extremity were higher in women than men. The most common diagnoses were sprains (men: n = 95, 21.2%; women: n = 203, 32.3%), strains (men: n = 122, 27.2%; women: n = 94, 15.0%), and fractures (men: n = 74, 16.5%; women: n = 77, 12.3%). Men had a higher proportion of severe injuries that were fractures (18.1% vs. 12.6%; IPR = 1.43, 95%CI: 1.14-1.81) and strains (27.2% vs. 15.0%; IPR = 1.82, 95%CI: 1.43-2.31). Women had a higher proportion of severe injuries that were sprains (32.3% vs. 21.2%; IPR = 1.52, 95%CI: 1.23-1.88) and stress fractures (6.7% vs. 3.1%; IPR = 2.14, 95%CI: 1.18-3.87). The most common mechanism of severe injuries was player contact (men: n = 104, 23.2%; women: n = 148, 23.6%). Distributions of mechanisms for severe injuries did not vary by sex. **Conclusions:** Our findings suggest prevention programs related to severe injuries may best benefit athletes when tailored by sex. Sex differences provide athletic trainers the ability to identify which severe injuries they are more likely to see in their setting and which injuries may require the most resources. Knowledge of these severe injuries can help clinicians advocate for the inclusion of appropriate preventative efforts to benefit patient outcomes. Additional research is warranted to drive the development and evaluation of interventions that aim to reduce the incidence and severity of injuries.

## Surveillance of Catastrophic Sport-Related Injury and Illness Among Middle School, High School, and College Athletes, 2013/14 to 2015/16

Kucera KL, Casa DJ, Drezner J, Guskiewicz KM, Register-Mihalik JK, Comstock RD, Dompier TP, Kerr ZY, Klossner D, Marshall SW, Siebert D, Stearns RL, Thomas LC, Wolff K, Wolf S, Yau RK, Cantu R: National Center for Catastrophic Sport Injury Research, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Exercise & Sport Science, University of North Carolina at Chapel Hill, Chapel Hill, NC; Korey Stringer Institute, University of Connecticut, Storrs, CT; Center For Sports Cardiology, University of Washington, Seattle, WA; Matthew Gfeller Sport-Related Traumatic Brain Injury Research Center, University of North Carolina at Chapel Hill, Chapel Hill, NC; Department of Epidemiology, Colorado School of Public Health, University of Colorado, Denver, CO; Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; Sports Medicine, Department of Athletics, University of Maryland, MD; Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, NC; Emerson Hospital, Boston, MA; Boston University, Boston, MA

**Context:** Surveillance is the first step to understanding the incidence and burden of public health problems, and is also an important step in evaluating the effectiveness of preventive measures designed to reduce incidence and burden. Catastrophic sport-related injuries/illnesses among athletes are relatively infrequent events, yet carry great significance for affected athletes, families, schools, and communities. **Objective:** To describe the incidence and characteristics of fatal and non-fatal catastrophic sport-related injuries/illnesses among middle school, high school, and college athletes in the U.S. **Design:** Catastrophic injury/illness surveillance conducted from 7/1/2013 to 11/4/2015. Events and details were captured through media searches of publicly-available news reports and reports from individuals. **Setting:** United States middle schools, high schools, and colleges. **Patients or Other Participants:** Middle school, high school and collegiate athletes in organized sports. **Interventions:** Characteristics of the athlete (gender, level of play), event (sport, event type, mechanism or activity) and injury (type, severity) were examined and stratified by catastrophic event type (cardiac, exertional/heat/environmental, or traumatic injury). **Main Outcome Measures:** Frequencies of fatal and non-fatal catastrophic sport-related injuries/illnesses were calculated. Incidence rates were reported per 100,000 participants. **Results:** There were 240 catastrophic injuries/illnesses captured from 7/1/2013 to 11/4/2015. Most occurred in males (90.4%), high school athletes (67.9%), and were non-fatal (54.6%). Half occurred during competition (50.0%) or during practice (32.1%). Over this period, traumatic injuries (43.8%) and cardiac-related events (41.3%) were most frequent, followed by exertional/heat/environment-related events (10.8%). Most traumatic injuries (n=105) were to the neck/cervical spine (45.7%) or head/brain (40.0%); due to player contact (75.2%); occurred during competition (81.0%) and in football (85.7%). Cardiac-related events included 99 cases of sudden cardiac arrest, 87.9% in males and 64.6% fatal; occurred most commonly during practice (40.4%), competition (29.3%), or strength/conditioning sessions (7.1%); and in male basketball (30.3%), football (30.3%), male soccer (10.1%), and track & field (5.7%). There were 26 exertional/heat/environment-related events including heat stroke (57.7%), heat exhaustion (15.4%), and other (26.9%). Most exertional/heat/environment-related events occurred during practice (73.1%) and in football (61.5%), cross-country (15.4%), or wrestling

(11.5%). Of the 109 fatal events, 58.7% were cardiac-related, 23.9% traumatic, 9.2% exertional/heat/environment-related, and 8.3% other; most occurred during practice (35.8%) or competition (30.3%). Traumatic injury incidence rates in high school and college were highest in football (2.1 and 3.5 per 100,000 participants respectively). The highest incidence of cardiac-related events in high school and college occurred in male basketball (1.2 and 13.5 per 100,000 participants) and football (0.9 and 2.1 per 100,000 participants). **Conclusions:** Catastrophic traumatic injury prevention remains an important area of focus particularly from player contact, during competitions, and in football. Sudden cardiac arrest and heat illness represented 52% of catastrophic events in young athletes with 60% resulting in death. Increased attention to proper emergency preparedness is critical to improve outcomes.

### Injury Epidemiology in a Youth Football Program

Oller DM, Blaszka BM, Pierce TP, Scillia AJ: Performance Physical Therapy & Sports Conditioning, Wayne, NJ; New Jersey Orthopedic Institute, Wayne, NJ; Saint Joseph's Regional Medical Center, Paterson, NJ

**Context:** While many football injury epidemiology studies have been conducted at the collegiate and high school levels, there is a paucity of studies evaluating youth football injuries for athletes ages 14 years and younger. Though participation in youth football remains popular, athletic trainers (ATs) are infrequently present at games to attend to injuries and to record data. **Objective:** The purpose of this study was to describe the football game injury experience of youth football athletes in one football club over one regular season of play. **Design:** Descriptive cohort epidemiology study. **Setting:** This field study was conducted with one township's football club for 4th through 8th graders, with one team allocated per grade. Data was collected weekly at games over an 8-week season. An AT was hired to provide athletic training services for all home and away games, and was responsible for documenting all AT-athlete contacts. A contact was defined as single episode in which an AT and athlete interacted for athletic training services, such as for an on-field injury assessment. **Patients or Other Participants:** Male and female athletes ages 9 through 14 years participating in a township's youth football club served as the target population. Enrollment for the 2015 season was 141 athletes, ranging from 16 through 36 athletes per team. **Interventions:** The independent variables are athlete school grade and team size. An injury surveillance instrument in SOAP-note format developed for this study was used to document each AT-athlete contact. The instrument was derived from the National Athletic Injury/Illness Reporting System (NAIRS), for which validity and reliability have been previously established. Any contact including a minimum of 2 variables of interest was included in the study, totaling 56 contacts over 29 games. Data were coded per the NAIRS. Frequency counts were obtained for all variables. **Main Outcome Measures:** Dependent variables included contact rates, injury rates, and injury type. Team enrollment was utilized to calculate rates per 100 exposures, measured in athlete-games, by grade. Chi-square tests were calculated to determine statistical significance of injury rates by team size. A p-value of less than 0.05 was considered statistically significance. **Results:** The AT-athlete contact rate was 1.4/100 athlete-games. The injury rate was 1.1/100 athlete-games. Grade 5, with 36 athletes, represented the lowest injury rate, 1.6/100 athlete-games. Grade 6, with 16 athletes, represented the highest, 12.5/100 athlete-games. Teams with less than 30 athletes were more likely to sustain injuries than teams with 30 or more athletes, $P < 0.001$. The majority of injuries were contusions, 31.1%. There were 2 fractures and 8 concussions. **Conclusions:** There was a relationship between team size and injury rates. Athletes on smaller teams were more likely to sustain injuries. The rate at which contacts and injuries occurred, and the types of injuries, demonstrated the need for ATs at youth football games.

# Free Communications, Oral Presentations: Functional Performance of Young Athletes

Saturday, June 25, 2016, 1:30PM-3:00PM, Room 316; Moderator: David Bell, PhD, ATC

### The Association of Sport Specialization and Training Volume With Previous Overuse Injury in Youth Athletes Participating in Youth Sports Tournaments

Post EG, Riekena JW, Trigsted SM, Rabas MR, McGuine TA, Brooks MA, Bell DR: The University of Wisconsin-Madison, Madison, WI

**Context:** Sport specialization is prevalent among youth athletes and has been associated with increased risk of injury in the clinical setting. However, the connection between specialization, training volume, and previous injury history in a more general sample of youth athlete is unknown. **Objective:** To examine the association of sport specialization with overuse injury in a broad sample of youth athletes participating in youth sports tournaments and to compare training volume between those who report a previous history of overuse injury and those who do not. **Design:** Case-control. **Setting:** Youth sports tournaments. **Patients or Other Participants:** 1893 youth athletes (905 female, 988 male) between the ages of 12-18 (mean age = 13.7 ± 1.6 years) were recruited at youth sports events to complete an anonymous survey. **Interventions:** Subjects completed a sport specialization survey that included questions regarding sport participation patterns, training volume, and sport-related injury history. Specialization was classified as low, moderate, or high, using a previously published 3-point scale. Chi-square tests were used to investigate associations of previous injury history by specialization category and independent t-tests were used to compare sport volume (months/year and hours/week) between participants with and without a previous history of injury (a-priori $p \leq .05$). **Main Outcome Measures:** Sport specialization categorization and sport volume (months/year and hours/week). **Results:** Overall, 656 subjects reported no previous history of injury, n = 497 reported a history of any overuse injury, n = 394 reported a previous lower extremity overuse injury, and n = 170 reported a previous upper extremity overuse injury. Subjects who reported any previous overuse injury (upper or lower extremity), lower extremity overuse injury, or upper extremity overuse injury were more likely to be highly specialized ($p < .001$), play their primary sport more months out of the year ($p < .001$) and more hours per week ($p < .001$), and play organized sports more months out of the year ($p < .001$) and hours per week ($p < .001$) than participants who reported no previous injury. Playing one sport more than 8 months out of the year was a risk factor for any overuse (OR = 2.0, 95% CI: 1.5-2.7, $p < .001$), lower extremity overuse (OR = 2.1, 95% CI: 1.5-2.8, $p < .001$) and upper extremity overuse injuries (OR = 2.2, 95% CI:1.5-3.4, $p < .001$). Similarly, playing more hours of organized sports per week than your age was a risk factor for previous overuse injury of any kind (OR=1.6, 95% CI: 1.3-2.0, $p < .001$), lower extremity overuse (OR = 1.6, 95% CI: 1.3-2.1, $p < .001$) and upper extremity overuse injuries (OR = 1.7, 95% CI:1.2-2.4, $p = .002$) **Conclusions:** Athletes who reported previous overuse injuries were more likely to be highly specialized and have greater sport participation volume than youth athletes with no previous sports-related injuries. Parents, coaches, and health care providers should be aware of the risks of early sport specialization and year-round sport participation.

### Peak Posterior Ground Reaction Force is Associated With Anterior Reach Distance During the Y-Balance Test in Adolescent Female Athletes

Goto S, Hannon JP, Christensen KB, Bothwell JM, Garrison JC: Texas Health - Ben Hogan Sports Medicine, Fort Worth, TX

**Context:** Ground reaction forces during jump landing tasks have been shown to increase loading to the anterior cruciate ligament (ACL), resulting in an increased risk of sustaining an ACL injury. The Y-Balance Test has been used to assess dynamic neuromuscular control, and decreased scores on this test have been shown to increase risk of lower extremity injuries. Currently, there are no studies that examine the relationship between these two measures. **Objective:** To examine the relationship between performance on the Y-Balance Test and ground reaction forces during a jump-landing task. **Design:** Cross-sectional correlations. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Twenty-seven high-school female athletes volunteered (Age = 16.15 ± 0.86 yr; Ht = 1.64 ± 0.06m; Mass = 59.43 ± 8.98 Kg). All participants were between the ages of 15-18 years, had IKDC scores ≥95, and were healthy at the time of testing. **Interventions:** Participants performed the anterior (ANT), posteromedial (PM), and posterolateral (PL) reaches of the Y-Balance Test. Ground reaction forces of dominant and non-dominant sides were collected with force plates while participants performed a jump-landing task by jumping from a 31cm high box, with a landing distance equivalent to 50% of the participants' height, followed by an immediate vertical jump. **Main Outcome Measures:** The maximal reach distance of ANT, PM, and PL of the Y-Balance Test of three trials were measured and normalized to the participant's leg-length. Peak vertical

ground reaction force (vGRF) and posterior ground reaction force (pGRF) were recorded during the stance phase of a jump-landing task, normalized to body weight, and averaged across three trials. Separate Pearson product moment correlations were performed to identify the association between each ground reaction force with each normalized reach distance ($\alpha < 0.05$). **Results:** There was a significant inverse correlation between the peak pGRF and ANT distance of the Y-Balance Test ($r = -0.447$, $p = 0.019$). No other significant correlations were observed between the other variables ($p > 0.05$). **Conclusions:** Greater ANT distance of the Y-Balance Test was associated with greater peak pGRF. Results of this study suggest that better performance on clinical measures of neuromuscular control and strength may not necessarily translate to a better kinetic performance during a jump-landing task. Those who perform better in ANT reach of the Y-Balance Test may adopt altered movement strategies that may increase pGRF. Future studies are warranted to investigate the common factors that contribute to this relationship.

## The Influence of Hip Strength on Landing Kinematics Across Functional Tasks in Adolescent Athletes

Whicker CR, Zuk EF, Van Wert KM, Baellow AL, Boling MC, Ford KR, Taylor JB, Pfile KR, DiStefano LJ, Williams MJ, Nguyen A: High Point University, High Point, NC; University of North Florida, Jacksonville, FL; University of Connecticut, Storrs, CT; College of Charleston, Charleston, SC; Wilmington Hammerheads FC, Wilmington, NC

**Context:** Decreased hip strength has been suggested to contribute to alter landing kinematics and increased risk of ACL injuries. Research has reported conflicting findings and is limited to adults. Limited studies have examined this relationship in a youth athlete population, where ACL injuries continue to increase. Furthermore, it is unknown whether a relationship exists across single and double leg landing tasks is. **Objective:** To examine the influence of hip strength on lower extremity kinematics in male and female youth athletes during functional tasks. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** One hundred and sixty four (86M, 78F: 11.0 ± 1.9 yrs, 144.7 ± 16.0cm, 38.7 ± 10.9kg) youth soccer players volunteered to participate. **Interventions:** Isometric strength of the hip external rotators (HER), abductors (HABD), and extensors (HEXT) was evaluated with a hand-held dynamometer and stabilization straps, using methods with known reliability (ICC > 0.80). Three-dimensional kinematics were assessed bilaterally using electromagnetic motion analysis system during a jump landing task (JL) and single leg hop (SLH). The JL was performed from a 30cm box set 50% of the participants' height away from a force plate. SLH trials were performed standing on a single leg, hopping forward over a 5" hurdle, and landing on the same leg (distance = 40% of height). **Main Outcome Measures:** The maximum isometric force across two trials was normalized to body weight (%BW). Hip and knee joint displacements in the frontal and transverse planes during the deceleration phase [peak knee flexion minus initial contact (GRF>10N)] of the JL and SLH were averaged over three trials. The mean values for the left and right were averaged for analysis. Separate step-wise, multiple linear regressions determined the extent to which hip strength predicted kinematics during each task in males and females. **Results:** During the JL, greater HABD (0.24 ± 0.04% BW) predicted less knee valgus displacement (-8.5±5.3°, $R^2 = 0.111$, $P = 0.003$), greater hip internal rotation displacement (9.7 ± 4.2°, $R^2 = 0.078$, $P = 0.015$) in females. During the SLH, greater HEXT (0.58 ± 0.21%BW) predicted greater knee external rotation displacement (-3.0 ± 3.1°, $R^2 = 0.057$, $P = 0.038$), greater hip adduction (13.1 ± 3.9°, $R^2 = 0.129$, $P = 0.001$) in females. Hip strength was not a significant predictor of hip and knee displacements in males and females during a JL and SLH task. **Conclusions:** Hip strength influences lower extremity motion during functional tasks in female youth athletes. Greater hip strength increased hip joint motion and decreased knee joint motion during a JL in females. Additionally, greater hip strength appeared to increase hip and knee joint motion during a SLH in females. Hip strength had no influence on lower extremity motion during functional tasks in male youth athletes. Future research should aim to clarify the role of hip strength on lower extremity biomechanics and it's influence on ACL injury risk.

## Sex Specific Influence of Hip Strength and Range of Motion on Landing Kinematics Across Maturation

Zuk EF, Baellow AL, Boling MC, Ford KR, Taylor JB, Pfile KR, DiStefano LJ, Williams MJ, Nguyen A: High Point University, High Point, NC; University of North Florida, Jacksonville, FL; College of Charleston, Charleston, SC; University of Connecticut, Storrs, CT; Wilmington Hammerheads FC, Wilmington, NC

**Context:** Changes in hip strength and ROM asymmetries during maturation may influence landing patterns, increasing knee injury risk in youth athletes. Whether this relationship is dependent on sex and maturation stage is unknown. Understanding this relationship is necessary in developing appropriate interventions to reduce knee injury risk. **Objective:** To examine the influence of hip strength and ROM asymmetries on landing kinematics across maturation in youth soccer athletes. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** One hundred and sixty-four (86M, 78F: 11.0 ± 1.9 yrs, 144.7 ± 16.0cm, 38.7 ± 10.9kg) youth athletes participated. **Interventions:** Passive hip internal rotation (IR) and external rotation (ER) ROM were measured using a digital inclinometer (ICC > 0.87). Isometric hip abduction (ABD) and extension (EXT) strength were evaluated using a hand-held dynamometer (ICC > 0.80). Bilateral, three-dimensional kinematics were assessed using an electromagnetic motion analysis system during a jump landing (JL) from a 30cm box set 50% of the participants' height from a force plate. The Pubertal Maturational Observational Scale (PMOS) determined maturation stage. **Main Outcome Measures:** Maturation groups: pre-pubertal (44M, 34F: PMOS < 2), pubertal (31M, 27F: PMOS = 2-5), and post-pubertal (11M, 17F: PMOS > 5). Asymmetrical unilateral hip rotation (AUHR) represented the average IR minus ER ROM. Normalized peak isometric hip strength (%BW), AUHR, and frontal and transverse plane hip and knee peak angles and joint displacements during the deceleration phase [peak knee flexion minus initial contact (vGRF ≤ 10N)] of the JL were used for analyses. Left and right values were averaged for analyses. Separate stepwise, linear regressions determined the extent to which hip strength and AUHR predicted lower extremity kinematics in males and females across maturation. **Results:** Pre-pubertal: In males, less EXT (0.62 ± 0.19% BW) predicted greater hip IR displacement (8.9 ± 5.2°, R2 = 0.150, P = 0.010), less peak knee ER (-3.8 ± 9.2°, R2 = 0.121, P = 0.024), and the combination of less AUHR (7.1 ± 9.4°, R2 = 0.181, P = 0.005) and EXT (0.61 ± 0.19 %BW, R2 change = 0.098, P = 0.026) predicted greater peak knee IR (11.5 ± 12.5°). In females, increased AUHR (16.6 ± 12.3°) predicted greater peak hip IR (3.3 ± 8.4°, R2 = 0.130, P = 0.039), while less ABD (0.24 ± 0.04%BW) predicted greater knee valgus displacement (-7.8 ± 4.4°, R2 = 0.170, P = 0.017). Pubertal: In males, greater AUHR (9.1 ± 11.5°) predicted greater hip adduction displacement (4.3 ± 2.3°, R2 = 0.198, P = 0.020) and less peak knee ER (-4.1 ± 6.4°, R2 = 0.183, P = 0.029). In females, less ABD (0.23 ± 0.05% BW) predicted greater peak knee IR (13.4 ± 11.9°, R2 = 0.206, P = 0.012). Post-pubertal: There were no significant predictors in males. In females, greater EXT (0.68 ± 0.18% BW) predicted greater peak hip IR (9.5 ± 12.0°, R2 = 0.326, P = 0.021). The combination of less EXT (0.68 ± 0.18% BW, R2 = 0.308, P = 0.026) and less AUHR (11.9 ± 6.7°, R2 change = 0.211, P = 0.033) predicted greater peak knee valgus (-6.8 ± 6.7°). Greater AUHR (11.9 ± 6.7°) also predicted greater peak knee ER (-6.8 ± 7.1°, R2 = 0.272, P = 0.038). **Conclusions:** The influence of hip strength on landing kinematics is specific to sex and maturation stage in youth soccer athletes. These sex specific relationships across maturation should be considered when developing youth injury prevention programs.

## Comparison of Saliva Hormones and Survey-Based Classifications of Maturational Stage in Youth Soccer Athletes

Wright AM, Zuk EF, Anderson T, Baellow AL, Boling MC, Ford KR, Taylor JB, Pfile KR, Lane AR, Hackney AC, Williams MJ, Nguyen A: High Point University, High Point, NC; University of North Carolina, Chapel Hill, NC; University of North Florida, Jacksonville, FL; College of Charleston, Charleston, SC; Wilmington Hammerheads FC, Wilmington, NC

**Context:** The risk of anterior cruciate ligament (ACL) injury in youth soccer athletes increases with age and physical maturation. Survey based, self-reported instruments to assess stage of physical maturation have limitations and questionable validity. The use of saliva sex steroidal hormones has been recommended to provide a more accurate depiction of maturational status. However, it is unknown whether sex hormone measures are reflective of survey-based assessments of maturation. **Objective:** To examine the relationship between sex hormones and survey-based assessments of maturation in youth soccer athletes. **Design:** Cross-sectional study. **Setting:** Field setting. **Patients or Other Participants:** Twenty-nine male (8.9 ± 0.8 yrs, 134.5 ± 6.7cm, 30.5 ± 4.6kg) and thirty-seven female (9.0 ± 0.8yrs, 125.4 ± 11.1cm, 29.0 ± 5.7kg) youth soccer athletes volunteered to participate as part of a multi-year screening project. **Interventions:** Resting salivary samples were collected on all participants prior to any physical activity. Chronological age, current height and weight of the athlete, and self-reported biological parent heights were recorded for the calculation of percent of predicted mature height (PMH). Participants and parents also completed the Pubertal Development Scale (PDS) and the Pubertal Maturation Observational Scale (PMOS). **Main**

**Outcome Measures:** Enzyme-linked immunosorbent assay procedures were used to determine free testosterone (males and females) and estradiol (females only). Percent PMH was calculated using the Khamis and Roche protocol. The total score for the PDS and PMOS were used for analyses. Separate Pearson correlations (r) examined the relationship between resting sex hormone levels and survey-based scores in males and females. **Results:** In males, there were no significant correlations observed between resting free testosterone and survey-based assessments of maturation (all $P > 0.05$). In females, percent PMH (0.71 ± 0.04) was correlated with resting free testosterone (19.7 ± 13.3 pg/mL, $r = 0.203$, $P = 0.010$), and estradiol levels (0.65 ± 0.39 pg/mL, $r = 0.270$, $P = 0.002$). **Conclusions:** Hormonal measures of maturation were not associated with survey-based assessments in male youth soccer athletes. Only percent PMH was associated with hormonal measures of maturation in youth females. Lack of significant correlation suggests that survey-based assessments of maturation may not be effective in evaluating stage of maturation in youth soccer athletes. However, our findings are limited due to sample size and the restricted age range of the subjects, requiring further research to clarify this relationship throughout a wider range of maturation stages.

## The Role of Maturation and Sex on Hip Strength and Core Endurance in Youth Soccer Players

Holmes VH, Zuk EF, Baellow AL, Nguyen A, Boling MC, DiStefano LJ, Williams MJ, Pfile KR: College of Charleston, Charleston, SC; High Point University, High Point, NC; University of North Florida, Jacksonville, FL; University of Connecticut, Storrs, CT; Wilmington Hammerheads FC, Wilmington, NC

**Context:** The development of core endurance and hip strength are critical factors in minimizing ACL injury risk. A lack of research exists regarding the influence of maturation on these measures for males and females. Understanding these relationships may be useful to clinicians in identifying at-risk athletes and developing preventative measures. **Objective:** To evaluate the relationship between core endurance and hip strength across maturation stages in youth soccer players. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** One hundred and sixty four (86M, 78F: 11.0 ± 1.9 yrs, 144.7 ± 16.0 cm, 38.7 ± 10.9 kg) youth soccer players volunteered to participate as part of a multi-year screening project. **Interventions:** The validated PMOS (Pubertal Maturation Observation Scale) was used to determine level of maturation. Core endurance was assessed using a side plank exercise (SPE). Previous research showed no significant differences between right and left SPE scores in healthy participants. Participants lay on their side with their dominant arm supporting them on the mat. When instructed, they lifted their pelvis superiorly to form a straight line from shoulder to feet while keeping the elbow flexed to 90° and feet in contact with the mat. They maintained this position for as long as possible. Using methods with known reliability (ICC > 0.80), two consecutive 5-second trials with a handheld dynamometer measured maximal voluntary isometric contraction (MVIC) for hip external rotation (ER), extension (EXT), and abduction (ABD) on the dominant kicking leg. **Main Outcome Measures:** Participants were grouped based on sex and maturation: pre-pubertal (PMOS < 2), pubertal (PMOS = 2-5) and post-pubertal (PMOS > 5). SPE times were measured using a stopwatch. MVICs were normalized to body weight (%BW). Separate correlations (Pearson and Spearman Rho, r) examined associations between MVICs and SPE times across maturation stages for males and females. **Results:** Pre-pubertal males (N = 44, 10.3 ± 1.8 yrs, 141.2 ± 11.2cm, 34.5 ± 8.8kg) had a significant correlation between SPE (46.3 ± 33.6sec) and EXT (64.3 ± 20% BW, $r = 0.384$, $P = 0.014$). Pre-pubertal females (N = 34, 9.5 ± 1.2 yrs, 129.0 ± 13.8cm, 30.0 ± 5.7kg) had a significant correlation between SPE (42.8 ± 37.7sec) and EXT (42.8 ± 37.7% BW, $r = 0.452$, $P = 0.007$). Pubertal males (N = 31, 11.6 ± 1.4yrs, 149.4 ± 10.0cm, 40.5 ± 7.7kg) had a significant correlation between SPE and EXT (74.9 ± 29.1% BW, $r = 0.545$, $P = 0.002$). There were no significant correlations between SPE and any MVICs for the pubertal female group (N = 27, 11.1 ± 1.6 yrs, 145.0 ± 13.5cm, 39.4 ± 8.8kg, 53.8 ± 38.0sec). Post-pubertal males (N = 11, 13.3 ± 0.6 yrs, 169.2 ± 10.6cm, 54.9 ± 10.2kg) had a significant correlation between SPE (109.6 ± 52.3sec) and ABD (24.5 ± 5.0%BW, $r = 0.657$, $P = 0.039$). Post-pubertal females (N = 17, 13.2 ± 0.9 yrs, 161.5 ± 4.8cm, 53.2 ± 5.8kg) had a significant correlation between SPE (84.9 ± 26.5sec) and EXT (69.1 ± 21.0% BW, $r = 0.559$, $P = 0.020$). **Conclusions:** All groups except the pubertal females showed a weak to moderate relationship between hip strength and core endurance. Maximal hip strength is not associated with core endurance in pubertal females and should be evaluated separately. These findings can be applied to ACL injury risk factor identification and prevention program implementation.

# Free Communications, Rapid Fire Oral Presentations: Factors Influencing Concussion Assessments

Thursday, June 23, 2016, 8:00AM-9:15AM, Room 317; Moderator: Tamerah Hunt, PhD, ATC

### The Effects of Aerobic and Anaerobic Fatigue During BESS Testing in High School Athletes

Clements AM, Brueck LA, Curran CM, Leeds CR, Linens SW: Georgia State University, Atlanta, GA

**Context:** The Balance Error Scoring System (BESS) is an objective balance test used to evaluate concussions, though the effect of fatigue on BESS testing in high school athletes is under-studied. **Objective:** The purpose of this study was to measure the effects of aerobic and anaerobic fatigue on BESS scores in high school athletes to determine a timeline for the return of static postural stability to baseline. **Design:** Repeated measures design. **Setting:** Four private high schools. **Patients or Other Participants:** Participants included 40 male and 40 female football, volleyball, soccer, and/or lacrosse athletes (age = 16.49 ± 1.06 years). Athletes with a concussion in the past year or an unresolved lower extremity injury were excluded. Sampling was determined based on sports with relatively higher rates of concussions where BESS was more likely to be preformed. The total number of participants was selected based on the need for data saturation. **Interventions:** Participants were tested using the BESS for a baseline measure and then performed the Yo-Yo Intermittent Recovery Test-Level 1 (Yo-Yo IR). The aerobic test began at Yo-Yo IR stage one and participants exercised until exhaustion. The anaerobic test began at Yo-Yo IR stage 23.1 and lasted two minutes. The BESS test was administered six times including one baseline test and five post-tests with five-minute increments. Each BESS test was video-recorded and scored at a later time. Pilot testing was completed prior to data collection to ensure inter-rater reliability. Statistical analyses were conducted using SPSS version 22 (SPSS Inc. Chicago, IL). **Main Outcome Measures:** Separate, 1-way repeated-measures analyses of variance were calculated to determine the recovery time course for the BESS for each exercise protocol. Three separate 2x6 repeated-measures analyses of variance were performed to determine if an interaction existed between exercise protocol, age groups, and gender verses recovery time. **Results:** Participants' BESS scores increased immediately after fatigue ($P < 0.0001$) and returned to baseline by post-test two ($P = 0.182$). There were no statistically significant differences on BESS scores between fatiguing protocols ($P = 0.917$), age ($P = 0.611$), and gender ($P = 0.622$). **Conclusions:** Since a deficit was seen in research in the high school population, our study was designed to assess high school athletes during their performance on the BESS over a period of time. The time period in which BESS should be administered after a high school athlete has been fatigued should be taken into consideration because recovery time was shown to have an impact on static postural stability. The BESS maintains its validity in our study and clinicians should continue to utilize this objective test as a concussion assessment. This study revealed an important implication where healthcare professionals should allow a time of at least eight minutes to rest before administering BESS when there is a suspected concussion.

### Repeat Computerized Neurocognitive Testing in Division I College Athletes

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**Context:** Computerized neurocognitive testing can be a useful tool to manage concussions. Experts recommend annual repeat computerized neurocognitive testing (RCNT). Recommended RCNT may introduce practice effects (improved performance) or "sandbagging" (diminishing performance) and adversely affect clinical decision-making. Alternatively, RCNT may not result in any meaningful change and, thus, unnecessarily burden athletic training resources (human, financial, and physical) to meet recommendations yielding no clinical value. **Objective:** To investigate neurocognitive test performance differences between initial baseline and RCNT sessions. **Design:** Longitudinal. **Setting:** Clinical research center. **Patients or Other Participants:** Eighty-seven NCAA Division I athletes (Male = 27; Female = 60; age = 19.7 ± 1.1 years) representing men's (football, soccer, and wrestling) and women's (crew, field hockey, lacrosse, soccer, softball, and tennis) sports. **Interventions:** Athletes completed an initial baseline computerized neurocognitive test battery (CNS Vital Signs) prior to the competitive season. The same participant group completed RCNT at least 5 months later (212 ± 43 days). Paired-samples t-tests were performed to analyze test-retest differences for all neurocognitive domain standard scores. **Main Outcome Measures:** CNS Vital Signs produces standard scores for verbal memory, visual memory, psychomotor speed, cognitive flexibility, complex attention, processing speed, reaction time, and executive functioning. The frequency of RCNT scores exceeding the reliable change index (RCI) for each neurocognitive domain was calculated.

Test scores identified as 'invalid' by CNS Vital Signs or outliers exceeding 2 standard deviations above or below the sample mean for each neurocognitive domain were omitted from our analyses. **Results:** Participants demonstrated statistically significant lower visual memory ($t78 = 3.63$; $P < 0.001$) during RCNT ($P > 0.05$ for all other domains), but the mean difference between original baseline and RCNT did not exceed the RCI. Comparison to established RCI values revealed the following frequencies of clinical improvement or decline comparing RCNT to initial baseline session: verbal memory (8.6% improved, 13.6% declined), visual memory (7.6% improved, 20.3% declined), psychomotor speed (11.5% improved, 15.4% declined), reaction time (18.5% improved, 27.2% declined), complex attention (20.0% improved, 13.8% declined), cognitive flexibility (13,0% improved, 23.4% declined), and executive functioning (15.2% improved, 17.7% declined). **Conclusions:** No statistical improvements with RCNT were observed, and the majority of our study participants did not demonstrate any clinical change from initial baseline testing with RCNT. Individually, more participants demonstrated a decline or no change in performance, which supports two important conclusions: 1) RCNT may introduce motivation issues (i.e. decline in performance), and/or 2) unnecessarily burden the athletic training human, financial, and physical resources to accomplish RCNT when the majority of participants will not see any change in performance. Future study should link RCNT changes to the attributes identifying athletes who may demonstrate clinically meaningful changes. This would allow clinicians to better target resources towards those specific athletes warranting RCNT.

## Test/ Retest Reliability for Pediatric ImPACT Post One to Two Years in Five to Eleven Year Olds

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**Context:** There is a scarcity of information regarding the pediatric population and sports-related concussions in the age range 5-11. Furthermore, there is no test on the market that assesses neurocognition in this age group. **Objective:** To assess the test retest reliability of a new Pediatric ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing) within a one to two year span. The ImPACT test was designed to test neurocognition in the pediatric population ages 5-11. **Design:** Cohort **Setting:** Quiet environment **Patients or Other Participants:** There were 39 students (6 females, 33 males) ages 5-11. Students were recruited from local sports (hockey and soccer) in a rural location to participate in this research. Mean BMI was 17.408 ± 3.685 and mean age 7.172 ± 1.535. The student's baselines were 15.859 ± 5.572 months apart for test/retest reliability. **Interventions:** Students were partnered with a trained Certified Athletic Trainer or athletic training student. The students worked one-on-one in a quiet environment. Each time the students participated they were rewarded with a small snack of their choice. The student's height and weight were measured or recorded from subjective parental report. **Main Outcome Measures:** Two-way mixed intraclass correlation coefficients (ICC) determined relationships between modules on the Pediatric ImPACT which are word list, design rotation, memory touch, stop and go and picture match. Pearson correlations examined if older children 7-11 were more reliable. **Results:** Intraclass correlation coefficients were strongly significant for Picture Match number correct [ICC = .858, P < .001] and average number of taps [ICC = .791, P < .001]. This improved in older children, ages 7 + (N = 25) Pearson correlations were strong for Picture Match number correct (r = .858, P < .001) and improved with children age 9 + (N = 7) (r = .966, P < .001). Results were moderately correlated for Stop and Go average time [ICC = .805, P < .001], Design Rotation average time [ICC = .716, P < .001] and Memory Touch number of sequences correct [ICC = .497, P = .019]. Weak, but significant correlations for Word Recall number correct [ICC = .275, P = .043] were found. **Conclusions:** This preliminary testing indicates that Pediatric ImPACT is consistent over time for several of the modules. The modules improve in consistency as a child's cognitive development changes over time.

## The Effect of Group Size on Baseline Computerized Neurocognitive Testing in Collegiate Athletes

DeWolf RM, Kaminski TW, Oldham JR, DiFabio MS, Bednarek AL, Buckley TA: University of Delaware, Newark, DE

**Context:** Baseline computerized neurocognitive testing (CNT) has become an essential piece to the diagnosis, treatment, and management of sports-related concussions. Typically, baseline CNT is performed in a group setting, despite recommendations and evidence that individual test results in better performance. However, the relationship between group size and CNT performance is currently unknown. **Objective:** The purpose of this study was to investigate the effects of group size during baseline CNT in collegiate student-athletes. **Design:** Prospective Cross-Sectional. **Setting:** Computer laboratory. **Patients or Other Participants:** Five hundred and sixty-nine NCAA Division I student-athletes (305 females; age: 19.9 ± 1.2). **Interventions:** Participants completed Immediate Post-concussion Assessment and Cognitive Test (ImPACT) prior to the start of the respective athletic season. Participants were tested in groups that ranged from 1-34 athletes at a time. Groups were divided into tertiaries (Small: 1-11, Medium: 12-23, Large: 24-34 participants). A multivariate MANCOVA, with Tukey post-hoc, compared CNT performance between groups with gender serving as a covariate. A linear regression was used to evaluate the effect of the number of participants during the test session. **Main Outcome Measures:** The dependent variables were the ImPACT composite scores (Verbal and visual memory, visual motor speed, reaction time, symptoms, and impulse control) and the independent variables were the group. **Results:** There was a significant main effect of the MANCOVA ($p < 0.001$) and there significant within group differences for Verbal Memory ($p = 0.007$), Visual Motor ($p < 0.001$), Reaction Time ($p < 0.001$), and Impulse Control ($p = 0.047$), but not for Visual Memory ($p = 0.091$) or Symptom Score ($p = 0.846$). There were limited significant post-hoc differences overall. Within Verbal Memory, the small group scored significantly higher than the large group (87.2 ± 11.2 and 85.9 ± 11.6 respectively, $p = 0.025$, $d = 0.11$). Visual motor, the medium group scored significantly higher than the small group (43.8 ± 5.8 and 40.6 ± 6.4 respectively, $p < 0.001$, $d = 0.52$) and the large group (43.8 ± 5.8 and 41.1 ± 6.4 respectively, $p < 0.001$, $d = 0.44$). Reaction time the small group scored significantly slower than the medium group (0.6 ± 0.09 and 0.56 ± 0.07 respectively, $p < 0.001$, $d = 0.50$) and the large group (0.6 ± 0.09 and 0.58 ± 0.08 respectively, $p = 0.005$, $d = 0.24$). There were no significant predictions for number of participants and the six dependent variables of interest. Multivariate Test Hotelling's trace determined significant difference ($p < 0.001$). **Conclusions:** There were significant differences that indicated group size differences, however, they were inconsistent with little difference and small effect sizes between groups. The results suggest that group size does not effect CNT performance. Future research should look into testing environment and test administer.

## Valid But Invalid: Suboptimal ImPACT Baseline Performance in College Athletes

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**Context:** Computerized neurocognitive tests are a common component of concussion protocols in sport. Valid baseline assessments are important when determining neurocognitive change following concussion, although recent investigations have noted high rates of invalid baseline test results in some populations. **Objective:** To investigate the frequency of suboptimal computerized neurocognitive test performance in college athletes. **Design:** Descriptive. **Setting:** Research Laboratory. **Patients or Other Participants:** Division I varsity athletes (n = 663) from 21 different sports. **Interventions:** Participants completed ImPACT testing per their institution's concussion management protocol individually or in pairs. Test results were reviewed to identify athletes who scored below the 16th percentile (i.e., below 1 SD < Mean) on any neurocognitive index compared to normative data. ImPACT was administered up to three times to athletes who scored below the 16th percentile. **Main Outcome Measures:** Paired t-tests were used to compare ImPACT Verbal (VEM) and Visual Memory (VIM), Visual Motor Speed (VMS) and Reaction Time (RT) composite scores between initial and subsequent administrations. The reliable change index (RCI) was used to determine clinically meaningful changes between tests. **Results:** In this sample, 81.3% (539/663) had valid baselines, 1% (7/663) were invalid based on ImPACT's validity criteria, and 18.1% (120/663) had at least one composite score below the 16th percentile but were not flagged as invalid by ImPACT. The latter criterion yielded 57 subjects who were readministered ImPACT with an average of 54.6 + 56.7 days between tests 1 and 2. The VEM (22/57) and

VIM (24/57) composite scores were the most frequent indices below our criterion. Significant improvements were observed for VEM ($t(56) = -3.96$, $p < 0.001$), VIM ($t(56) = -5.76$, $p < 0.001$), VMS ($t(56) = -5.33$, $p < 0.001$) and RT ($t(56) = 4.64$, $p < 0.001$) between tests 1 and 2. On the second administration, VEM (5/57), VIM (5/57) and VMS (6/57) were the most frequent indices below our criterion (RT 1/57). A third assessment was administered to those 17 athletes, and significant improvements were seen on VMS ($t(16) = -2.538$, $p = 0.22$) and RT ($t(16) = 2.67$, $p = 0.17$). Based on the RCI, 12 subjects showed decreased performance on at least one index during their second administration, and 3 subjects showed a decrease during the third. **Conclusions:** Overall, 18.1% of athletes who completed a baseline ImPACT assessment scored below the 16th percentile on at least one index, suggesting suboptimal performance. Upon reassessment, 88% of our sample improved to within normal limits. The RCI flagged 15 decreases in 14 different subjects, even though scores were above our criterion score. Clinician awareness of substandard baseline performance may increase the clinical utility of baseline assessments. Future research should address potential causes of "valid" but invalid baseline test performance.

## Minimum Detectable Change of Tandem Gait in Collegiate Athletes Following Concussion

Oldham JR, DiFabio MS, DeWolf RM, Best C, Kaminski TW, Buckley TA: University of Delaware, Newark, DE

**Context:** Impaired postural control is a cardinal symptom of concussion and is commonly assessed with the Balance Error Scoring System (BESS); however, the BESS has been heavily criticized for numerous limitations. As an alternative to BESS, tandem gait has been recommended as a clinically feasible dynamic balance test; however, there is limited data on changes post-concussion or with repeat administration. **Objective:** To examine post-concussion tandem gait scores and determine if they exceeded the minimum detectable change score (MDC) of the healthy controls. **Design:** Prospective Longitudinal **Setting:** Research laboratory **Patients or Other Participants:** Twenty healthy NCAA Division I student-athletes (Age: 19.65 ± 0.99 years; Height: 167.01 ± 4.19 cm; Weight: 59.81 ± 3.50 kg) made up the control group, and six NCAA Division I student-athletes (Age: 19.5 ± 1.87 years; Height: 182.03 ± 13.21 cm; Weight: 77.42 ± 10.3 kg; Concussion history: 0.67 ± 0.82 concussions) with diagnosed sports-related concussions were in the concussed group. **Interventions:** All participants completed four tandem gait trials during pre-season baseline testing (T1). A tandem gait trial consisted of each participant walking heel to toe down a 3m line and back as quickly as possible. The control group was retested at the end of their season (~3 months after baseline testing), and the concussed group was retested acutely (24-48 hours) post-injury (T2). An MDC score was calculated from the healthy controls to determine the smallest amount of change that would be considered meaningful. The MDC was calculated using the formula (1.96)(SEM)(2), where SEM was the standard error of the mean, and the data were compared using a 2x2 (group x time) ANOVA. **Main Outcome Measures:** The dependent variable was the best tandem gait score of the four trials. **Results:** There was not a significant interaction between group and time ($p = 0.47$). There was no significant group change between T1 and T2 for the post-concussion group (10.17 ± 2.12 s and 10.73 ± 3.77 s respectively, $p = 0.125$) or the control group (9.99 ± 1.82 s and 9.93 ± 1.57 s respectively, $p = 0.863$). Three of the six post-concussion participants had slower tandem gait times acutely post-concussion, but only two exceeded the calculated MDC of 0.63 seconds. **Conclusions:** Three of the six student-athletes had a worsening in tandem gait time following concussion, but only two of the three exceeded MDC. This is a preliminary study, with a limited sample size, and future investigations should examine tandem gait in a dual-task setting, which has demonstrated success in uncovering postural control impairments following concussion.

## Effect of Fatigue on Ocular Motor Assessments

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**Context:** Ocular motor assessment, along with balance and signs and symptoms assessments are used during immediate sideline concussion evaluations. Fatigue from rigorous physical activity can negatively affect balance possibly leading to a false positive concussion diagnosis. However, the effect of fatigue on ocular motor assessments remains unknown. **Objective:** To evaluate the effect of fatigue on two ocular motor tests; Near Point of Convergence (NPC) and King Devick test (KD). **Design:** Crossover Design **Setting:** University gymnasium **Patients or Other Participants:** Fifteen physically active individuals (8 male, 7 female; height = 171.07 ± 9.45cm, weight = 73.80 ± 15.35kg, age = 21.64 ± 1.21 yrs) from a convenient sample volunteered and verbally agreed to IRB approved consent forms. **Interventions:** Every subject participated in two data collection sessions (control and fatigue) and were randomly assigned a session to start. During the control session outcome measures were assessed before and immediately following twenty minutes of rest. During the experimental session outcome measures were assessed before and immediately following a 20 minute previously validated physical activity fatigue protocol. Four 2 (group) x 2 (time) ANOVAs with repeated measures on both factors were used for data analyses using IBM SPSS Statistics Version 21 ($p < 0.05$). **Main Outcome Measures:** The primary dependent variables were NPC and KD. During the NPC assessment participants were seated and a visual target was moved towards the eyes at 1cm/sec using an accommodative ruler. The participant signaled when they experienced diplopia or deviation of the eye was observed, and the distance (cm) was recorded. During the KD assessment participants read a series of numbers aloud from 3 test cards and were assessed on speed (sec) and accuracy (errors). Rate of perceived exertion (RPE) and heart rate (HR) were assessed using the Borg scale and a heart rate monitor, respectively, to confirm fatigue during experimental session. **Results:** No significant interaction effect was observed for NPC, $F(1,14) = 0.42$, $p = .527$, or KD, $F(1,14) = 1.55$, $p = .234$. The overall NPC average was 4.41 ± 3.44cm (95% CI = 2.51-6.31), and the overall KD average was 36.05 + 1.42sec (95% CI = 33.01-39.09; only 1 error was recorded). A significant group x time interaction effect was observed for HR, $F(1,14) = 363.79$, $p < .001$, and RPE, $F(1,14) = 1,829.33$, $p < .001$. During the experimental condition only, HR (179.80 + 4.55 bpm; 95% = 170.03-189.57, $p < .001$) and RPE (17.26 + .28; 95% CI = 16.65-17.87, $p < .001$) post test scores were significantly greater than HR (79.20 + 2.23 bpm; 95% CI = 74.41-83.98, $p < .001$) and RPE (6.13 + .09; 95% CI = 5.93-6.32, $p < .001$) pretest scores. **Conclusions:** Our results suggest that fatigue from physical activity does not affect NPC or KD scores. Therefore, there is less risk of a false positive concussion diagnosis due to fatigue during immediate sideline evaluation using these ocular motor assessments.

## The Sensory Organization Test: Does Testing Order Influence Reliability?

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**Context:** The Sensory Organization Test (SOT) is an accepted clinical measure of postural stability prior to and following a sport concussion (SC). Despite its clinical use, the SOT has been demonstrated to have variable evidence of reliability and sensitivity. Potential rationale for this variability is systematic error. One source of systematic error is the order in which SOT trials are administered. **Objective:** The purpose of this study is to compare the test-retest reliability of the SOT using serial and random administration of the SOT trials. **Design:** Crossover Trial **Setting:** Research laboratory **Patients or Other Participants:** Thirty-four participants (16 males and 18 females): mean age 21.2 + 2.08 years with an average height of 170.7 + 9.58 cm. **Interventions:** Participants were assessed on Days 1, 2, 45, and 50. At Day 1 all participants were administered the SOT trials in a serial order in order to minimize inherent practice effects. Participants were then randomly assigned into two groups which received either serial or random administration first followed by the alternate trial administration for Days 2, 45 and 50. **Main Outcome Measures:** Repeated measures analysis of variance (ANOVA) was used to assess performance across time for the SOT composite score and somatosensory, visual, and vestibular sensory ratios. Greenhouse-Geisser corrections were performed to account for violations of sphericity. Post hoc analyses were performed using paired t tests. Intraclass correlation coefficients (ICC) were calculated using a one-way random model to assess reliability between time points. ICC values > .75 were considered acceptable reliability for clinical utility. Analyses were performed with $\alpha = .05$. **Results:** For serial administration,

significant differences were noted across time for the SOT composite score ($F_{3,96} = 15.24$, $p < .001$), visual ratio ($F_{2.30,73.74} = 6.927$, $p = .001$), and vestibular ratio ($F_{3,96} = 5.396$, $p = .002$). For random administration, significant improvements across time were observed for the SOT composite score ($F_{(2.198,70.34)} = 19.770$, $p < .001$) and somatosensory ($F_{(2.30,73.53)} = 6.571$ $p = .001$), visual ($F_{(2.36,75.37)} = 8.513$, $p < .001$), and vestibular ($F_{(1.81, 57.90)} = 9.270$, $p < .001$) sensory ratios. The majority of significant improvements occurred between Day 1 and Days 2, 45, and 50 ($p < .05$) for both serial and random administration. Strong to weak reliability values were observed for serial (0.85 – 0.02) and random (0.94 - 0.07) administration. Approximately 58% and 75% of ICC values met the criteria necessary for clinical utility for serial and random administration, respectively. **Conclusions:** Overall, random administration of the SOT trials resulted in higher reliability coefficients when compared to serial delivery. Our results also suggest clinicians must be cognizant of the practice effects associated with repeated administration of the SOT when implementing the test into a concussion management protocol. Future research is needed to address the reliability of the SOT using a larger sample size to substantiate our findings.

## False Positive Rate of the Multifaceted Concussion Battery in Health Division I Collegiate Athletes

Hellwig C, Langdon JL, Munkasy B, Graham V, Buckley TA: Valor Christian High School, Highlands Ranch, CO; Georgia Southern University, Statesboro, GA; University of Delaware, Newark, DE

**Context:** Accurate assessment and diagnosis of concussions is critical to protect athletes from further injury. As part of the multifaceted concussion battery, typical clinical concussion management compares post-injury performance to baseline and degraded performance on any component is viewed as a failed test. There is limited investigation of the multi-faceted test false positive rate, which contributes to calculation of specificity. Further, the false positive relative the time difference between baseline and assessment has not been established. **Objective:** (1) evaluate the false positive rate of a clinical concussion assessment battery (BESS, SAC, ImPACT) in a healthy Division I collegiate athlete population and (2) examine differences in test scores based on time from baseline. **Design:** Prospective longitudinal study. **Setting:** Athletic Training facility. **Patients or Other Participants:** Forty-eight Division I collegiate athletes (70.8% Male, Age: 19.8 + 1.21) across 11 sports participated. Participants were grouped by time elapsed, by months, since baseline testing. **Interventions:** Participants completed the multifaceted concussion battery, including administration of the BESS, SAC, and ImPACT tests one day after an exercise session, in the same manner as a suspected concussion. **Main Outcome Measures:** The failure rates for each test were determined based on any increase in BESS score, any decrease in SAC score, or change in an ImPACT composite score exceeding the reliable change index. A failure in any one component was classified as a false positive test for the overall battery. A one-way repeated measures ANOVA was run to determine changes in baseline and current scores by time elapsed since baseline for each test. **Results:** The multifaceted concussion battery produced an 81% (39/48) false positive rate, with 20.8% of participants failing all three tests, 47.9% failing 2 tests, and 12.5% failing 1 test. BESS produced the most false positives (N = 30, 62.5%), followed by ImPACT (N = 16, 33.3%), and SAC (N = 13, 27.1%). No significant interactions were found between the time from baseline testing and differences in ImPACT or SAC scores. There was a significant main effect across time between BESS baseline scores and current testing scores ($p < .01$) with baseline scores (12.73 + 5.91) being significantly lower than current scores (15.35 + 7.02). All other statistical tests revealed no interactions or main effects. **Conclusions:** Eighty-one percent of athletes demonstrated a deficit from their baseline scores on one or more of the assessments, thus potentially failing the concussion battery and providing objective evidence of a possible concussion. These individuals may subsequently be removed from participation, which potentially elevates the likelihood of subsequent underreporting of potential concussion symptoms. Concussion tests, like all diagnostic tests, need to balance high sensitivity with high specificity to improve the overall healthcare of student-athletes.

# Free Communications, Rapid Fire Oral Presentations: NCAA Injury Surveillance and Epidemiology

Thursday, June 23, 2016, 9:30AM-11:00AM, Room 317; Moderator: Johna Register-Mihalik, PhD, ATC

### A Prospective Investigation Into Injury Occurrence and College Athletes' Perception of Susceptibility to Sport-Related Injury

Sigmund KJ, Arvinen-Barrow M, Earl-Boehm J: University of Wisconsin-Milwaukee, Milwaukee, WI

**Context:** Current psychological models suggest that an individual's perception of susceptibility to a health risk can impact the occurrence of that health risk. An athlete's perception of susceptibility to sport-related injury may have an effect on their cognitive appraisal of a potentially injurious situation, which could in turn affect muscle tension, attentional focus and direction, and injury may be more likely to occur. The Perceived Susceptibility to Sports Injury (PSSI) scale assesses an athlete's perceptions of their sports injury susceptibility. The PSSI is a 4-item scale that measures absolute and comparative risk perceptions on a 5-point Likert Scale (1 low-5 high), and has been shown to have acceptable levels of reliability and validity. While increased PSSI scores have been associated with self-reported previous injury history, an evaluation of PSSI score and injury occurrence has not been conducted **Objective:** To determine whether injury occurrence differed between varying levels of PSSI score. **Design:** Prospective, descriptive cohort **Setting:** Midwestern University **Patients or Other Participants:** 213 intercollegiate athletes (103 Male, 110 Female; 20 ± 1.4 years) across 8 teams from a NCAA Division one university were included. **Interventions:** The PSSI was completed prior to the 2014 fall season. Injury was defined as any musculoskeletal condition causing an athlete to seek care from their athletic trainer, excluding medical or skin conditions. Participants were divided into cohorts (injured, uninjured) based on injury occurrence over one year. **Main Outcome Measures:** Total PSSI was determined by averaging the scores of each inventory item. A higher PSSI score represented greater perceived susceptibility. PSSI scores were divided into quartiles ("very low": 1.0-1.75; "low": 2.0-2.25; "moderate": 2.50-2.75; "high": 3.0-4.75). The relationship between injury occurrence and quartiled PSSI scores was analyzed using a chi-square test. **Results:** Cohorts were similar (112 injured, 102 uninjured). No significant difference was found in the distribution between injured and uninjured athletes across the PSSI quartiles ($\chi^2 2(3) = 0.777$; $p > 0.05$). The distribution of the cohorts did not vary significantly among PSSI quartiles (very low PSSI: 25% uninjured, low PSSI: 27% uninjured, moderate PSSI: 21% uninjured, high PSSI: 29% uninjured; very low PSSI: 24% injured, low PSSI: 26% injured, moderate PSSI: 21% injured, high PSSI: 29% injured.) The number of athletes who sustained an injury was the same as those who were not injured in the high quartile (50% injured, 50% uninjured). **Conclusions:** Athletes were just as likely to sustain an injury regardless of perceived susceptibility to sport-related injury. It is possible that other psychological and physical factors contributed to the athlete's perceived susceptibility, and including these factors together may be more predictive of injury. A limitation of this study is that injury occurrence was examined, which does not include exposure level to consider injury rate.

### Interrelationships Among Factors Associated With Injury Risk Among College Football Players

Colston MA, Wilkerson GB, Butler MK, Masdon HM: University of Tennessee at Chattanooga, Chattanooga, TN

**Context:** Previous injury and volume of contact sport participation are well-recognized injury risk factors in football. Neuromuscular responsiveness to changing environmental conditions may be an important modifiable factor that can be evaluated with tests of reaction time and postural stability. **Objective:** To develop a multi-factor prediction model for the occurrence of core or lower extremity (Core/LE) injury among college football players. **Design:** Cohort study. **Setting:** Athletic facilities. **Patients or Other Participants:** 89 NCAA Division I-FCS football players (Mass: 101.11 ± 18.82 kg, Height: 1.85 ± .06 m). **Interventions:** Pre-participation injury risk screening. **Main Outcome Measures:** The primary analysis defined injury as any Core/LE sprain or strain that required evaluation and treatment over the course of a 19-week season. A secondary analysis of time-loss injuries was limited to those that completely restricted activity for ≥ 1 practice session or game. Visuomotor reaction time (VMRT) was quantified by a 60-s test on a Dynavision D2 system. Neurocognitive reaction time (NCRT) was obtained from a computerized ImPACT test. Postural stability was assessed by a 60-s unilateral squat hold (USH) task that was performed with the area of support limited to the forefoot and maintenance of 45 degrees of knee flexion. The Sway Balance mobile testing system was used to determine the standard deviation of instantaneous change in body mass acceleration (g), which was averaged for tests of both extremities. Self-reported history of concussion and Core/LE injury

was acquired at the pre-participation examination. Level of exposure to impact loading was represented by starter versus non-starter status in at least one game. Prediction models were developed from receiver operating characteristic and logistic regression analyses. **Results:** A 3-factor prediction model using the activity modification injury definition for occurrence of Core/LE injury included USH antero-posterior sway standard deviation ≥ 0.024 (ORadj = 9.53), Core/LE injury history (ORadj = 4.08), and starter status (ORadj = 3.58). Core/LE injury were 5 times greater among players who exhibited any 2 of 3 risk factors (OR 90% CI: 2.28, 10.95). A 2-factor prediction model for time-loss injury included Core/LE injury history (ORadj = 21.58) and concussion history (ORadj = 1.68). The odds for a time-loss Core/LE sprain or strain was 20 times greater among players who exhibited either 1 of 2 risk factors versus none (OR 90% CI: 5.56, 72.20). **Conclusions:** Pre-season screening results can be used to estimate the injury risk level of individual college football players. Although missing data for 37 players precluded retention of slow VMRT ≤ 743 ms in either of the multi-factor prediction models, a strong association with Core/LE injury was observed among the 52 players who completed the test (OR = 3.60; 90% CI: 1.27, 10.22). History of concussion and/or Core/LE sprain or strain may elevate Core/LE injury risk through adversely effects on neuromuscular responsiveness.

## Lower Extremity Injury Risk Among College Athletes Participating in Non-Contact Sports

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**Context:** Previous injury and poor postural stability are well-recognized injury risk factors in sports. An association between rapid fatigue of the core musculature and acute core or lower extremity (Core/LE) sprain and strain has been documented among athletes participating in a contact sport. However, relatively little evidence currently exists to guide assessment of risk for either acute or overuse injury among athletes who participate in non-contact sports. **Objective:** To identify predictors of acute or chronic Core/LE injuries in college athletes who participate in non-contact sports. **Design:** Cohort study. **Setting:** Athletic facilities. **Patients or Other Participants:** Twenty-three NCAA Division I athletes who were available for a pre-participation injury risk screening session. Sports represented included cross-country (2 male; 8 female), men's tennis (8), and golf (2 male; 3 female). **Interventions:** Pre-participation administration of physical tests for injury risk assessment. **Main Outcome Measures:** Injury was defined as any acute or chronic Core/LE injury that required evaluation and treatment over the course of the sport season. Body Mass Index (BMI) was calculated from height and body weight measurements. Core muscle endurance was measured by the Horizontal Trunk Hold (HTH) test, which measured the amount of time the participant could maintain a kneeling test position of 90 degrees knee flexion, 90 degrees of hip flexion, and a horizontally oriented torso. Postural stability was assessed by a 10-s unilateral squat hold (USH) task, which was performed with body weight evenly distributed between the forefoot and rearfoot and with the knee maintained in 45 degrees of flexion. The Sway Balance mobile testing system was used to determine the standard deviation of instantaneous change in body mass acceleration (g), which was averaged for tests of both extremities and designated as Postural Sway. Prediction models were developed from receiver operating characteristic and logistic regression analyses. **Results:** A Core/LE injury was sustained by 35% of the participants (8/23). A 3-factor prediction model (Naglekerke R2 = .60) for occurrence of Core/LE injury included Postural Sway (≥ .023), HTH (≤ 58 s), and BMI (≥ 22.7). The odds for a Core/LE sprain or strain was 28 times greater among athletes who exhibited ≥ 2 of the 3 risk factors (OR 90% CI: 3.59, 218.40). **Conclusions:** Pre-season screening results can be used to estimate the injury risk level of athletes who participate in non-contact sports for both acute and chronic injuries. The measures can easily be acquired during pre-participation screening in less than 5 minutes per athlete. Individualized training programs that target deficiencies in postural stability and core endurance may reduce injury risk.

## Comparison of Pitching Injuries Between NCAA Softball and Baseball Pitchers, 2009/10 – 2014/15

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**Context:** Injuries sustained while pitching are of growing concern in baseball; however, there are limited descriptive data on pitching injuries among softball pitchers. Given the difference in pitching biomechanics, it is surprising the likely differences in injury types between the sports has not been explored. **Objective:** To examine the differences in body site, diagnoses, and time loss of pitching injuries between National Collegiate Athletic Association (NCAA) baseball and softball players. **Design:** Descriptive epidemiology study. **Setting:** College baseball and softball. **Patients or Other Participants:** College pitchers during 2009/10-2014/15 academic years from 42 baseball and 52 softball programs reporting 83 and 131 team-seasons, respectively. Interventions: We analyzed injuries sustained while pitching from the NCAA Injury Surveillance Program (ISP). **Main Outcome Measures:** Injury proportion ratios (IPR) comparing distributions of injuries by body site, diagnosis, and time loss between baseball and softball pitchers were reported with 95% confidence intervals (CI). IPRs with 95% CIs that did not include 1.00 were considered statistically significant. Body site was categorized as head/face/neck; upper extremity (i.e., shoulder, arm/elbow, wrist, and hand); trunk; and lower extremity (i.e., hip/groin thigh/upper leg, knee, lower leg, ankle, and foot). **Results:** Overall, 161 and 115 pitching injuries were reported in baseball and softball, respectively. Most baseball pitching injuries were to the upper extremity (68.9%), whereas most softball pitching injuries were to the lower extremity (37.4%). Compared to softball, a larger proportion of baseball pitching injuries were upper extremity injuries (68.9% vs. 33.9%, IPR = 2.03, 95% CI: 1.54-2.68). Compared to baseball, a larger proportion of softball pitching injuries were to the head/face/neck (12.2% vs. 2.5%, IPR = 4.90, 95% CI: 1.66-14.50), trunk (16.5% vs. 7.5%, IPR = 2.22, 95% CI: 1.12-4.38), and lower extremity (37.4% vs. 19.9%, IPR=1.88, 95% CI: 1.27-2.78). The most common diagnoses in baseball pitching were shoulder strains (10.6%) and arm/elbow inflammation (10.6%). The most common diagnoses in softball pitching were shoulder inflammation (8.7%) and trunk strains (7.0%). Compared to softball, a larger proportion of baseball pitching injuries were shoulder strains (10.6% vs. 3.5%; IPR = 3.04; 95% CI: 1.05-8.78) and arm/elbow inflammation (10.6% vs. 2.6%; IPR = 4.05; 95% CI: 1.21-13.49). Most pitching injuries resulted in time loss <24 hours (baseball: 53.4%; softball: 67.8%). More pitching injuries resulted in time loss >21 days in baseball than softball (15.5% vs. 8.7%), although this finding was not significant (IPR = 1.79; 95% CI: 0.89-3.57). **Conclusions:** Baseball pitchers sustain a higher proportion of upper extremity injuries than softball pitchers. Conversely, softball pitchers report a significantly higher proportion of lower extremity injuries than baseball pitchers. Our findings provide important data to understand differences in injury proportions between the sports. With further study (e.g., epidemiology, biomechanics), these data will allow clinicians to develop more focused and effective injury prevention strategies.

## The Epidemiology of Deltoid Ligament Sprains in 25 National Collegiate Athletic Association Sports

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**Context:** Injuries to the deltoid ligament can result in significant time loss and disability in the athletic population. No previous studies have described the incidence of deltoid ligament sprains in a large sample of National Collegiate Athletic Association (NCAA) student-athletes. Such research is needed to understand the injury prevalence, injury mechanisms, and recovery patterns in NCAA student-athletes. **Objective:** To describe the epidemiology of deltoid ligament sprains in 25 NCAA championship sports. **Design:** Descriptive epidemiology study. **Setting:** Collegiate athletics. **Patients or Other Participants:** Student-athletes from 25 NCAA sports who were diagnosed with deltoid ligament sprains. **Interventions:** Deltoid ligament sprains were analyzed from the NCAA Injury Surveillance Program during the 2009/10-2014/15 academic years. **Main Outcome Measures:** Deltoid ligament sprain frequencies, injury rates, and rate ratios (RRs) were reported with 95% confidence intervals (CI). **Results:** During the study period, 380 deltoid ligament sprains were reported, resulting in an injury rate of 0.77/10000 athlete-exposures (AEs) (95% CI: 0.70, 0.85). Most deltoid ligament sprains occurred in practices (54.2%, n = 206). However, the competition rate was higher than the practice rate (1.92 vs. 0.51/10000 AE; RR = 3.73; 95% CI: 3.05, 4.57). The highest deltoid ligament sprain rates were in Women's Gymnastics (2.30/10000 AE; 95% CI: 1.05, 3.55), followed by Men's Soccer (1.71/10000 AE; 95% CI: 1.13, 2.30), Women's Soccer (1.60/10000 AE; 95% CI: 1.12, 2.08), and Men's Football (1.40/10000 AE; 95% CI: 1.18, 1.62). Nearly half

of all deltoid ligament sprains (49.7%, n = 189) were due to player contact. Of all sports, Men's Football had the highest proportion of deltoid ligaments sprains that occurred due to player contact (69.4%, n = 109). Also, 39.5% (n = 150) resulted in participation restriction time less than 24 hours; 6.6% (n = 25) resulted in participation restriction time over 21 days. Only 8.2% (n = 31) of deltoid ligament sprains were recurrent. **Conclusions:** Although the highest deltoid ligament sprain rates were found in Women's Gymnastics, the rate was imprecise (i.e., wide CI), thus highlighting the need for further surveillance of deltoid ligament sprains in the sport. Men's and Women's Soccer, and Men's Football also had high deltoid ligament sprain rates, which warrants further attention in those sports as well. More research is needed to further investigate this trend towards higher injury rates with softer playing surfaces. Most deltoid ligament sprains were due to player contact, and so future research should evaluate rules changes that may increase player safety (e.g., chop-blocking in football, illegal slide tackles in soccer). Although isolated deltoid ligament sprains are rare, clinicians need to be aware that properly recognizing and diagnosing these injuries can prevent the development of chronic ankle instability.

### The Epidemiology of Ankle Sprains in Youth, High School, and Collegiate Football

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**Context:** Variations in ankle injury rates and distributions among competition levels are unclear, but may help inform strategies to prevent ankle injuries during American football. **Objective:** Describe the epidemiology of ankle sprains in youth, high school (HS), and collegiate American football. **Design:** Descriptive epidemiology study. **Setting:** Youth, HS, and collegiate football athletics. **Patients or Other Participants:** Youth, HS, and college football athletes. **Interventions:** Injury and athlete-exposure (AE) data were collected by certified athletic trainers (ATs) from three injury surveillance programs: (1) the Youth Football Safety Study (YFSS); (2) the National Athletic Treatment, Injury and Outcomes Network (NATION); and (3) the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP). During the 2012-2014 seasons, the YFSS, NATION, and NCAA ISP included 310, 184, and 71 football team-seasons, respectively. **Main Outcome Measures:** Ankle sprain rates were calculated. Rate ratios (RR) compared ankle sprain incidence across competition levels. Injury proportion ratios (IPR) compared distributions of ankle sprains that were severe (i.e., time loss over 21 days) and recurrent (as defined by ATs) across competition levels. RRs and IPRs with 95% confidence intervals (CI) excluding 1.00 were considered statistically significant. **Results:** A total of 124, 897, and 643 ankle sprains were reported in youth, HS, and college football, respectively. This led to respective rates of 0.59, 0.73, and 1.19/1000AE. The ankle sprain rate in college was larger than that of HS (RR = 1.64, 95% CI: 1.48-1.82) and youth (RR = 2.01; 95% CI: 1.65-2.43). Most ankle sprains involved the lateral ligament complex (youth: 79.0%, n = 98; HS: 76.6%, n = 687; college: 60.5%, n = 389), followed by the anterior inferior tibiofibular ligament/syndesmosis (youth: 4.8%, n = 6; HS: 20.3%, n = 182; college: 24.4%, n = 157). The proportion of ankle sprains that were severe in college (6.4%, n = 41) was higher than those in HS (3.8%, n = 34; IPR = 1.68; 95% CI: 1.08-2.62) and youth (0.8%, n = 1: IPR = 7.91; 95% CI: 1.10-56.95). Specific locations of the most severe ankle sprains varied by competition level. In youth, the one severe ankle sprain involved the lateral ligament complex; in HS, most involved the lateral ligament complex (58.8%, n = 20); in college, most involved the anterior inferior tibiofibular ligament/syndesmosis (61.0%, n = 25). The proportion of ankle sprains that were recurrent in youth (15.3%, n = 19) was higher than those in HS (5.6%, n = 50; IPR = 2.73; 95% CI: 1.68-4.50) and college (7.0%, n = 45: IPR = 2.19; 95% CI: 1.33-3.61). At each competition level, most recurrent ankle sprains were to the lateral ligament complex (youth: 89.5%, n = 17; HS: 78.0%, n = 39; college: 57.8%, n = 26). **Conclusions:** Ankle sprain rates were highest in college. At all competition levels, most ankle sprains involved the lateral ligament complex. However, level-specific variations in ankle sprain severity and recurrence may highlight the need to develop level-specific policies and prevention strategies to reduce the incidence of these injuries.

## Perception of Risk of Injury on Grass Versus Indoor Field Turf Surfaces in Collegiate Football Players

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**Context:** Often perception of risk of injury can alter an individual's self-efficacy relating to playing a sport. Athletic trainers should consider discussing perception of risk when consulting with patients. **Objective:** To determine if perception of risk of injury changes when comparing surface types in collegiate football players. **Design:** Cross-Sectional Cohort. **Setting:** Football Team Meeting. **Patients or Other Participants:** Male Division II Football Players compared grass and new turf (n = 94). Football players that had experience on the old indoor turf compared it to the new indoor turf (n = 54). **Interventions:** Players completed the Risk of Injury in Sports Scale (RISSc) relating to their perception of risk of injury on old vs new indoor turf and new indoor turf vs. grass surface. The 24-item RISSc requires athletes to rate on a scale from 1 "very unlikely" to 6 "very likely" how likely it was that they would be injured while playing football through various methods. Using Cronbach's Alpha the internal consistency was .64 to .82. **Main Outcome Measures:** Paired T-Test compared perceptions of injury (RISSc) within two dependent surface groups (new vs old turf, new turf vs grass). **Results:** New Turf vs Grass (df = 93): Players felt on the new turf they were significantly more at risk of having the same injury as someone on their team (P = .012, Mean diff = 2.550, SD = .961) or more likely to injury themselves on a dangerous piece of equipment (P = .029, Mean diff = .181, SD = 789). Additionally, players felt they were more likely to be injured on grass from a poor playing surface (wet, bumpy, hard) (P < .001, Mean diff = -.883, SD = 1.440) or injure their ankle (P = .055, Mean diff = -.298, SD = 1.48). Old turf vs New Turf (df = 53): Players felt they were significantly more likely to be injured on the old turf: by collision with an opponent (P = .009, Mean diff = -.528, SD = 1.409), in practice (P = .001, Mean diff = -.604, SD = 1.198), from falling down (P < .001, Mean diff =-.868, SD = .194), after being tripped (P = .002, Mean diff = -.528, SD = 1.154), from a "cheap shot" (P = .044, Mean diff = - .302, SD = 1.067), from a poor playing surface (P < .001, Mean diff = -.792, SD = .902), to injure their neck or spine (P = .038, Mean diff = -.264, SD = .902), to have an arm or wrist injury (P = .007, Mean diff = -.375, SD = .985) or to injure their shoulder (P = .003, Mean diff = -.346, SD = .789). **Conclusions:** Players perceived the new turf to be similar to grass in injury rates, with more injuries related to irregular surface on grass. Furthermore, they felt more likely to suffer a multitude of injuries on the old turf compared to the new turf. Knowledge of perception of risk of injury may allow the Athletic Trainer to provide surface injury risk information when discussing self-efficacy in football players.

## Timing of Injuries and Exposure Type in Division I College Football: A 4-Year Program Analysis

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**Context:** Multiple factors related to injury have been evaluated in college football. To optimize injury prevention, whether a player competes on offense or defense, time in the season of injury, and exposure type (game or practice) need to be evaluated. **Objective:** To examine the injury relationships between offensive and defensive football players, period of the season and exposure activity (game or practice). **Design:** Prospective observational epidemiological study **Setting:** Division I college football team facilities. **Patients or Other Participants:** 63 NCAA Division I football players (186.1 ± 5.6 cm, 108.3 ± 24.8 kg) consented to participate as incoming freshmen. **Interventions:** During the 2012-2015 football seasons, consenting players were evaluated by a team physician for musculoskeletal injuries using the NCAA Injury Surveillance System (ISS) reportable injury definition during games and practice. Attendance was recorded to calculate athlete-exposures. **Main Outcome Measures:** Athletes were grouped based on whether they played offense or defense. Attendance and injury details were divided into time in the season (pre-, 1st half or 2nd half) and exposure type (game or practice). Descriptive statistics were calculated for all variables. Injury rates (IR) and confidence intervals (CI) were tabulated for all variables. Mid-P exact tests were used to calculate injury rate ratios (IRR) for comparison. **Results:** 73 injuries were documented (23 offense, 50 defense) with 13,078 athlete-exposures (5924 offense, 7154 defense). Offensive players showed a higher injury rate in the pre-season (IR: 4.782, IRR: 8.966, p = .014) and 1st half

of the season (IR: 5.892, IRR: 11.05, p = .002) compared to the 2nd half of the season (IR: 0.533) with no statistically significant difference between exposure type (p = .669). Defensive players showed no statistically significant difference between pre-,1st half and 2nd half of the season (p = .669, p = .577, p = .356); however, they experienced a significantly increased injury rate in games (IR: 19.722, IRR: 3.76, p < .001) versus practice (IR: 5.245). No statistical differences were noted between offensive and defensive players in the pre-season (p = .214) or 1st half (p = .604) of the season. Defensive players had an increased injury rate ratio in the 2nd half of the season (p = .003) compared to offensive players. No difference was noted in practice (p = .352); however, defensive players had a significantly increased risk in games (IRR: 7.11, p = .002). Overall, defensive players had an increased risk (IRR: 1.8, p = .017) when evaluating total injuries. **Conclusions:** Injury rates are significantly higher in games for defensive players and occur earlier in the season for offensive players. Further research is necessary to evaluate the importance of these trends by continuing to understand underlying causes for injury timing and type of exposure in college football. Understanding injury rates and trends will continue to advance training and optimize injury prevention.

## Injury Rates on Natural Grass and Artificial Turf Fields in Collegiate Men's Soccer, 2009/10 to 2014/15 Academic Years

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**Context:** In National Collegiate Athletic Association (NCAA) men's soccer, numerous injuries have been attributed to playing surface contact. Most college soccer fields are natural grass, although some are artificial turf. Few studies have compared injury rates occurring on both surface types in men's soccer. **Objective:** Compare injury rates on natural grass and artificial turf fields in collegiate men's soccer **Design:** Descriptive epidemiology **Setting:** NCAA men's soccer. **Patients or Other Participants:** Men's collegiate soccer student-athletes from 44 programs provided 104 team-seasons of data during the 2009/10 to 2014/15 academic years. **Interventions:** Men's soccer injury data from the NCAA Injury Surveillance Program during the 2009/10-2014/15 academic years. Injuries were restricted to those occurring on natural grass (grass) or artificial turf (turf), and sustained to the lower extremity hip/groin, thigh, knee, lower leg, ankle, foot **Main Outcome Measures:** Injury rates per 1000 athlete exposures (AE) were calculated. Rate ratios (RRs) compared rates by playing surface type. All 95% confidence intervals (CIs) that did not include 1.00 were deemed significant. **Results:** Overall, 1513 injuries were reported. Most injuries occurred on grass (71.2%, n = 1077), although the injury rate on turf was slightly higher (8.91 vs. 7.68/1000AE; RR = 1.16; 95%CI: 1.04-1.30). This finding was retained when restricted to those injuries resulting in time loss of at least 24 hours (4.45 vs. 3.36/1000AE; RR = 1.33; 95% CI: 1.13-1.56). Most injuries occurred to the ankle (turf: 18.0%, n = 78; grass: 15.0%, n = 162) and thigh (turf: 14.2%, n = 62; grass: 19.9%, n = 214). The ankle injury rate was higher on turf than natural grass (1.59 vs. 1.16/1000AE; RR = 1.38; 95% CI: 1.05-1.81). No other body part-specific rates differed by playing surface type. The most common diagnoses were hamstring strains (turf: 8.0%, n = 35; grass: 9.7%, n = 104) and ankle lateral ligament complex sprains (turf: 10.1%, n = 44; grass: 8.6%, n = 93). However, rates for these injuries did not differ by surface type. Approximately one quarter of injuries were due to non-contact on both surfaces (turf: 26.6%, n = 116; grass: 25.5%, n = 275). However, injury rates did not differ (2.37 vs. 1.96/1000AE; RR = 1.21; 95% CI: 0.97-1.50). Also, about 1 in 10 injuries were due to surface contact on both surfaces (turf: 10.3%, n = 45; grass: 11.1%, n = 120), and rates on grass and turf did not differ (0.92 vs 0.86/1000AE; RR = 1.07; 95% CI; 0.76-1.51). **Conclusions:** The larger count of men's collegiate soccer injuries on grass may be attributable to more players in our sample playing on grass fields. However, the injury rate on turf was higher than grass. It is important to note, we were unable to stratify for artificial turf type. Further research should continue to investigate this association between playing surface type and injury risk, while also examining additional extraneous factors such as turf type, weather and shoe traction.

### Incidence and Time-Loss Associated With the Five Most Common Injury Diagnoses in the National Collegiate Athletic Association's Injury Surveillance Program: 2009/10 – 2014/15

Roos KG, Kerr ZY, Djoko A, Dompier TP: Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

**Context:** Sports injuries are common in college athletes. However, common injuries can result in a variety of outcomes ranging from no time lost to career ending injuries. **Objective:** To describe the incidence and outcomes of the five most common injury diagnoses found in the National Collegiate Athletic Association's Injury Surveillance Program (NCAA-ISP). **Design:** Descriptive epidemiology. **Setting:** US collegiate athletics. **Patients or Other Participants:** Student-athletes from 25 NCAA sports from 2009/10–2014/15. **Interventions:** The five most common injury diagnoses were identified from NCAA-ISP data. The incidence and outcomes of these diagnoses, as well as the distributions of time loss were analyzed. **Main Outcome Measures:** Injury counts, percentages and mean number of days lost to sport were calculated for five injury diagnoses, and within strata of time-loss (TL), and season ending injuries. TL injuries were defined as injuries resulting in absence from sport ≥24 hours. Non-time loss injuries (NTL) were defined as those resulting in absence from sport <24 hours. **Results:** Of the 33,203 total injuries from this time period, the five most common injury diagnoses were: Ankle Ligament Sprain (n = 3,288, 9.9%), Concussion (n = 2,091, 6.3%), Hamstring Strain (n = 1,409, 4.2%), Medial Collateral Ligament (MCL) Sprain (n = 969, 2.9%) and Acromioclavicular (AC) Sprain (n = 847, 2.6%). Nearly all Concussions (n = 1894, 90.1%) were TL. AC Sprains had the highest percentage of NTL injuries (n = 403, 47.6%), followed by Ankle Ligament Sprains (n = 1,352, 41.1%), Hamstring Strains (n = 506, 35.9%) and MCL Sprains (n = 289, 29.8%). Concussions had the fewest NTL injuries (n = 109, 5.2%). MCL Sprains and Concussions had the largest percentage of season-ending injuries (n = 105, 10.8% and n = 113, 5.4% respectively). Ankle Ligament Sprains (n = 51, 1.6%), Hamstring Strains (n = 17, 1.2%), and AC Sprains (n = 10, 1.2%) had relatively few season-ending injuries. Of the TL injuries where the athlete returned within the same season, the mean length of time lost from sport was longest for MCL Sprains (16.4 days ± 23.7), followed by Concussion (11.3 days ± 10.0), Hamstring Strains (10.3 days ± 13.1), AC Sprains (10.2 days ± 10.3) and Ankle Ligament Strains (8.7 days ± 13.1). **Conclusions:** Three of the five most common injuries in college sports occur to the lower extremity, although the severity of these common injuries varied by diagnosis. Although most concussions were TL injuries, MCL Sprains had the longest average length of time loss. Sports medicine professionals should be prepared for the diversity of presentation and severity of these common diagnoses, and the immediate care and long term treatment that they require.

### The Epidemiology of Musculoskeletal Injuries of the Coxofemoral Joint in National Collegiate Athletics Association Men's and Women's Ice Hockey in the 2009/10 to 2014/15 Academic Years

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**Context:** Ice hockey is fast-paced and unpredictable in nature with an inherent high-risk of injury. There is limited research regarding the epidemiology of coxofemoral joint injuries in ice hockey, the majority of which is restricted to injuries resulting in participation restriction time of at least 24 hours. Furthermore, current research has focused on hip impingement injuries with particularly increasing concerns of femoroacetabular impingement (FAI). **Objective:** To describe the epidemiology of coxofemoral joint injuries reported by athletic trainers in collegiate men's and women's ice hockey from the 2009/10 to 2014/15 academic years. **Design:** Descriptive epidemiology **Setting:** Aggregate injury and exposure data from National Collegiate Athletics Association (NCAA) men's and women's ice hockey. **Patients or Other Participants:** Men's and women's collegiate ice hockey student-athletes during the 2009/10 to 2014/15 academic years. **Interventions:** Coxofemoral joint injury data from the NCAA Injury Surveillance Program (ISP) during the 2009/10 to 2014/15 academic years were analyzed. **Main Outcome Measures:** Injury rates per 1000 athlete exposures (AE), rate ratios (RRs), and injury proportion ratios (IPRs) were reported with 95% confidence intervals (CIs). **Results:** A total of 421 and 114 coxofemoral joint injuries were reported in men's and women's ice hockey. The coxofemoral joint injury rate was higher in men than women

(1.03 vs. 0.78/1000AE; RR=1.32; 95%CI: 1.08, 1.63). In addition, 55.6% and 71.1% of coxofemoral joint injuries in men's and women's ice hockey, respectively, resulted in participation restriction time less than 24 hours. Also, 7.6% and 0.9%, respectively, resulted in participation restriction time over three weeks. The proportion of coxofemoral joint injuries with participation restriction time less than 24 hours was greater in women than men (IPR=1.28; 95%CI: 1.11, 1.48). However, men had a higher proportion of coxofemoral joint injuries with participation restriction time over three weeks than women (IPR=8.67; 95%CI: 1.20, 62.73). The most common coxofemoral joint injury diagnosis was strain (men: 67.2%; women: 76.3%). Also, 12 (2.9%) and 3 (2.6%) cases of hip impingement were noted in men's and women's ice hockey, respectively. **Conclusions:** In ice hockey, coxofemoral joint injury rates were higher in men than women, which may be partially attributable to the checking rule difference between sexes; checking is not allowed in women's ice hockey. Although not reflected in our sample, FAI is an increasingly common diagnosis in the literature, likely due to the career affecting nature of the injury. Previous research states FAI has been misdiagnosed as strains, thus, the low incidence of FAI and high incidence of strains in our sample may support the previous literature. Future research should examine techniques to better detect FAI cases resulting in improved management and outcomes to avoid hip osteoarthritis.

# Free Communications, Rapid Fire Oral Presentations: Trends and Interventions for Heat and Hydration Risk Reduction

Thursday, June 23, 2016, 11:30AM-1:15PM, Room 317; Moderator: Brendon McDermott, PhD, ATC

## Professional Ice Hockey Athletic Trainers' Knowledge of Hydration Guidelines and Implementation of Practice

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**Context:** Proper hydration remains an important strategy for maintaining health and performance during physical activity. However, existing literature does not address hydration practices in ice hockey. **Objective:** To examine hydration strategies and techniques currently used by professional ice hockey athletic trainers (ATs). Second, to determine ATs' knowledge of established hydration guidelines and the effects of substances (ie, alcohol and caffeine). **Design:** Quantitative-qualitative survey. **Setting:** Varying competition levels of professional ice hockey. **Patients or Other Participants:** Professional Hockey Athletic Trainers' Society members currently working in the National Hockey League, American Hockey League, East Coast Hockey League, or Southern Professional Hockey League participated in the study (N = 82/109; 75% response rate; 69 males, 13 unidentified). **Interventions:** The Survey was administered through SurveyMonkey and sent to potential participants on 3 separate occasions. **Main Outcome Measures:** Questions consisted of: hydration assessment, available fluids and locations, available electrolyte supplements and protocol for administering, patient hydration education, knowledge of the National Athletic Trainers' Association (NATA) Position Statement on Fluid Replacement, knowledge on the effects of alcohol and caffeine on hydration, years as AT, and years in professional ice hockey. **Results:** Majority of ATs (n = 73) utilized at least one hydration status assessment; with weight charts pre-post practice and games most common (n = 60 and n = 52, respectively). Frequently available fluids, other than water and sports drinks, included coffee pre-post practice (n = 75) and games (n = 69), energy drinks pre-post (n = 44) and during games (n = 35), and protein recovery drinks pre-post practice and games (n = 59). Alcohol was more commonly available while traveling (n = 10). When determining need for electrolyte supplementation, 54 reported athletes had open access, 16 provided to any athlete who asked, and 4 provided supplements to athletes who experienced signs or symptoms. Only 1 AT reported not educating athletes about proper hydration. Of those who educated athletes, 46 did so throughout the entire season. There was a significant difference between years in professional ice hockey and hydration education ($\chi 2 = 21.9$, $P = 0.038$). Majority of ATs (n = 47) knew NATA pre-activity fluid recommendations, but were not aware of sodium supplementation recommendations (n = 57). ATs were less knowledgeable regarding caffeine, with the majority incorrectly indicating regular moderate caffeine (180mg) consumption increases urine output (n = 60), dehydrates individuals (n = 47), and delays fluid recovery (n = 47). There was a significant difference between AT experience and knowledge of caffeine increasing urine output ($\chi 2 = 12.8$, $P = 0.046$). **Conclusions:** Professional ice hockey ATs assessed hydration status, educated on proper hydration, and knew alcohol effects on fluid balance. There continues to be a misconception regarding caffeine effects on hydration and ATs were unfamiliar with the NATA recommendations for sodium supplementation to aid fluid balance. Furthermore, many ATs reported athletes had open access to hydration/electrolyte supplements, which poses potential issues regarding interactions with other supplements/medications, drug testing, and general health.

## The Physiological Effects of Individualized Sodium and Fluid Replacement After Exercise Induced Dehydration in Collegiate Football Players

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**Context:** Differences exist between individuals in sweat rate and sweat sodium concentration. It is known that higher levels of sodium in electrolyte beverage are more effective in fluid retention. Research has been done on individualized replacement, but 100% of fluid and sodium has not been studied. **Objective:** To investigate three different methods of oral rehydration when 100% of individual sodium and fluid losses are replenished. **Design:** Randomized crossover study. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** A volunteer sample of seven male Division II Collegiate football athletes (n = 7, height = 182.1 ± 4.2cm, weight = 111.1 ± 17.9kg, body fat = 21.6 ± 7.9%, and age = 22 ± 2 years) who were unacclimatized to heat. **Interventions:** Three rehydration methods: a low carbohydrate electrolyte control beverage (LCE = 6% CHO, 19 meq/L Na+), a high carbohydrate electrolyte beverage (HCE = 10% CHO 52 - 65 meq/ L Na+), and chicken noodle soup plus water (Soup = 28 g/L CHO, ~69 meq/L Na+). **Main Outcome Measures:** Urine and serum osmolality through freezing point depression. Serum and urine electrolytes (Na, K, Cl) through an ion selective electrode. Plasma volume through hematocrit and hemoglobin. Blood glucose through blood glucose meter. Net sodium balance, ad lib fluid consumption, urine volume, and fluid balance were all calculated. Statistical analysis between trials and across time was calculated by one-way ANOVA and ANOVA with repeated measure. Tukey post hoc test

was compiled to find differences within each trial. **Results:** The net sodium balance was significantly higher in the soup trial than LCE ($P < .032$) and in the HCE than LCE ($P < .009$). The plasma volume in the LCE trail is slightly less than HCE and soup at 30 ($P < .124$), 45 ($P < .258$), and 60 ($P < .302$) minutes. Blood glucose of LCE beverage was statistically different from the baseline at 0 min ($P < .046$), 30 min ($P < .006$), 60 min ($P < .036$) and 120 min ($P < .019$). Net sodium balance was statistically different between trials ($P < .008$) with Soup (1408 ± 1244mg) and HCE (1786 ± 1408mg) in positive sodium balance and LCE (-295 ± 631mg) in negative sodium balance. Amount of fluid retained in the trials was 0.59 ± 0.30L for LCE, 0.76 ± 0.18L for HCE, and 0.82 ± 0.16L for Soup, with a trend for LCE to be lower than the other trials approaching significance ($P < .072$). **Conclusions:** HCE and Soup were more effective than LCE in optimizing rehydration. This study suggests higher carbohydrate and sodium content should be used to optimize fluid retention particularly in warmer climates with multiple practice sessions a day where rehydration and sodium replenishment are difficult to achieve.

## Use of the Heat Stress Score to Predict Preparedness to Run in an Outdoor, Warm Weather Race

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**Context:** Literature has shown heat acclimatization optimizes one's preparedness to perform in the heat; however, obtaining physiological measurements of heat acclimatization status in the field has its limitations. Preliminary attempts to quantify heat exposure using a previous version of the Heat Stress Score (HSS) found minor correlations in predicting performance in an outdoor, warm weather race. **Objective:** To examine if the HSS equation is improved by integrating the magnitude of intensity in addition to the amount of heat exposure during exercise. **Design:** Observational, cohort study. **Setting:** Controlled laboratory testing was conducted for aerobic fitness measures. All participants completed an 11.26km road race in Falmouth, MA on August 16, 2015 (ambient temperature [TAMB] 25°C, relative humidity [RH] 69%). **Patients or Other Participants:** Fourteen participants (n = 8 males, n = 6 females) participated in the study (age 39 ± 11 y, body mass 67 ± 8.45kg, body fat 16.94 ± 4.58%, VO2max 51.05 ± 6.32mlkg-1min-1). **Interventions:** Participants completed VO2max testing approximately two weeks before race day in a laboratory setting, and logged their exercise for 28-days leading up to race day via an online questionnaire. Modes of exercise were outdoor, indoor, and indoor non-air-conditioned. Zip codes were used to retrospectively calculate weather data (TAMB, RH, Heat Index [HI]) using an online weather database (Weather Underground©). For indoor exercise bouts, the condition was standardized to TAMB = 20°C, RH = 30%, and HI = 18.89°C. HSS during training (HSST) and during the race (HSSR) using the equation HSS = (TAMB [°C]exercise duration [min]) was calculated to determine total heat exposure. Edward's Training Impulse Score (TRIMP = exercise duration [min]heart rate weighting factor) was used to quantify exercise intensity for both training (TRIMPT) and the race (TRIMPR). For each exercise bout, HSS and TRIMP were weighted and entered into the updated equation where HSS = 2(HSST/HSSR) + 1(TRIMPT/TRIMPR). **Main Outcome Measures:** Finish time (FT), VO2max predicted FT (VDOT-FTP), and self-predicted FT (FTP) were dependent variables; HSS and VO2max were independent variables. Pearson correlation was used to find significant associations between values, and values with clinical significance were analyzed via linear regression. Significance level was set a priori $P < 0.05$. **Results:** Average HSS was correlated with participant's FTP ($r = -0.562$, $R^2 = 0.32$, $P = 0.046$). Additionally, average HSS was moderately associated with FT ($r = -0.452$, $R^2 = 0.20$, $P = 0.104$) and VDOT-FTP ($r = 0.387$, $R^2 = 0.15$, $P = 0.171$). Average HSS and VO2max combined predicted 88% of the variance observed in FT ($r = 0.936$, $R^2 = 0.88$, $P < 0.001$), and 97% of the variance observed in VDOT-FTP ($r = 0.985$, $R^2 = 0.97$, $P < 0.001$). **Conclusions:** Average HSS during the 28-days prior to race day is a good predictor of FTP; furthermore, when combined with VO2max, average HSS is a strong predictor of FT. Therefore, athletes preparing for an outdoor, warm weather race may use the HSS to assist in achieving their FTP. Finish time prediction can be augmented if an individual's VO2max is known. Further research is needed to investigate the efficacy of the HSS in outdoor, warm weather races.

## No Group Differences in Resting Heart Rate or Blood Pressure in Collegiate Football Players When Supplemented With High or Low Sodium Concentration Fluids During Preseason

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**Context:** Football players are known to increase sodium intake during preseason to replace sweat sodium losses, however, this could lead to unhealthy cardiovascular side effects. **Objective:** To have two groups of football players consume either high or low sodium fluids in addition to normal daily sodium intake during preseason and measure serum electrolytes, osmolality, percent changes in plasma volume (%Change PV), resting heart rate (RHR), resting blood pressure (RBP) and mean arterial pressure (MAP). **Design:** Observational cohort. **Setting:** Training camp of one NCAA Division II team. **Patients or Other Participants:** Six pairs of physically matched players volunteered. The low sodium group (LNa+) were age = 22 ± .9 y, ht = 187 ± 2.1cm, wt = 107 ± 24.7kg, and BSA = 2.3 ± .33m2·kg-1) and high sodium group (HNa+) were age = 21.5 ± .5 y, ht = 187.3 ± 4.9cm, wt = 106.4 ± 23kg, and BSA = 2.3 ± .25 m2·kg-1. **Interventions:** Starting the morning of day5, on days with 1 practice/d LNa+ consumed 600mg·d-1 and HNa+ consumed 3000mg·d-1 of sodium in 2L of fluid. On days with 2 practices/d, LNa+ consumed 900mg·d-1 and HNa+ consumed 4500mg·d-1 of sodium in 3L of fluid. Low (300mg Na·L-1) and high (1500mg Na+·L-1) sodium fluids were identical in all other ingredients and taste, so players were blinded to treatment. Blood draws via 21g needle were done on day1 for baseline measures and in the mornings of days 5, 7 and 9 of training camp. Whole blood was analyzed for Hb, Hct, and serum was analyzed for electrolytes and osmolality. RHR and RBP were recorded every day (days 1-9) at least 4 times/d. From days 5–8 players practiced 6 times (half in shells and half in full pads). Practices lasted 2 to 2.5h. **Main Outcome Measures:** Serum Na+, K+ Cl-, osmolality, % Change PV, RHR, RBP and MAP. **Results:** Serum Na+ was not different over time in LNa+ but in HNa+ was higher (P = .03) on day7 (140.7 ± 1.8 mmol·L-1) and day 9 (141 ± .41 mmol·L-1) compared to baseline (138 ± 1.3mmol·L-1). No % Change PV occurred over time in LNa+ but in HNa+ PV was +11 ± 7.4% on day5, and +18 ± 14% on day9 above baseline (P = .002). There were no differences between groups in serum Cl- but both increased over time (P < .001). In both groups Sosm changed over time (P = .007) and was higher on day5 (289.2 ± 4.1mOsm·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 day 5. There were no group or time differences in RHR, RBP, MAP or serum K+. **Conclusions:** Football players who consumed high sodium fluids (4500 mg·d-1 above normal dietary intake) did not experience a rise in resting BP, HR or MAP even though this sodium intake increased PV and serum Na+ compared to players who consumed low sodium fluids. Increased serum Na+ and PV has been shown to assist in acclimatization and aid football players during preseason in hot and humid environments.

## Athletic Trainers' Knowledge and Practice Beliefs Regarding Exertional Heat Stroke Before and After an Educational Intervention

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**Context:** Death from exertional heat stroke (EHS) is preventable when evidence-based guidelines are followed. The assessment of body temperature using rectal thermometry and the treatment of cold/ice water immersion for patients' with EHS is the standard of care; however, rectal temperature assessment is still very controversial. Athletic trainers (ATs) may lack knowledge and comfort with the skills, and/or have concerns about privacy and liability. Educational interventions have yet to be examined as a means to increase comfort with the skills of rectal temperature assessment and immersion. **Objective:** Examine ATs' knowledge and practice beliefs before and after an educational intervention. **Design:** Pre/post quantitative experimental **Setting:** Participants attended one of two three hour workshops on EHS; one was held in a university classroom and the other was held at a state annual symposium. **Patients or Other Participants:** 38 ATs attended one of two workshops. Twenty-five (66%) ATs (primarily District 9; various settings; 21-60 years old) completed the pre and post questionnaires and were included in the analysis. **Interventions:** Educational intervention designed to increase knowledge and address concerns regarding EHS evaluation and treatment. The same questionnaire was completed before and after the educational intervention. **Main Outcome Measures:** Four paired samples t-tests were calculated to determine whether significant differences existed between participants' pre- and post- mean scores for factors of: attitudes toward use of cold water immersion (8 questions); attitudes regarding rectal temperature

in EHS evaluation (3 questions); attitudes toward use of other "cold" methods (3 questions); and perceptions regarding non-exertional influences on EHS (2 questions). **Results:** 78.2% of ATs reported that they use oral/ear assessment, or no body temperature assessment, to evaluate for EHS. Of those who did not use rectal temperature assessment, reasons included: lack of equipment/budget; concerns about liability/lack of consent especially when dealing with minors; concerns over the privacy/embarrassment/compliance of the athlete; and a lack of training to perform the skill. 41.7% reported cold immersion as their definitive method of cooling an athlete suspected of having EHS. Following the educational intervention: attitudes toward the use of cold/ice water immersion treatment for EHS were significantly improved ($t(24) = 4.187$, $p < .001$); attitudes toward the use of rectal temperature to assess body temperature for EHS evaluation were significantly improved ($t(24) = 8.663$, $p < .001$); and attitudes regarding the use of other 'cold" methods to treat EHS were not significantly changed ($t(24) = 1.684$, $p = .105$). **Conclusions:** The three hour educational intervention demonstrated a positive influence on increasing knowledge and possibly modifying practice beliefs related to the use of rectal thermometry and cold/ice water immersion in the short-term. An educational intervention that promotes best practices and current recommendations for clinical practice may be useful to increase compliance with evidence based practice guidelines.

### Certified Athletic Trainers' Use of Weight Charts to Measure Hydration Status

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**Context:** Determining an athlete's hydration status is important as it allows athletic trainers (ATs) to address hypo- or hyper-hydration concerns before they result in significant medical, thermoregulatory, or performance issues. Weight charts are an accurate, non-invasive measure of changes in hydration status. However, their clinical use by ATs is unknown. **Objective:** To determine the current practices of certified ATs' use of weight charts in athletic settings. **Design:** Mixed-methods survey. **Setting:** High school (HS), NCAA Division I, II, III, and NAIA colleges. **Patients or Other Participants:** 354 ATs (males = 162, females = 175) responded. One thousand random NATA members, meeting clinical site criteria, were initially recruited (response rate: 25% [250/1000]). An additional 104 ATs responded through social media and convenience emailing efforts to diversify clinical setting responses. **Interventions:** The fifteen-question survey housed on a website (SurveyMonkey) was developed by 3 content experts and 1 graduate student. The survey was piloted twice with local clinical ATs to determine the need for additional answer options and definition clarifications before data collection. ATs were sent reminder emails every 2 weeks during the 6 week data collection period. Frequency statistics (respondent number/354) were calculated for each question. **Main Outcome Measures:** Participants answered demographic questions followed by questions focused on weight chart use within the areas of: implementation, barriers, timing, and calculations. **Results:** ATs represented all clinical settings of DI (45.7%), DII, DIII, NAIA combined (19.9%), and HS (34.4%). The majority (57.2%) of ATs do not use weight charts to measure hydration status changes; citing time, space and help as barriers. Of those responders, the majority (67.7%) do not use another method to measure hydration status, indicating athlete education and self-monitored urine color as alternate interventions. Of those who use weight charts, 76% implement with football, 28% with soccer, and 6% with wrestling. Most (63.3%) ATs reported using weight charts 2 or 3 weeks in pre-season. Implementation included a paper chart (47.2%), in which the athlete (42.2%) or AT student (32.6%) record values in pounds (99.3%) versus kilograms (0.7%). The staff AT (56.2%) calculates changes as either an absolute (42.2%) or percent (36.7%) change from pre to post practice. Only 11.7% use a baseline weight for calculations. The majority (83.3%) of ATs do not verify a hydrated baseline weight prior to implementation of weight charts. **Conclusions:** Survey responses indicate the current culture of ATs in athletic settings is to not use weight charts due to administrative barriers. Of those who use weight charts, primary focus is on football athletes for 3 weeks in preseason using within-in practice changes only. Educational workshops or technology applications could be developed to begin changing culture to encourage weight chart use with more teams and calculate percent differences from verified, hydrated baseline weights.

## Policy Changes Reduce Exertional Sickling Related Deaths in Division I Collegiate Football Players

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**Context:** Division I collegiate football players with sickle cell trait (SCT) are 37 times more likely to die during exertion than those without SCT. In response to the exertional sickling-related death of an athlete in 2006, the National Collegiate Athletics Association (NCAA) enacted a bylaw beginning August 1, 2010 at Division I (DI) level requiring all institutions to offer SCT determination through screening or documentation of prior screening in all DI student-athletes. To date no evidence is available to indicate whether this policy has been effective in reducing the risk of exertional sickling-related deaths in collegiate football players. **Objective:** To examine the occurrence of exertional sickling related death in NCAA DI collegiate football players prior to and after the 2010 bylaw was mandated. **Design:** Descriptive epidemiological design. **Setting:** NCAA DI collegiate football. **Patients or Other Participants:** Collegiate football players participating at the NCAA DI level from academic years 2000/01 to 2014/15. **Interventions:** Time period before the SCT testing bylaw (2000/01 to 2009/10) compared to after (2010/11 to 2014/15). **Main Outcome Measures:** Exertional sickling-related deaths during sanctioned DI collegiate football activities, including conditioning sessions, practices, and competitions. Data surrounding collegiate football deaths was gathered from the National Center for Catastrophic Sport Injury Research 2014 report on football fatalities, the Korey Stringer Institute Sudden Death Registry, and independent research, allowing for the retrieval of indirect (non-traumatic) football fatalities at the collegiate level. Descriptive statistics include the frequency and percentage of exertional sickling-related deaths before and after enactment of the SCT bylaw. Fisher's exact probability test was used to determine the association between exertional sickling-related deaths in DI college football and before and after the implementation of the bylaw. Statistical significance was set a priori $p < 0.05$. **Results:** From academic years 2000/01 to 2009/10, 10 out of 21(48%) DI collegiate football non-traumatic training deaths were attributed to an exertional sickling episode, resulting in an average of 1.0 deaths•yr-1. The academic years 2010/2011 to 2014/2015 saw a significant reduction in non-traumatic exertional sickling-related deaths with only 1 out of 14 (7%) deaths attributed to an exertional sickling episode, ($p = 0.042$). The number of exertional sickling-related deaths out of the total non-traumatic training deaths in 5-year blocks was: 2000/01 to 2004/05 had 4/10 (40%); 2005/06 to 2009/10 had 6/11 (55%); and 2010/11 to 2014/15 had 1/14 (7%). **Conclusions:** Since the implementation of the 2010 NCAA bylaw regarding SCT status determination, there has been a statistically significant reduction in exertional sickling-related deaths among DI collegiate football student-athletes. These results suggest that policy changes, such as knowledge of SCT status, coupled with targeted education and tailored precautions should be considered at other collegiate levels to reduce the risk of sudden death during participation in athletes with sickle cell trait.

## The Effect of Water Content and Temperature on Relative Humidity in a Controlled Environment

McFadden NP, Konz SM, Garrett WZ, Timmons M: Marshall University, Huntington, WV

**Context:** The NATA instructs athletic trainers to use Bacharach Sling Psychrometers to measure relative humidity (RH) to determine environmental hazard risks towards athletes. Athletic trainers may not have the necessary materials every time to conduct heat index testing as per NATA guidelines. The exact methods are in question due to unclear instructions. **Objective:** To determine the difference in temperature and relative humidity when distilled and tap water at differing temperatures. **Design:** Controlled laboratory study. **Setting:** A temperature controlled room within a research laboratory. **Patients or Other Participants:** None. This was equipment reliability research. **Interventions:** The study investigated two water temperatures (39°F and 67°F) and two water sources (distilled and tap). Two Bacharach Sling Psychrometers doused in cold (39°F) and room temperature (67°F) water samples with no cross-contamination of water samples were used. Four RH measurements were recorded for each temperature and water source combination. The slide-rule method determined calculated RH, as well as equated RH. **Main Outcome Measures:** Temperature (F°) and relative humidity (%) were the dependent variables. A univariate analysis analyzed the data with significance set at the .05 level. **Results:** Water source main effect was significant ($F(1,16) = 15.000$, $p = 0.002$, mean difference = 1.25°F). Tap water samples created higher WBT and RH readings than did the distilled samples. The mean dry bulb temperature was higher during the tap water trials (75.5 ± 0.22°F). The water temperature main effect was significant ($F(1,16) = 5.400$ $p = 0.039$, mean difference = 0.75°F). The mean dry bulb temperature was higher during the cool water trials

(75.25 ± 0.22.°F). The water source by temperature interaction was also significant ($F(1,16) = ,5.400$ $p = 0.039$), with significant differences being found in the dry bulb temperature between the distilled and tap water measures during the room temperature trials. **Conclusions:** The results indicate the content of the water used within the sling psychrometer influenced the RH readings. Tap water generated higher WBT and RH readings than distilled water. These readings are capable of persuading athletic trainers to recommend different workloads for the same environment.

## Occurrence of Exertional Heat Stroke in High School Football Athletes Before and After Implementation of Evidence-Based Heat Acclimatization Guidelines

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**Context:** Exertional heat stroke (EHS) is consistently one of the three leading causes of death in high school athletes. This is quite unfortunate since most cases are preventable with proper precautions. The 2003 implementation of evidence based heat acclimatization (HA) guidelines has been extremely effective in reducing the incidence of EHS related fatalities at the collegiate level, however, there is no evidence purporting the efficacy of HA guidelines in reducing the risk of EHS deaths at the high school level. **Objective:** To examine the occurrence of EHS related deaths during preseason high school football practice before and after implementation of HA guidelines. **Design:** Descriptive epidemiological design. **Setting:** High school preseason football practices. **Patients or Other Participants:** High school athletes participating in football that succumb to EHS. **Interventions:** Implementation of HA guidelines mandated by state high school athletics' associations. **Main Outcome Measures:** Data were acquired through reports from: National Center for Catastrophic Sport Injury Research, the Korey Stringer Institute Sudden Death Registry, and subsequent Lexus Nexus media search examining EHS related death in high school football during preseason. Since 2011, 14 states have adapted the minimum standards for HA; NJ, TX in 2011; NC, GA, AR, AZ, FL in 2012; CT, MO, IA UT, MS in 2013; AL in 2014; and NE in 2015, cumulatively totaling 48 preseasons among the 14 states. The total number of EHS deaths and comparisons EHS deaths prior to and following implementation of HA guidelines were compared. **Results:** From 1980-2015, there have been 44 EHS related deaths during participation in preseason high school football practices. Prior to implementation of HA guidelines, states that have since adopted guidelines accounted for 22 out of the 44 total EHS deaths from 1980-2015 (a total of 456 preseasons). After implementation, there has only been 1 death in states that have adopted HA guidelines, however, the death occurred in a situation where the school was in violation of the state mandated HA guidelines. EHS deaths during preseason practices were 2.5 times greater in states before they adapted HA guidelines versus after implementation of the guidelines. **Conclusions:** Of the cumulative 48 preseasons in the 14 states that have adapted HA guidelines only one EHS death has occurred. While the overall occurrence of EHS related deaths during high school football has averaged 1.2 deaths over the 36 year reporting period, the data suggests that implementation of HA guidelines is effective method of reducing the risk of EHS death in high school football preseason practices.

## A Comparison of Five Heat Index Measuring Devices to the Local Weather Service

Powell RK, Konz SM, Garrett WZ, Timmons M: Marshall University, Huntington, WV

**Context:** The National Athletic Training Association's position statement recommends using the sling psychrometer as the gold standard for heat index measurement. However, athletic trainers are relying more on digital technology to evaluate heat index than previous. The technology is cheaper and easier to use. There have been limited studies comparing the validity and reliability between hand-held devices and their relevance to athletic training practice. **Objective:** To determine if hand-held devices reliably measure temperature and relative humidity when compared to the gold standard of the local weather service. **Design:** 3 x 3 x 6 Repeated measures. **Setting:** Outdoor on grass. **Patients or Other Participants:** No patient population used. This was an equipment reliability study. **Interventions:** Four digital devices were suspended in a frame on an outdoor grass surface. A sling psychrometer was the fifth device. The researcher calibrated the devices to manufacturer standards, allowed equalization, and followed procedures according to manufacturer instructions. Three measurement readings were taken from each device at three times during the day (0800, 1200, and 1800). The readings included temperature and relative humidity. This procedure occurred over three days. The researcher acquired data from the local weather service for comparison. Reported temperature and relative humidity outcomes from devices were analyzed using 1-way ANOVA with post hoc measures and ICC (3, k). **Main Outcome Measures:** Temperature (F°) and Relative Humidity. **Results:** Temperature (mean ± standard deviation): US local weather service 64 ± 12, Sling 59 ± 10, Extech watch 61 ± 10. Extech pen 62 ± 12, Digital Sling 59 ± 10, Skyscan 60 ± 10. Relative humidity mean with standard deviation: local weather service 43 ± 17.6, Sling 50 ± 17.8, Extech watch 41 ± 17.0. Extech pen 44 ± 17.4, Digital Sling 44 ± 18.5, Skyscan 40 ± 16.8. No significance was found when comparing temperature ($F = .280$; $P = .992$) or relative humidity ($F = .330$; $P = .892$) between five devices and the local weather service. The ICC (3,k) = .984 when all five devices were compared revealing a high reliability rating. **Conclusions:** The null hypothesis for both temperature and relative humidity was accepted. The results indicated there was no difference between temperature and relative humidity measures reported from each device compared to the local weather service. Time of day did not affect outcome measurements; nor did day collected. These hand held devices show reliability and validity.

# Free Communications, Rapid Fire Oral Presentations: Factors Influencing Head Impact Exposure in Lacrosse, Ice Hockey, and Divers

Friday, June 24, 2016, 7:30AM-8:30AM, Room 317; Moderator: Theresa Miyashita, PhD, ATC

### Difference in Mechanism of Head Impacts Measured Between Men's and Women's Intercollegiate Lacrosse Athletes

Le RK, Saunders TD, Bowman TG, Bradney DA, Breedlove KM: Lynchburg College, Lynchburg, VA, and Purdue University, West Lafayette, IN

**Context:** Men's and women's lacrosse are rapidly growing sports in the United States. Comparing magnitude and frequency across sex based on impact mechanism will provide data to improve injury-prevention techniques and reduce risk of head injuries. **Objective:** To analyze and compare the difference in magnitude and frequency of head impact mechanisms occurring in NCAA Division III intercollegiate lacrosse athletes. **Design:** Descriptive epidemiology study. **Setting:** Lacrosse fields. **Patients or Other Participants:** A total of 31 NCAA Division III intercollegiate lacrosse athletes (16 men age = 21 + 1 years, height = 179.70 + 5.82 cm, mass = 80.71 + 6.33 kg; 15 women age = 20 + 1 years, height = 165.43 + 5.25 cm, mass = 64.08 + 7.59 kg) participated in the study. **Interventions:** Participants wore an xPatch (X2 Biosystems, Seattle, WA) sensor during every practice and game during the spring 2015 season. The sensors recorded magnitude, frequency, and location of head impacts over 10 g. Recorded film footage from the event was synchronized with the time of each head impact to allow verification and mechanism coding. Head impacts were classified into 10 mechanisms (head to head, head to body, head to ground, stick to head, long stick to head, ball to head, goal to head, combination, padding to head, and unknown) that served as an independent variable along with sex. **Main Outcome Measures:** The dependent variables of linear and rotational acceleration of head impacts between the sexes based on impact mechanism were analyzed using MANOVA. We also calculated incidence rates per 1000 exposures and incidence rate ratios (IRRs) with 95% confidence intervals (CI) to determine frequency differences. **Results:** MANOVA results reported that there was a significant interaction between impact mechanism and sex (multivariate $F_{10,1796} = 3.682$, $P < .001$, $\eta^2 = .04$), and main effects for mechanism (multivariate $F_{18, 1796} = 3.762$, $P < .001$, $\eta^2 = .071$) and sex (multivariate $F_{2, 898} = 7.454$, $P < .001$, $\eta^2 = .016$). In men's lacrosse events, head to body (IR = 299.06, CI = 266.14-331.98) was the most common mechanism while stick to head (IR = 154.43, CI = 124.32-184.55) was the most common mechanism in women's lacrosse events. **Conclusions:** Across both sports, mechanisms of head to body and stick to head are penalty causing actions, but occur frequently suggesting a focus on stressing rule enforcement is warranted. Since mechanism and sex affect magnitude of head impacts, proper offensive and defensive techniques against opponents should be encouraged to reduce head impacts.

### The Effects of Preparedness and Activity on Head Impacts in Lacrosse Athletes

Rogerson CR, Jackson BC, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA, and Purdue University, West Lafayette, IN

**Context:** Head impacts are very common in sport and may have long term neurocognitive effects. Anticipation of an impact has been found to alter impact characteristics in ice hockey, but no similar studies have investigated a similar effect in lacrosse. **Objective:** To compare the magnitude and frequency of Division III intercollegiate lacrosse players' head impacts based on anticipation and impact activity during games and practices. **Design:** Descriptive epidemiology study. **Setting:** Collegiate lacrosse fields. **Patients or Other Participants:** A total of 16 male (20.8 + 1.11 years old, 179.7 + 2.29 cm, 80.7 + 13.9 kg) and 17 female (19.9 + 1.03 years old, 165.4 + 2.07 cm, 64.08 + 16.7 kg) lacrosse athletes participated voluntarily. **Interventions:** Participants wore xPatch sensors (X2 Biosystems, Seattle, WA) over the right mastoid process during every game and practice for the duration of the season. We filmed every practice and game in order to verify and code each impact. The level of anticipation (whether the athlete was in a ready position for the impact) and impact activity (whether the athlete was delivering or receiving the impact) were the independent variables. **Main Outcome Measures:** Magnitude (linear and rotational accelerations) and frequency were measured. Magnitude differences were determined using a MANOVA. Incidence rates (IRs) and incidence rate ratios (IRRs) with 95% confidence intervals (CIs) were used to calculate and compare frequencies. We set the alpha level to .05 a priori. **Results:** There were 701 verified impacts for men during 1060 exposures (IR =

661.32, CI = 612.36-710.28) and 214 verified impacts for women during 654 exposures (IR = 327.22, CI = 283.38-371.06; IRR = 2.02, CI = 1.73-2.36). Men and women who are anticipating an impact, with good body position, are 5 times more likely to sustain a head impact than when unprepared (Men: IRR = 4.75, CI = 3.92-5.90, Women: IRR = 5.19, CI = 3.43-7.83). Men and women most commonly received impacts (men IR = 357.55, CI = 321.55-393.54; women IR = 186.54, CI = 153.44-219.65) rather than deliver impacts (men IR = 198.11, CI = 171.32-224.91, IRR = 1.80, CI = 1.52-2.14; women IR = 62.69, CI = 43.50-81.88, IRR = 2.89, CI = 2.09-4.24). The independent variables did not significantly alter the combined dependent variables of linear and rotational acceleration ($F_{8,1774}$ = .525, P = .838, $\eta^2$ = .005, 1-$\beta$ = .752). **Conclusions:** Although men and women's lacrosse have very different rules, the likelihood of anticipating a hit with good body position compared to being unprepared is similar. Since the magnitudes for men and women's lacrosse based on anticipation and impact activity are not significant, focus at practice for men and women should be on receiving contact with good body position since those impacts are the most frequent.

## Characterizing Head Impacts in Boys' High School Varsity Lacrosse Players

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**Context:** High school boys' lacrosse concussion incidence has been shown to be second to only football. While studies have examined head impacts in other helmeted sports, no studies have investigated head impacts among boys' high school lacrosse players. **Objective:** To characterize head impacts during boys' varsity high school lacrosse games recorded by a wearable sensor and using video analysis. **Design:** Prospective cohort. **Setting:** Boys' high school varsity lacrosse games. **Patients or Other Participants:** 48 male high school lacrosse players (16.6 ± 1.2 years, 1.77 ± 0.06m, 73.4 ± 12.2kg) volunteered for this study (19 games: 2014 and 2015 seasons). **Interventions:** Boys' lacrosse helmets were instrumented with gForce Tracker sensors (GFT). Game video was recorded by a trained videographer using a camera located at highest point at the midfield location, and framed 1/3 of field. All GFT impacts were compared with video recordings for verification. Impacts were considered valid if the following criteria were met: a) linear acceleration ≥20g, b) player was identified on the field, c) player was in camera view, and d) impact mechanism could be clearly identified. **Main Outcome Measures:** Descriptive statistics (frequency, mean, standard deviation and median (M) of linear (g) and rotational velocity (RV) were calculated. **Results:** 1060 impacts (2014 = 542, 2015 = 518) were recorded by GFT (g = 46 ± 31; RV = 1093 ± 661degrees/s) during 368 player-games. Of these, 690 (65%) impacts were confirmed by video. On average, 36.3 verified impacts ≥20g occurred per game, corresponding with an average exposure of 11.5 impacts ≥20g per player-season. The 3 most frequent impact mechanisms were player (n = 448, 46.8 ± 31.9, M = 35.0g), stick (n = 164, 52.4 ± 38.9, M = 36.9g), and ball (n = 9, 71.2 ± 44.7, M = 51.6g) contact. The 3 most frequent body locations impacted were head (n = 322, 46.7%) followed by the torso (n = 127, 18.4%) and then shoulder (n = 120, 17.4%). Midfielders (n = 308, 44.6%) received the most impacts followed by attackmen (n = 201, 29.1%), defensemen (n = 89,12.9%) and goalies (n = 9,1.3%). Most impacts (n = 387, 56.1%) occurred in the offensive half of the field. The top 2 field locations for impacts were within the attack area (n = 462, 66.9%) followed by the midfield (n = 207, 30.0%) zone. The most frequent player activities at impact were delivering a body check (n = 160, 23.2%), followed by chasing a loose ball (n = 147, 21.3%) and advancing with the ball (n = 145, 21.0%). In most cases, the struck athlete received impact from the side (n=297, 43.0%) or front (n = 249, 36.1%) and did not anticipate the impact (n = 352, 51.0%). **Conclusions:** Our findings indicate that most head impacts were confirmed by video. Many of these impacts resulted from unanticipated bodily collisions striking the side of the helmet. Although greatest in number player collisions were associated with lower g forces compared with stick or ball impacts. Verification of impact mechanisms using video is critical to collection of sensor data. Support: US Lacrosse Sports Science and Safety Committee.

## Characterizing Head Impacts in Girls' High School Varsity Lacrosse Players

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**Context:** Girls' have higher rates of non-concussive head and facial injuries than boys' lacrosse players. Decreasing head impacts has been proposed as a strategy for reducing the risk of head injury. Yet, no studies have characterized head impacts among girls' high school lacrosse players. **Objective:** To characterize game related head impacts by mechanism, player position, and game situation during two seasons of girls' high school lacrosse. **Design:** Prospective cohort. **Setting:** Girls' high school varsity lacrosse games. **Patients or Other Participants:** 35 female participants (16.2 ± 1.2 years, 1.66 ± 0.05m, 61.2 ± 6.4kg) volunteered for the study during 28 games in the 2014 and 2015 lacrosse seasons. **Interventions:** Participants were instrumented with xPatch sensors affixed to the right mastoid process prior to each game. Game video was recorded by trained videographer using a single camera located at highest mid field location. Camera and x2 software were time synchronized at the start of each game. All game impacts recorded by the sensors were reviewed using video. Impacts were considered valid using the following criteria: a) linear acceleration ≥ 20g, b) player was identified on the field, c) player was in camera view, and d) impact mechanism could be clearly identified. **Main Outcomes Measures:** Descriptive statistics (frequency, mean, standard deviation and median (M) of linear (g) and rotational acceleration (RA) were calculated for all impacts. **Results:** 203 impacts (2014 n = 80, 2015 n = 123) were recorded by the xPatch (g = 36 ± 25; RA = 6573 ± 3517rad/s$^2$) during 477 player-games. Of these, 58 (28.6%) impacts were confirmed by video analysis. The median g and RA were 31.0 ± 19.7g and 4,976.5 ± 3,411.4rad/s$^2$ for all impacts. On average, 2.1 verified head impacts ≥ 20g occurred per game, corresponding with an average exposure of 1.70 impacts ≥ 20g per player-season. The top 3 mechanisms were contact with stick (n = 25, 37.1 ± 19.6, M = 31.4g), body (n = 17, 34.7 ± 16.4, M = 28.3g), and ball (n = 7, 44.6 ± 15.7, M = 38.8g). The top 3 body locations contacted were head (n = 28, 48.3%) followed by the torso (n = 12, 17.2%) and then shoulder (n = 10, 20.7%). Midfielders (n = 28, 48.3%) received the most impacts followed by defenders (n = 12, 20.7%), attackers (n = 11,19.0%) and goalies (n = 7,12.1%). Most impacts (n = 32, 55.2%) occurred in the defensive half of the field. The top 2 field locations for impacts were within the attack area (n = 36, 62.1%) followed by the midfield (n = 18, 31.0%) zone. Only 2 (3.4%) impacts resulted in a penalty. **Conclusions:** The incidence of verified head impacts in girls' high school lacrosse is quite low (~2 per game). Although fewest in number, ball impacts were associated with the highest impact magnitudes. While stick and body contact are illegal in girls' high school lacrosse, rarely did such impacts result in a penalty. Verification of impact mechanisms using video review is critical to collection of impact sensor data. Supported by the US Lacrosse Sports Science and Safety Committee.

## Comparison of Head Impact Magnitudes and Frequencies Between Intercollegiate Men's and Women's Lacrosse Players

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**Context:** Subconcussive impacts may lead to a decline in cognitive function later in life. Research studies have examined the effect of player position and type of play on head impacts in intercollegiate football players, but there is little available information on head impacts in lacrosse players. **Objective:** To compare magnitude and frequency of head impacts between lacrosse players based on player position and type of play. **Design:** Descriptive epidemiology study. **Setting:** Lacrosse fields. **Patients or Other Participants:** 31 National Collegiate Athletic Association (NCAA) Division III lacrosse players, 15 women (19.93 ± 1.03 years old, 65.13 ± 2.06 cm, 64.07 ± 16.74 kg) and 16 men (20.81 ± 1.10 years old, 70.75 ± 2.29 cm, 80.71 ± 13.95 kg), volunteered to participate. **Interventions:** Participants wore xPatch sensors (X2 Biosystems, Seattle, WA) for every game and practice during the 2015 spring season. Sex, player position, and the type of play (offensive, defensive, transition, man up, man down, or face-off) were the independent variables. We used film to verify and code all head impacts. **Main Outcome Measures:** The frequencies and magnitudes (linear and angular accelerations) of head impacts for each individual player were measured. We calculated incidence rates (IR) per 1000 exposures and incident rate ratios (IRR) with corresponding 95% confidence intervals (CI) to examine for differences in frequencies of head impacts. MANOVA was used to examine the effects of sex, player position, and type of play across both linear and angular accelerations. **Results:** We found sex, position, and type of play did alter the combined dependent

variables (F8,1776 = 2.171, P = .027, η2 = 0.019). In women, defensive plays had the highest number of impacts (IR = 142.20, CI = 106.44-162.67) while in men offensive plays had the highest number of impacts (IR = 236.79, CI = 207.50-266.09; IRR = 1.66, CI = 1.31-2.11). Based on player position, women's lacrosse defenders were most likely to sustain a head impact (IR = 174.31, CI = 142.31-206.31) and in men, midfielders were most likely to have head impacts (IR = 382.08, CI = 344.86-419.29; IRR = 2.19, CI = 1.78-2.69) **Conclusions:** Identifying player positions and activities during sports that are prone to high frequency of head impacts may allow more effective implementation of strategies to reduce head impacts and improve safety.

## Boys' Lacrosse Video Analysis Verification of Helmet Sensor Impacts

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**Context:** Collision sports have a high incidence of impacts resulting in concussions. Recent technology taking advantages of small and wearable sensors are increasingly being used in attempts to quantify the relative exposure (frequency and magnitude) of head impacts in such sports. Thus far, little research has verified the accuracy of impacts recorded by sensors using other sources of information (e.g., video). **Objective:** To verify the frequency of head impacts during boys' high school lacrosse games recorded by a wearable sensor technology (gForce Tracker) using video analysis. **Design:** Prospective cohort **Setting:** Field **Patients or Other Participants:** Thirty male participants (16.6 ± 1.2 years, 1.77 ± 0.06 m, 73.4 ± 12.2 kg) volunteered for this study and were monitored during 19 games in the 2014 and 2015 boys' high school lacrosse seasons **Interventions:** Boys' lacrosse helmets were instrumented with gForce Tracker sensors (GFT). Simultaneous game video was recorded by trained videographer using a single camera located at highest point at the mid field location. Videographers framed 1/3 of field, and followed the ball during game play. Camera and GFTs, including "dummy sensor", were time synchronized. A "dummy sensor" was triggered in view of the camera signaling the start and end of each game. All impacts recorded by the GFTs during games were compared relative to video evidenced head impacts. Impacts were considered valid if the following criteria were met: a) linear acceleration ≥20g, b) player was identified on the field, c) player was in camera view, and d) impact mechanism could be clearly identified. **Main Outcome Measures:** Descriptive statistics (frequency, mean and standard deviation of linear (g) and rotational velocity (RV) of all impacts were calculated. **Results:** A total of 3372 game day impacts ≥20g were recorded (2014 n = 2109, 2015 n = 1263) by the GFT. Of these total recorded impacts, 1060 impacts (2014 n = 542, 2015 n = 518) were recorded between game start and end times (g = 46 ± 31; RV = 1093 ± 661 degrees/s). From the 1060 impacts, 690 game time impacts were verified via video analysis (65%; g = 48 ± 34; RV = 1242 ± 617 degrees/s). Of these 690, 252 (37%) were between 20-29.9g, 234 (34%) 30-49.9g, 88 (13%) were between 50 and 69.9g, and 116 (17%) ≥ 70g. **Conclusions:** Overall, 65% of all head impacts recorded during boys' lacrosse game play were verified by video. The remaining 35% either were not a result of game play or could not be identified on video. Helmet sensors are an emerging technology providing opportunities to quantify head exposure to impacts during gameplay. Our findings indicate the need to cross verification of accelerometer data using other sources of information (e.g., video) or use of enhanced data recording/post processing techniques. Support: US Lacrosse Sports Science and Safety Committee.

## The Effect of Sex, Age Group, Position, Event Type, and Location on Head Impact Biomechanics in Youth Ice Hockey Players

Teel EF, Wasserman EB, Marshall SW, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Concussions represent a greater proportion of all injuries in youth ice hockey than in any other sport. While an established concussion injury threshold is not yet known, it is believed that sustaining high-magnitude head impacts increases injury risk. Thus, identifying factors related to higher magnitude head impacts may lead to enhanced skill development strategies or league rules designed to enhance player safety. **Objective:** To determine the odds of sustaining higher magnitude head impacts based on sex (females vs. male), age group (U14 vs. U16), position (forwards vs. defensemen), event type (game vs. practice), and head impact location (back, top, or side vs. front). **Design:** Prospective cohort. **Setting:** Field. **Patients or Other Participants:** Male (n = 112; height = 172 ± 9cm; mass = 66 ± 12kg; age = 15 ± 2 yrs) and female (n = 27; height = 160 ± 7cm; mass = 52 ± 10kg; age = 14 ± 1 yrs) competitive ice hockey players. **Interventions:** Participants' helmets were equipped with the Head Impact Telemetry System (Riddell, Rosemont, IL). **Main Outcome Measures:** Linear and rotational accelerations during all games and practices were collected. Multilevel binary logistic regression was used to model the relative odds of sustaining high-magnitude hits, defined as impacts above 95th percentile for linear (≥45g) and rotational acceleration (≥4000 rad/s$^2$) based on sex, age group, position, event type, and head impact location. **Results:** The odds of sustaining a high-magnitude linear impact ≥45g were increased for impacts to the back (OR: 2.49; 95% CI: 2.16, 2.86) and top (OR: 2.73; 95% CI: 2.32, 3.22) compared to the front of the head ($P < 0.001$). For rotational acceleration, the odds of sustaining a high-magnitude rotational impact ≥4,000rad/s$^2$ were higher during games than practices (OR: 1.45; 95% CI: 1.26, 1.68, $P < 0.001$) and higher for impacts to the back (OR: 1.35; 95% CI: 1.17, 1.55) and side (OR: 1.27; 95% CI: 1.11, 1.55) of the head compared to the front of head ($P < 0.001$). The odds of sustaining a high-magnitude rotational impact ≥4,000rad/s$^2$ were lower in the younger age group (U14 vs. U16, OR: 0.54, 95% CI: 0.41, 0.71; $P < 0.001$) and for top of the head hits (OR: 0.69; 95% CI: 0.55, 0.88, $P < 0.001$) compared to the front of head. There were no significant differences based on sex or playing position. **Conclusions:** Head impact location and event type appear to elevate the odds of sustaining more severe head impacts. Our data suggest impacts to the side and back of the head have higher magnitude. These locations are often associated with blindside body checks. Given this association, coaches and referees should emphasize and enforce proper technique, league rules, and good sportsmanship during hockey participation. The elevated odds of sustaining higher magnitude accelerations in games compared to practices may partly explain the higher concussion incidence rates during games compared to practice.

## Head Impact on the Brain in College-Aged Recreational, Experienced and Professional Divers

Hawkins HM, Moore MT: Northern Michigan University, Marquette, MI

**Context:** High contact athletics are the main media focus regarding neurocognitive deficits following concussion, conversely, low impact sports like diving are not often considered a risk. A paucity of research exists regarding potential gravitation forces the brain is subjected to in college aged divers in a single or repetitive diving situation. **Objective:** This research aims to provide preliminary data on the gravitational forces that the head encounters when a person dives head first into the water with three repetitions. **Design:** Quasi-experimental. **Setting:** In the dive tank of the pool at a Midwestern Division II University. **Patients or Other Participants:** There were 24 participants from ages 18 to 22 years, with an average BMI of 23.087 + 2.306 that were divided into three groups by skill: recreation (n = 8), some experience (n = 10) and professional (n = 6). **Interventions:** Participants wore a head-mounted accelerometer measuring g-force under a swim cap centered on the top of the head when diving from a series of three different heights to quantify the forces: 0 meters (side of pool), 1 meter and 3 meter diving boards. **Main Outcome Measures:** A one way ANOVA determined the differences between groups. Our independent variable was skill level (recreation, some experience, and professional). Our dependent variables were height of dive (0 meter, 1 meter, 3 meter). Average force of impact per height was reported. **Results:** A one way ANOVA found a significant difference between skill levels with 0m ($P = .040$), 1m ($P = .004$), 3m ($P = .001$). Post hoc comparisons found the largest difference at 0 meters was between the some experience and professional group with a mean difference of

23.844g (P = .039). At 1m there was a mean difference of 39.805g (P = .005) between recreation and professional, a mean difference between some experience and professional of 33.022g (P = .014). At 3 meters there was a mean difference of 52.097g (P = .001) between recreation and professional and a mean difference of 28.141g (P = .032) between some experience and professional. The results of this study showed that from a height of 0 meters, the average force of impact was 39.606 ± 24.785g, from 1 meter it was 50.806 ± 31.961g, and from 3 meters it was 61.791 ± 37.061g. Overall there were a total of 108 mild impacts (0-50 g's), 63 hard impacts (51-80 g's), and 43 severe impacts (81-130 g's). The some experience group had the most severe impacts with 23 total (average 2.3 per person). **Conclusions:** These findings indicate that an increase in dive height results in an increase in impact force whereas an increase in dive skill results in a decrease in impact gravitational force. Athletic Trainers should be aware of potential risks of water impacts for all levels of divers.

1. White A. Sports-Related Head Injuries. Journal of Emergency Nursing. 2012;38(5):463-465.
2. Naunheim RS et al. Comparison of impact data in hockey, football, and soccer. J Trauma. 2000; 48(5):938-941.

# Free Communications, Rapid Fire Oral Presentations: The Mind Matters: Psychosocial Factors of Injury

Friday, June 24, 2016, 8:45AM-10:00AM, Room 317; Moderator: Johanna Hoch, PhD, ATC

### Examination of Eating Disorder Risk Among Collegiate Equestrian Athletes

Dodson K, Torres-McGehee TM, Kimmel M, Emerson D: University of South Carolina, Columbia, SC, and University of Kansas, Lawrence, KS

**Context:** Due to the aesthetic demands of Equestrian, athletes are at a high risk for eating disorders and an increase in psychological risk factors. **Objective:** To examine eating disorder (ED) risk among collegiate equestrian athletes. A secondary purpose was to examine differences between riding discipline (English vs. Western). **Design:** Cross-sectional study. **Setting:** NCAA Division I institution. **Patients or Other Participants:** A convenience sample of female collegiate Equestrian athletes (n = 29; age: 19.4 ± 1.3 years; height: 166.4 ± 5.1cm; weight: 61.9 ± 7.1kg, body fat%: 16.3 ± 3.4%) participated in the study which consisted of physical measurements and 3 surveys. Response rate was 72.5% (n = 29/40). **Interventions:** Participants completed 3 surveys which consisted of: basic demographic background information, and completed the Eating Disorder Inventory-3 (EDI-3) and Eating Disorder Symptoms Checklist. The EDI-3 measures 2 major subscales: 1) ED Risk (drive for thinness, bulimia, and body dissatisfaction) and 2) Psychological Risk (e.g., low self-esteem, personal alienation, emotional dysregulation, maturity fears, perfectionism, etc.). In addition, each participant was measured for height, weight, had a 7 site caliper body fat assessment. The independent variable is equestrian discipline (English vs. Western). **Main Outcome Measures:** Basic descriptive statistics were used to calculate means and standard deviations for all physical measurements. Crosstabulations were used to examine the proportion of participants classified as at risk for EDs and all ED and psychological subscales. Chi-square analyses examine the differences in Western vs. English riders at risk for ED and psychological risk. **Results:** No significant differences were found between English and Western riding disciplines for ED and Psychological risk subscales. However, English riders presented the only risk for drive for thinness (17.2%), bulimia (13.8%), and body dissatisfaction (6.9%), with no Western risk. Psychological risk (typical and elevated clinical) for all participants included: low self-esteem (3.4%: n = 1), personal alienation (13.8%: n = 4), interpersonal insecurity (34.4%: n = 10), interpersonal alienation (41.3%: n = 12), interpersonal deficits (3.4%: n = 1), emotional dysregulation (24.1%, n = 7), perfectionism (62.0%, n = 18), asceticism (10.3%: n = 3), and maturity fears (44.8%: n = 13). The overall composite scores are: Interpersonal Problems Composite (31%: n = 9) and Overcontrol Composite (31%: n = 9). Pathogenic behaviors consisted of: dieting (58.6%, n = 17), exercise to control weight (17.2%, n = 5), binge eating (24.1%, n = 7), vomiting (3.4%, n = 1), laxatives (3.4%, n = 1), diet pills (3.4%, n=1), and diuretics (3.4%, n = 1). **Conclusions:** While only the English division had the presence of eating disorder risk, both English and Western divisions had a presence of multiple psychological risks. Athletic trainers working with equestrian athletes should be mindful of these risk factors and be prepared to refer athletes to receive the appropriate care as needed. All medical professionals must understand that this is a sensitive topic to aesthetic based athletes and should handle each case with tact and discretion.

### Examination of Depression, Low Self-Esteem, and Eating Disorder Risk in Female Collegiate Track and Field Athletes

Keretses EO, Torres-McGehee TM, Emerson DM, Monsma E: University of South Carolina, Columbia, SC, and University of Kansas, Lawrence, KS

**Context:** Revealing uniforms and intense training may predispose female track and field athletes to eating disorders (ED) and mental health concerns (i.e., depression and low self-esteem [LSE]). Little research has examined the differences among track and field position and depression, LSE, and EDs risk. **Objective:** To estimate prevalence of depression, LSE, and ED risk among female, collegiate track and field athletes. A secondary purpose will examine the differences between sport position and academic status and depression, LSE, and ED risk. **Design:** Cross-sectional study. **Setting:** NCAA Division I and II institutions. **Patients or Other Participants:** Female collegiate track and field athletes (n = 405; ages: 20 ± 1.7years; height: 167.3 ± 7.0cm; weight: 61.5 ± 11.6kg) across 13 NCAA Division I and 5 Division II institutions participated in an online survey. Sport position distribution included: sprinters: n = 74; middle distance: n = 57; distance: n = 142; lean field events: n = 69; non-lean field events: n = 37; multi-event: n = 26. The response rate was 43.1% (n = 405/940). **Interventions:** Participants completed an online survey which consisted of: self-reporting height, and weight and completed the Eating Attitudes Test, Center for Epidemiological Depression Scale and the Rosenburg Self-Esteem Scale. The independent variables included sport position and academic status (freshman, sophomore, junior, senior). **Main Outcome Measures:** Crosstabulations examined proportion of participants classified as at risk for

depression, LSE and EDs. Chi-square analyses examined the differences in sport position and academic status. Odds ratios determined risk between co-morbid factors (depression, LSE and ED risk). **Results:** Overall prevalence for mental health risk were: 30.1% (n = 116) depression; 10.8% (n = 42) LSE; and 24.7% (n = 100) ED risk. No significant differences were found between sport position and academic status for depression, LSE, and ED risk. However, mental health risk was highest for distance runners: depression at 9.1% (n = 35); LSE at 4.6% (n = 18) and ED at 8.9% (n = 36). Whereas, sophomores were highest for depression and LSE respectively (9.1%, n = 35 and 4.4, n = 16) with ED risk highest among freshman (7.2%, n = 29). All athletes reported 12.8% (n = 52) binging, 4.2% (n = 17), 6.7% (n = 27) used diet pills, laxatives, or diuretics, and 4.2% (n = 17) engaged in excessive exercise to control weight. Odd ratios revealed if a student-athlete reported LSE they were 19.8X more likely to have depression symptoms and 6.5X likely to be at risk for EDs. If at risk for EDs, the athlete is 4.9X likely to be at risk for depression. **Conclusions:** Female track and field athletes are at risk for depression, LSE, and EDs. More specifically, distance runners had the highest risk for these mental health conditions. For athletes with mental health conditions, it is common to find co-morbid factors existing with the primary condition. With better understanding of these conditions, athletic trainers will be able to develop and integrate prevention strategies to decrease mental health risk.

## Health-Related Quality of Life in Collegiate Dance Students

White HM, Hoch JM, Hoch MC: Old Dominion University, Norfolk, VA

**Context:** Injuries are common amongst dancers and may be associated with decreased health-related of quality of life (HRQOL). With the growing emphasis on patient-centered care, it is important to consider the impact of injury on the HRQOL in an array of patient populations, including dancers. **Objective:** To examine HRQOL in collegiate dance students. **Design:** Cross-sectional. **Setting:** Field. **Patients or Other Participants:** Thirty-three female collegiate dance students (age: 20.8 ± 2.4 yrs, height: 163 ± 6.1 cm, weight: 62.0 ± 10.4 kg, years of dance: 12.6 ± 6.1) participated. All participants were fully participating in all dance related activity. **Interventions:** All participants completed the modified Disablement in the Physically Active Scale (DPA) during a single data collection session. The DPA is a generic patient-reported outcome developed specifically for use in patients who are physically active. Participants were asked to complete the instrument as instructed by the directions at the top of the page. The completed instrument was scored based on established guidelines. **Main Outcome Measures:** The DPA consisted of 16 total items. DPA responses were based on a 5-point Likert scale ranging from 'no problem' to 'severe'. Overall scores could range from 0-64 with higher scores indicating increased disablement. The DPA Physical Summary Component (DPA-PSC) (score range = 0-48) addressed items specific to impairment, activity limitations and participation restrictions. The DPA Mental Summary Component (DPA-MSC) (score range = 0-16) addressed items specific to psychosocial well-being. The DPA has high test-retest reliability (ICC = 0.943) and internal consistency (α = 0.890–0.908). Internal consistency for the DPA–PSC and DPA–MSC are 0.941 and 0.878, respectively. To examine the HRQOL profile of collegiate dance students, the total DPA, DPA-PSC, and DPA-MSC scores were examined descriptively using mean and standard deviations. Additionally, each DPA item was examined descriptively to identify consistent and more severe sources of disablement. **Results:** The mean DPA total score was 12.8 ± 10.4 (range = 0-37). The mean DPA–MSC and DPA–PSC scores were 3.8 ± 4.1 (range = 0-16) and 8.9 ± 8.6 (range = 0-34) respectively. The individual DPA-PCS items which demonstrated the greatest average scores included "Do I have pain?" and "Do I have impaired motion?" which were rated as 1.4 ± 1.1 and 1.4 ± 1.0, respectively. The DPA-MCS item which demonstrated the greatest average score was "Do I have difficulty with increased uncertainty, stress, pressure, and/or anxiety?" which was rated as 1.5 ± 1.4. The remaining items demonstrated lower average ratings which less consistently contributed to increases in DPA scores. **Conclusions:** The main finding of this study is that collegiate dance students demonstrated clinically relevant levels of disablement despite fully participating in dance related activities. Pain, impaired motion, and stress are among the greatest contributors to increased disablement in these individuals. The DPA-PSC and DPA-MSC scores observed in this study indicate these individuals may have a history of injury which warrant physical and mental intervention.

## Physical Predictors of Perceived Susceptibility to Sport Injury Among Collegiate Athletes: An Exploratory Investigation

Ildefonso K, Gnacinski SL, Earl-Boehm J, Arvinen-Barrow M: University of Wisconsin, Milwaukee, WI

**Context:** The Perceived Susceptibility to Sports Injury (PSSI) Scale is a 4-item measure that assesses absolute and comparative PSSI on a 5-point Likert scale. Research shows athletes' PSSI is influenced by self-reported previous injury occurrence, personality, and passion in sport. Evidence also exists to support the use of physical assessments in the prospective identification of sport injury risk. There is likely a relationship between athlete's PSSI and potential physical risk factors, however this has not been investigated yet. **Objective:** To explore the relationship between athletes' PSSI and selected physical sport injury predictors. **Design:** Cross-sectional mixed methods study. **Setting:** Midwestern D-I University, field based research. **Patients or Other Participants:** As part of a larger study, 222 intercollegiate student-athletes were tested for potential psychosocial, nutritional, and physical sport injury risk factors. Of those, 152 division I (78 Male, 74 Female; age = 19.8 ± 1.41 years, height = 176.18 ± 15.58 cm, weight = 75.25 ± 14.38 kg) representing soccer, cross country, track and field, basketball, volleyball, baseball, and tennis with complete data were included in the analyses. **Interventions:** Prior to 2014 fall season, PSSI was measured using the PSSI Scale, which has psychometric validity and reliability ($\alpha$ = .81). Previous injury history was self-reported according to the definitions of the National Athletic Injury/Illness Reporting System. The above data was collected as part of a larger web-based survey (powered by Qualtrics). Dynamic balance was assessed via Y-Balance test, movement quality was assessed via Functional Movement Screen (FMS), and landing biomechanics were assessed via Landing Error Scoring System (LESS). These physical data have been linked to lower extremity injury risk in previous research. **Main Outcome Measures:** A hierarchical multiple regression was conducted to assess the extent to which the physical predictors and self-reported injury history influenced PSSI ($\alpha$ set to $p < .05$). **Results:** Self-reported previous sport injury history explained 7.3% of the model's variance [$F(1,141) = 11.17$, $p < .001$]. A small positive correlation was found between self-reported previous injury history and PSSI $r = .27$, $n = 143$, $p < .001$. A larger injury history was associated with higher levels of PSSI. No significant correlations between PSSI and Y-Balance, FMS and LESS scores were found (all $p > .05$). **Conclusions:** Consistent with other research findings, the relationship between previous injury experiences and athletes' PSSI was found to be significant. Athlete's PSSI was not related to selected physical sport injury predictors. Such could be due to number of reasons; for example it is not known if at the time of data collection the athletes had any knowledge of their physical risk factors. It is likely that such prior knowledge would have influenced PSSI. Future research should examine whether or not acquired knowledge of actual physical risk factors has an impact on PSSI.

## Psychosocial Indicators of Injury Concealment Among Young Male Athletes

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**Context:** Injury concealment has implications for both short and long-term health outcomes among athletes. As the potential for male athletes to conceal injury symptoms is high due to perceived masculinity, competitiveness, among others, it is imperative to discover core psychosocial constructs predictive of injury concealment. **Objective:** The influence of social norms, perceived masculinity, and other external influences on athlete populations were explored to understand the reasons why athletes mask injuries. **Design:** A cross-sectional study design was executed in the Central Florida region employing an original validated survey, designed to measure potential predictors of injury concealment among male athletes. **Setting:** Current and former athletes were recruited from the Orlando metropolitan area to complete an online survey. **Patients or Other Participants:** A convenience sample of males aged 18-30 (n = 150) currently playing a college sport and/or those who lettered in a high school varsity sport were recruited. **Interventions/Main Outcome Measures:** A panel of experts consulted on core predictor variables of male athlete injury concealment. A 35-item survey was then designed to solicit information on demographics, perceived masculinity ($\alpha$ = .826), vulnerability ($\alpha$ = .396), fear of losing a performance role ($\alpha$ = .697), injury ramification awareness ($\alpha$ = .338), factors regarding pressures from the team ($\alpha$ = .619), and injury concealing behaviors. Primary measures were operationalized via an 11-point scale where lower scores indicated that the individual disagreed with the statement (0 = Strongly Disagree) and higher scores indicated agreement with the

statement (10 = Strongly Agree). A series of means-tests, linear regressions, and Chi-square analyses were included in the analytical plan to test the study's hypotheses. The analysis centered on differences in primary scores among athletes who were categorized into the low, intermediate, and high potential to conceal injuries and if athletes categorized into primary variables categories were more or less likely to conceal an injury. **Results:** Findings indicated that significantly higher masculinity [$F(2,93) = 21.084$, $p < .001$] and fear of losing a performance role [$F(2,92) = 13.739$, $p < .001$] in athletes indicated they were more likely to conceal injuries than the other groups. Individuals with low potential to conceal an injury were significantly more likely to participate in non-team sports than individuals in the intermediate and high potential injury concealment groups [$X2(2,96) = 17.885$, $p < .001$]. **Conclusions:** Athletes with higher masculinity scores and those athletes who may be fearful of losing a performance role were more likely to conceal their injuries. Athletes who are a part of a team were also likely to behave the same way. Understanding athlete injury concealment reasoning and behaviors can help improve athlete safety in the years to come.

## Spinal Cord Injury Recovery: Stress, Coping, Resiliency and Quality of Life

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**Context:** Approximately 276,000 people in the United States are living with spinal cord injury (SCI) and 12,500 new injuries are reported yearly (NSCISC, 2015). Consistent with a biopsychosocial approach to patient care, psychological and social factors should be addressed in connection with physical recovery. **Objective:** To examine stress, coping, resilience, and quality of life for people engaged in SCI activity-based recovery and for their caregivers. **Design:** Cross-sectional. **Setting:** Project Walk® activity-based recovery center. **Patients or Other Participants:** Upon IRB approval, clients with SCI and their caregivers were recruited for participation. Following informed consent, 28 participants [18 clients with SCI (11 male, 7 female; mean age 33.61 years, range 21-54 years; mean length of time since injury 6.35 years, range 2.75-14 years) and 10 caregivers (4 male, 6 female; mean age 40.4 years, range 18-54 years)] completed the study. **Intervention:** Data was collected in both paper and online forms, based on participants' preference. A researcher assisted participants with survey completion as needed (e.g., dictated responses). **Main Outcome Measures:** Survey measures included the 10-item Perceived Stress Scale (Cohen et al, 1983), 28-item Brief COPE (Carver, 1997), 6-item Brief Resiliency Scale (Smith et al, 2008), and 66-item Quality of Life Index-III or 74-item Quality of Life Index for SCI-III (Ferrans & Powers, 1998). **Results:** Clients' perceived stress was 15.61 (range 5-30; SD = 6.77) and caregivers' was 14.4 (range 10-22; SD = 4.53). Clients and caregivers both endorsed active coping as their main coping behavior; however clients reported greater self-blame than caregivers [$t(26) = 2.611$, $p = .015$)]. Clients' resiliency was 3.71 (SD = .68) and caregivers' was 3.95 (SD = .84). Clients' quality of life was 19.85 (SD = 4.29) and caregivers' was 21.31 (SD = 3.79). Clients' perceived stress was related to: resilience ($rs = -.741$, $p < .001$), quality of life ($rs = -.822$, $p < .001$), active coping ($rs = -.522$, $p = .026$), denial ($rs = .558$, $p = .016$), behavioral disengagement ($rs = .733$, $p = .001$), positive reframing ($rs = -.636$, $p = .005$), humor ($rs = -.521$, $p = .026$), acceptance ($rs = -.557$, $p = .016$), self-blame ($rs = .548$, $p = .019$). Clients' resilience was related to: quality of life ($rs = .528$, $p = .024$), denial ($rs = -.476$, $p = .046$), behavioral disengagement ($rs = -.681$, $p = .002$), positive reframing ($rs = .476$, $p = .046$), self-blame ($rs = -.517$, $p = .028$). Clients' quality of life was related to: active coping ($rs = .714$, $p = .001$), denial ($rs = .-.535$, $p = .022$), emotional support ($rs = .482$, $p = .043$), behavioral disengagement ($rs = -.818$, $p < .001$), positive reframing ($rs = .625$, $p = .006$), humor ($rs = .555$, $p = .017$). Caregivers' perceived stress was related to: active coping ($rs = -.656$, $p = .039$), instrumental support ($rs = -.637$, $p = .048$), planning ($rs = -.899$, $p < .001$). Caregivers' quality of life was related to: resilience ($rs = .646$, $p = .044$), humor ($rs = -.642$, $p = .045$), religion ($rs = -.636$, $p = .048$). **Conclusions:** Although clients with SCI and their caregivers experience stress, and reported levels are consistent with the general US population (Cohen & Janicki-Deverts, 2012), findings show that clients' stress is negatively related to resiliency and quality of life. Future research should continue to investigate stress and coping skills to enhance clients' and caregivers' rehabilitation experiences.

## Adolescent Athletes' Perceptions of Health-Related Quality of Life Following a Sport-Related Concussion

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**Context:** The importance of managing both the physical and mental consequences of sport-related concussion (SRC) has gained significant attention. Previous studies have identified the impact of SRC on health-related quality of life (HRQOL) through the use of patient-report outcome measures. However, there has been little research exploring the underlying mechanisms that influence these perceptions of HRQOL among adolescent athletes who have sustained a SRC. **Objective:** To qualitatively explore adolescent athletes' perceptions of their HRQOL following a SRC. **Design:** A consensual qualitative research tradition was used as the primary approach for this study. **Setting:** Individual face-to-face interviews were conducted with each participant. **Patients or Other Participants:** 12 interscholastic athletes (4 females, 8 males; age = 15.7 ± 1.7 years; grade level = 10.2 ± 1.4; sports = football, soccer, volleyball, basketball, and wrestling) were interviewed. **Data Collection and Analysis:** A semi-structured interview protocol was used to allow for themes to emerge from the interviews. Interviews focused on injury details, and explored the physical, psychosocial, emotional, and spiritual components of health. Once all interviews were transcribed, the research team individually coded transcripts. Themes and categories were identified based on the consensus process by a three-person research team. A comprehensive codebook that captured the main themes and categories resulted. The research team then met to establish a consensus codebook that represented the data appropriately. To reduce researcher bias, triangulation of the data occurred via the use of multiple researchers to accurately analyze the data **Results:** Following SRC, participants identified increasing difficulty with their emotions, roles at school, and in their social environment with less of an impact on their spiritual role. Specifically, becoming irritable and easily frustrated were common responses related to emotions. Participants also reported issues with concertation and fatigue, which made it difficult for them in the classroom. Additionally, concerns of letting the team down and not being able to contribute to the team were frequently mentioned regarding societal role. As a result, participants expressed how they tried to minimize or mask their symptoms in order to decrease the potential of being teased or viewed differently by their peers. **Conclusions:** The perceptions of interscholastic athletes regarding their SRC demonstrated an impact on perceived HRQOL. Anticipatory guidance, with education regarding the possible signs and symptoms, risk factors pre- and post-injury, and recovery expectations following a concussion are important to include in post-injury management. A better understanding of SRC and expected recovery could help to improve perceptions of this injury among interscholastic athletes. Additionally, best practices regarding academic adjustments should be identified to assist healthcare professionals and school personnel in the development of temporary adjustments or formal academic adjustment policies in the secondary school setting, therefore assuring that the patient receives the support they need to maintain their role as a student.

## The Influence of Participation Status on Quality of Life in Collegiate Athletes

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**Context:** Health-related quality of life (HRQL) is a broad term for the impact of injury or illness on physical, psychological, and social health dimensions. Injury has been associated with decreased HRQL in athletes. **Objective:** The purpose of this study was to compare HRQL in collegiate athletes based on participation status. **Design:** Cross-sectional. **Setting:** Athletic facilities. **Patients or Other Participants:** Four hundred and forty-two collegiate athletes (186 males, 256 females; 19.5 ± 1.3 y, 173.7 ± 10.6 cm, 71.8 ± 13.8 kg) were recruited from Division-I (N = 283) and Division-III (N = 159) institutions. The sample included athletes from seventeen sports with a variety of current and past injury histories ranging from no history to severe musculoskeletal injuries. **Interventions:** Participants completed an injury history form, the Disablement in the Physically Active scale (DPA), and Fear-Avoidance Beliefs Questionnaire (FABQ). The DPA is a 16-item generic instrument with Physical (score range = 0-48, Cronbach $\alpha = 0.94$) and Mental (score range = 0-16, Cronbach $\alpha = 0.88$) summary components. The FABQ (score range = 0-66, Cronbach $\alpha = 0.89$) is a 16-item dimension-specific instrument. Higher scores represented increased disablement and elevated fear, respectively. **Main Outcome Measures:** Dependent variables included DPA-Physical, DPA-Mental, and FABQ scores. Separate Kruskal-Wallis tests were used to compare HRQL scores in athletes based on participation status (full participation, participating injured, or not participating due to injury). FABQ scores were only compared in athletes with an injury history (N = 424). In

the event of significant Kruskal-Wallis tests ($p < 0.05$), pairwise Mann-Whitney U-tests were performed with a p-value correction to account for multiple comparisons ($p < 0.017$). Descriptive statistics are reported as median (interquartile range). **Results:** All HRQL measures significantly differed based on participation status. For DPA-Physical scores, athletes not participating due to injury (N = 32, 29.00(22.00-36.75)) reported increased scores in comparison to full participation (N = 311, 3.00 (0.00-10.00), $p < 0.001$) and participating injured (N = 99, 16.00 (10.00-24.00), $p < 0.001$) groups. Athletes participating injured reported increased DPA-Physical scores compared to the full participation group ($p < 0.001$). For DPA-Mental scores, athletes not participating due to injury (4.00 (0.25-8.00), $p = 0.003$) and athletes participating injured (2.00 (0.00-6.00), $p = 0.010$) reported increased scores compared to the full participation group (1.00 (0.00-4.00)). No differences were detected between the injured groups ($p = 0.199$). In those with an injury history, athletes not participating due to injury (N = 34, 46.00 (35.50-52.25)) reported increased fear-avoidance beliefs compared to full participation (N = 291, 25.00 (12.00-34.00), $p < 0.001$) and participating injured (N = 99, 34.00 (26.00-41.00), $p < 0.001$) groups. Athletes participating injured reported increased fear-avoidance beliefs compared to those engaged in full participation ($p < 0.001$). **Conclusions:** Athletes with a current injury exhibited increased disablement and fear-avoidance beliefs. These findings draw attention to the fact that despite returning to play, athletes engaged in competition with an existing injury still display HRQL deficits. Thus, HRQL should be considered in conjunction with physical markers and functional testing to ensure a complete recovery.

## Program Evaluation of a Short-Course Foundations of Evidence-Based Practice Workshop for Athletic Trainers


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**Context:** The Board of Certification (BOC) requires athletic trainers (AT) to obtain 10 Continuing Education Units (CEUs) in Evidence-Based Practice (EBP) each reporting period. Nearly 400 CEU programs exist with the designation of Clinical EBP, while less than 100 programs have been approved within the Foundations of EBP category which, enhances a clinician's ability to find, evaluate, and apply evidence to clinical practice. It is not known if programming in the Foundations category of CEUs results in improved knowledge and confidence of EBP. **Objective:** To determine the effectiveness of a single day workshop in increasing knowledge and confidence of EBP concepts among ATs. A secondary aim was to determine perceptions of ATs regarding barriers to use of EBP. **Design:** Within subjects design with pre/post-intervention evaluation of ATs' EBP knowledge via the Evidence-Based Concepts: Knowledge, Attitudes, and Use (EBKAU) survey. **Setting:** An EBP CEU workshop hosted at two Division I Universities. **Patients or Other Participants:** 123 ATs (63 males, 59 females, 1 preferred not to answer, 11.9 ± 10.2 years experience) from a convenience sample of CEU workshop attendees completed both pre and post-workshop surveys. **Interventions:** A five hour BOC approved Foundations of EBP workshop was conducted to review history of EBP, creation of clinical questions, literature searching, use of informatics in searching, literature appraisal, and implementation of patient reported outcomes. Previously reported Cronbach's alpha and Kuder-Richardson values support reliability ($\alpha$ = .70, K20 = .25) of the EBKAU. **Main Outcome Measures:** ATs' EBP knowledge was assessed via multiple choice questions scored by giving a value of "1" to correct answers and then summated. Paired t-tests established differences in pre/post-intervention knowledge scores. Confidence in EBP knowledge was tabulated according to Likert responses ranging from not at all confident (1) to extremely confident (4) for knowledge questions. Wilcoxon match pairs signed ranks (T) evaluated confidence in knowledge differences. Open ended questions assessed barriers and were analyzed qualitatively. **Results:** For the 11-point knowledge score, there was a significant increase in knowledge ($t = -12.42$, $p < .001$, $d = 1.31$, 95 % CI -2.41 and -1.75) pre-workshop (mean = 6.39 ± 1.63) to post-workshop (mean = 8.47 ± 1.55). Confidence in knowledge increased significantly ($z = -9.51$, $p < .001$) pre-workshop (mean = 25.8 ± 6.248) to post-workshop (mean = 37.18 ± 4.59). ATs identified barriers to use of EBP as time, resources (internet, previous experience, and coworker conversation), environment, and experience in EBP. **Conclusions:** This workshop was effective in improving immediate foundational knowledge and confidence of EBP. Although a larger number of clinical EBP programs have been submitted to and approved by the BOC, Foundations EBP programming is valuable for CEU opportunities in order to narrow the evident gap regarding EBP knowledge. Future research should investigate long-term behavior change after attending a Foundations EBP session.

At the conclusion of this session, participants will be able to:

1. Discriminate between foundations and clinical evidence-based practice continuing education opportunities.
2. Express effectiveness of a short-course evidence-based practice workshop.
3. Summarize resources for, and barriers to, effective implementation of evidence based practice into clinical practice.


References


1. Hankemeier DA, Walter JM, McCarty CW, et al. Use of evidence-based practice among athletic training educators, clinicians, and students, part 1: perceived importance, knowledge, and confidence. J Athl Train. 2013;48(3):394-404.
2. Welch CE, Van Lunen BL, Hankemeier DA. An evidence-based educational intervention for athletic trainers: a randomized control trial. J Athl Train. 2014;49(2):210-219.

## Athletic Trainers' Current Behaviors Associated With Evidence-Based Practice Implementation and Strategies to Improve Implementation

Keeley K, Hankemeier D, Walker SE, Martin M, Cappaert T: Slippery Rock University, Slippery Rock, PA; Ball State University, Muncie, IN; Rocky Mountain University of Health Professions, Provo, UT

**Context:** Athletic trainers (ATs) are supportive of implementing evidence-based practice (EBP) to drive their clinical practice, but are not implementing EBP. Investigation is needed to understand the current level of implementation. From that knowledge, specific strategies could be developed to increase the implementation of EBP. **Objective:** To examine athletic trainers' current use of EBP and investigate suggestions to improve EBP implementation. **Design:** Grounded theory qualitative study. **Setting:** Phone interviews **Patients or Other Participants:** Twenty-eight ATs (11 females, 17 males; age = 34.5 ± 8.60 years, athletic training experience = 9.96 ± 7.27 years) from 9 NATA districts participated. **Data Collection and Analysis:** Interviews were conducted using a semi-structured interview guide, were audio recorded and transcribed verbatim. Data were analyzed using an inductive approach to determine common themes and subthemes. Trustworthiness was established through member checks and peer debriefing. **Results:** Two themes emerged from the data; behaviors associated with EBP implementation and strategies to improve EBP implementation. Participants described examples of implementing EBP such as asking clinical questions, searching literature, and applying findings into clinical practice. Participants engaged in these activities but these behaviors were performed inconsistently and infrequently. ATs reported using clinical experience and previous training to make clinical decisions in lieu of evidence. Participants felt there were some strategies, which could improve implementation. Subthemes related to strategies for improvement of EBP implementation included 1) EBP as a priority, 2) access to resources, 3) condensed information, and 4) EBP community. Participants discussed the importance of implementing EBP into clinical practice a priority by spending time focusing on implementing evidence, rather than on tasks unrelated to patient outcomes. Participants with difficulty accessing full-text peer-reviewed publications due to lack of time or availability felt that access would improve the implementation of EBP. A condensed version of evidence (e.g., NATA News Clinical Bottom Line) which could be easily accessed and read would help with time constraints as well as their understanding of the evidence also leading to better implementation. Participants identified the need for a place for clinicians to discuss current evidence and clinical questions with each other. ATs identified this EBP community, to include online discussion forums, and access to EBP mentors, to provide a better understanding of the available evidence, which would increase implementation. **Conclusions:** In order to increase the frequency of EBP implementation ATs must begin to make it a priority. In part, that includes recognizing and utilizing existing resources, such as open access journals, and the NATA News Clinical Bottom Line. Development of a community with other ATs or healthcare professionals where ATs can share evidence could increase their implementation of EBP.

Learning Objectives:

Following the attendance of this presentation, participants will be able to:

Understand the athletic trainers' current use of evidence-based practice.

Recommend strategies athletic trainers can use to implement evidence-based practice.

References:

1. Welch CE, Hankemeier DA, Wyant AL, Hays DG, Pitney WA, Van Lunen BL. Future direction of evidence-based practice in athletic training: perceived strategies to enhance the use of evidence-based practice. J Athl Train. 2014;49(2):234-244.

2. McCarty CW, Hankemeier DA, Walter JM, Newton EJ, Van Lunen BL. Use of evidence-based practice among athletic training educators, clinicians, and students, part 2: attitudes, beliefs, accessibility, and barriers. J Athl Train. 2013;48(3):405-415.

## Clinical Reasoning Abilities of Athletic Training Preceptors Using the Diagnostic Thinking in Athletic Training Inventory

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**Context:** Clinical reasoning (CR) is the metacognitive process that includes decision-making, problem-solving, or focused thinking used in the evaluation and management of a patient. The Diagnostic Thinking Inventory for Athletic Training (DTI-AT) measures CR abilities in athletic trainers but has yet to be tested in AT preceptors to discern differences regarding gender, work setting, years of experience, or other factors. It is important to understand clinical preceptors' level of CR so that athletic training programs can provide appropriate professional development to enhance this skillset to benefit student learning. **Objective:** To assess the CR level of athletic training preceptors. **Design:** Cross sectional survey. **Setting:** Athletic training education classroom. **Patients or Other Participants:** A convenience sample of 50 (22 males, 28 females) preceptors representing four athletic training settings: clinic (n = 2), high school (n = 18), college (n = 28), and professional (n = 2). Participation was voluntary. **Main Outcome Measures:** The 41-item Likert scale DTI-AT was used to assess preceptor's level of CR. The DTI-AT produces 3 scores relative to CR skills: total diagnostic thinking (DTI-AT max score = 246), structure of memory (SOM, max score = 120) and flexibility in thinking (FIT, max score = 126). Separate independent t-tests assessed group differences on the 3 DTI-AT scores by gender, years of experience, number of co-workers, and setting. **Results:** Fifty preceptors (22 males, 28 females) completed the inventory. There were no significant differences for any of the 3 scores as related to gender, years of experience, or working with additional ATs. However there was a significant difference related to setting. Preceptors in the high school setting (with average of 12.2 years of experience) scored significantly higher on the overall DTI-AT than those in the university/college setting (with average of 14 years of experience); high school DTI-AT = 164.9 ± 7.3, college = 158.8 ± 7.9, p = .011. While the preceptors in the high school setting's mean scores were higher on the FIT (high school: 83.8 ± 4.8, college: 80.7 ± 6.8, p = .069) and SOM (high school: 81.0 ± 3.5, college: 78.5 ± 5.1, p = .066), there was no statistical significance. **Conclusions:** The results of this study provide early exploration into potential internal and external factors that influence preceptors' ability to engage in CR. The high school setting may promote immediate and regular reflection, metacognition and use of CR because of professional isolation and differing clinical decision priorities than university/college setting. University/college preceptors may not be taking full advantage of inherent collaborative opportunities, or have other external barriers to independent decision making in their setting. To better develop students' CR skills, enhance professional practice and patient outcomes, AT programs must ensure preceptors are aware of their own level of CR and how it can be improved in any setting in which students gain clinical experience.

## Athletic Trainers' Perceptions of the Primary Characteristics of Clinicians Engaged in Advanced Clinical Practice

Sauers EL, Anderson BE, Welch Bacon CE: A.T. Still University, Mesa, AZ

**Context:** The new education framework for athletic training promotes the development of both clinical experts and advanced practice leaders, but little is known about the characteristics of clinicians who possess these higher levels of competency and proficiency. While peer health professions have formal education and training programs and specialized credentials to denote those who have achieved recognition as advanced practice clinicians, such mechanisms are only now emerging in athletic training. However, as training and credentialing programs advance it is important to understand the perceived characteristics of clinicians engaged in advanced clinical practice. **Objective:** To qualitatively explore how athletic trainers from diverse settings perceive the characteristics of clinicians engaged in advanced clinical practice. **Design:** The emergent design of this qualitative investigation was modeled after the consensual qualitative research approach. An open-ended survey was used to allow for flexibility in accordance with the emergent design. To solicit participants, a criterion sampling method was utilized. **Setting:** Self-reported online survey. **Patients or Other Participants:** 321 participants (16.0% response rate) from a convenience sample of ATs (144 = males, 156 = females, 1 = missing, age = 32.5 + 8.6) employed in a variety of clinical practice settings. **Data Collection and Analysis:** Once developed, two qualitative and survey research experts reviewed the survey to ensure face validity. The survey consisted of a series of 10 open-ended questions designed to capture participants' perceptions and experiences with ACP; ATs were solicited via email to participate. Final themes and categories were determined

via consensus of a three-person research team. Each researcher independently coded the data and created a preliminary codebook. The research team then met to discuss and finalize a consensus codebook that richly captured the data. To decrease researcher bias, triangulation occurred through the inclusion of multiple researchers. **Results:** Athletic trainers' perceptions of the primary characteristics of clinicians engaged in advanced clinical practice were categorized into three emergent themes. First, athletic trainers defined primary characteristics according to personal attributes. This theme revealed two sub-categories, including (a) intra-personal attributes (e.g., leadership, critical thinking), and (b) interpersonal attributes (e.g., empathy, communication). The second major theme for primary characteristics was professional attributes, which consisted of three sub-categories: (a) discipline specific knowledge and skills (e.g., manual therapy), (b) experiences (e.g., years of experience, specific patient care experience), and (c) non practice-related characteristics (e.g., research). The third theme was uncertainty from respondent's regarding the primary characteristics of clinicians engaged in advanced clinical practice. **Conclusions:** Athletic trainers identify the primary characteristics of clinicians engaged in advanced clinical practice according to personal and professional attributes, although many are uncertain what the primary characteristics should be. These findings highlight the need to further define, and build capacity for developing, clinical experts and advanced practice leaders with key personal and professional attributes.

## A Preliminary Survey to Explore How Athletic Trainers Define Advanced Clinical Practice

Anderson BE, Sauers EL, Welch Bacon CE: A.T. Still University, Mesa, AZ

**Context:** The strategic priorities for education and the educational framework for athletic training education place an increased emphasis on moving clinicians beyond professional education. Specifically, mechanisms for creating clinical experts and advanced practice leaders have been promoted. However, unlike peer health professions such as nursing, the athletic training profession has yet to develop a unified definition and vision for advanced clinical practice. **Objective:** To qualitatively explore how athletic trainers from diverse settings define advanced clinical practice. **Design:** The emergent design of this qualitative investigation was modeled after the consensual qualitative research approach. An open-ended survey was used to allow for flexibility in accordance with the emergent design. To solicit participants, a criterion sampling method was utilized. **Setting:** Self-reported online survey. **Patients or Other Participants:** 321 participants (16.0% response rate) from a convenience sample of ATs (144 = males, 156 = females, 1 = missing, age = 32.5 + 8.6) employed across a variety of clinical practice settings. **Data Collection and Analysis:** Once developed, two qualitative and survey research experts reviewed the survey to ensure face validity. The survey consisted of a series of 10 open-ended questions designed to capture participants' perceptions and experiences with ACP; ATs were solicited via email to participate. Final themes and categories were determined via consensus of a three-person research team. Each researcher independently coded the data and created a preliminary codebook. The research team then met to discuss and finalize a consensus codebook that richly captured the data. To decrease researcher bias, triangulation occurred through the inclusion of multiple researchers. **Results:** Athletic trainers' definitions of ACP were categorized into three emergent themes. First, athletic trainers defined ACP based on education and training that occurs beyond entry level. This theme revealed four sub-categories, including (a) formal training (e.g. continuing education courses), (b) informal training (e.g. patient care experiences), (c) specialization (e.g. residency programs), and (d) additional credentials or certificates (e.g. post-professional education programs). The second major theme for ACP focused on the knowledge and behaviors that an athletic trainer possesses. This included examples such as evidence-based practice, application of research, and collection of clinical outcomes. The third theme was uncertainty in the meaning of ACP, where participants were uncertain of how ACP should be defined in athletic training. **Conclusions:** Athletic trainers define ACP as including both education and training beyond entry level and the actual knowledge and skills an athletic trainer possesses. However, it is clear that significant work is necessary to further define ACP in athletic training to support attaining the strategic priorities for education and developing advanced practice leaders. Athletic training is in the early stages of efforts to improve the post-professional continuum of learning and consensus on what constitutes clinical expertise and advanced clinical practice are vital to advancing these efforts.

## Novice Athletic Trainers' Perceptions of Self-Efficacy

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**Context:** Self-efficacy is the belief that one embodies the necessary skills and abilities to perform a task which yields a specific, desired outcome. The majority of athletic training research focuses on professional socialization with little investigation into the self-efficacy of athletic trainers (ATs). **Objective:** To determine how novice athletic trainers perceive their sense of self-efficacy and the experiences that facilitate self-efficacy in their current job setting. **Design:** Qualitative, general inductive approach. **Setting:** Collegiate, secondary school, industrial. **Patients or Other Participants:** We used purposeful criterion sampling to recruit novice athletic trainers, certified for three years or less, from common work settings. After collecting data from participants in collegiate and secondary settings, we employed snowball sampling procedures to recruit participants from the industrial setting in order to reach data saturation. Thus, a total of 9 athletic trainers (3 females, 6 males, average age 25 + 1.7 years) participated in our study. While the clinical setting is a common work setting for novice ATs, we did not select it for our research. Athletic trainers in the clinical setting often have dual outreach responsibilities to other settings which could have confounded results. **Data Collection and Analysis:** We conducted in-person focus group and individual interviews, which were then transcribed verbatim. The participants' responses were analyzed using a constant comparative and general inductive approach along with member checks and multi-analyst triangulation to establish trustworthiness and credibility of the study. **Results:** Data analysis revealed that the self-efficacy of novice athletic trainers is facilitated or inhibited by several factors. The four facilitators included 1) formal and informal socialization to new roles and responsibilities; 2) gaining membership in the community and culture of job setting; 3) authentic experiences; and 4) legitimizing sources. Barriers to self-efficacy included 1) role ambiguity; 2) lack of knowledge or clinical skills; and 3) limited decision-making opportunities. The facilitating factors varied by setting while the barriers were not exclusive to any setting. **Conclusions:** Professional self-efficacy (PSE) is affected by positive or negative socialization. Poor socialization, lack of legitimization, and limited autonomy can exacerbate role ambiguity experienced during the transition from student to novice athletic trainer. Our research suggests formal and informal socialization, along with networks of support, and role clarity increase the PSE of the novice athletic trainer. Novice athletics trainers could benefit from formal orientation as well as from informal interactions with peers and mentors within the work setting.

### The Correlation of Frontal Plane Ankle Joint Laxity to Frontal Plane Time-to-Stabilization Measures in Healthy and Ankle-Injured Patients


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**Context:** Patients who suffer ankle sprains and experience repeated instability of their ankle are described as having chronic ankle instability (CAI). Conversely, patients who sustain a single ankle sprain and report no subsequent instability are described as copers. Numerous measures have been used to further categorize patients with functional instability, mechanical instability, perceived instability, or some combination of these. Understanding how these categories are related in CAI patients may inform treatment and interventions to prevent further injury. **Objective:** To determine if the mechanical measure of inversion/eversion ankle joint laxity is correlated to the functional measure of medial-lateral time-to-stabilization (MLTTS) in subjects differentiated by perceived instability for CAI, coper, and healthy. **Design:** Cross-sectional. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** NCAA Division I athletes volunteered for the study: 73 females, 77 males, height = 177.6 ± 11.3cm, mass = 78.9 ± 18.3kg, age = 19.1 ± 1.7 years. **Interventions:** Patients were placed into three groups by reports of ankle sprain and perceived instability through Cumberland Ankle Instability Tool (CAIT) scores: 1) CAI reported ≥1 ankle sprain(s) and CAIT score of ≤25, N = 63; 2) Copers reported 1 ankle sprain and CAIT score of ≥27, N = 41; and 3) Healthy reported 0 ankle sprains and CAIT score of ≥27, N = 46. Patients completed a single-legged lateral hop over a 6cm hurdle onto a force platform (Advanced Mechanical Technology Inc., Watertown, MA) where their ability to stabilize in the medial-lateral direction was measured by calculating a 3rd order polynomial line fitting method of MLTTS. An ankle arthrometer (Blue Bay Research Inc., Milton, FL) was used to measure joint laxity through total joint excursion of inversion and eversion. **Main Outcome Measures:** A Pearson product-moment correlation coefficient analysis was used to measure the relationship between MLTTS upon landing a lateral hop and ankle inversion/eversion joint laxity. **Results:** No significant correlations were found between CAI MLTTS times (0.48 ± 0.22sec) and inversion/eversion joint laxity (58.00 ± 12.35dmm), (r = 0.01, P = 0.97). No significant correlations were found between copers MLTTS times (0.44 ± 0.21 sec) and inversion/eversion joint laxity (55.44 ± 12.42mm) (r = 0.15, P = 0.334). No significant correlations were found between healthy MLTTS times (0.46 ± 0.21seconds) and inversion/eversion joint laxity (55.01 ± 12.52mm), (r = 0.20, P = 0.18). **Conclusions:** Although it would be fair to reason that ankle ligamentous instability would correlate to difficulty in stabilizing a lateral hop, these data continue to confirm that mechanical and functional instability characteristics can exist separately in CAI and coper patients with no statistical correlation. Elements of functional, mechanical, and perceived ankle instability should be evaluated and treated on an individual patient basis. Continued research in measuring and treating specific deficits in CAI patients is warranted, as these elements seem to exist independently of each other.


### Diminished Foot and Ankle Muscle Volumes in Young Adults with Chronic Ankle Instability


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**Context:** Chronic ankle instability (CAI) patients demonstrate altered neuromuscular function and decreased muscle strength when compared to healthy counterparts. Up to this point, muscle volumes have not been analyzed in CAI patients to determine if deficits in muscle size are present following recurrent sprain. **Objective:** To analyze intrinsic and extrinsic foot and ankle muscle volumes as measured by magnetic resonance imaging (MRI) and four-way ankle strength in young adults with and without CAI. **Design:** Cross-sectional **Setting:** Laboratory **Patients or Other Participants:** Five CAI patients (Height: 165.4 ± 8.8cm, Mass: 66.5 ± 7.3kg, Age: 23.0 ± 4.0, Sex: 1M/4F, Foot and Ankle Ability Measure Sport: 54.4 ± 22.1%, Identification of Functional Ankle Instability: 24.0 ± 3.8, Number of previous sprains: 3.2 ± 1.6) and 5 healthy controls (Height: 166.9 ± 8.1cm, Mass: 65.0 ± 13.1kg, Age: 23.8 ± 4.5, Sex: 1M/4F) participated. **Interventions:** Novel fast-acquisition MRI was used to scan from above the femur to the toes. The perimeter of each muscle was outlined on each axial slice and then the 2D area was multiplied by the slice thickness (5mm) to calculate the muscle volume. Maximal isometric force (N/kg) for plantar flexion, dorsiflexion, inversion, and eversion were measured over three 5-second trials using a hand-held dynamometer. **Main Outcome Measures:** Massheight normalized muscle volumes ($cm^3$/mkg) were used to compare groups. We compared the individual muscle volumes, summed compartmental (anterior, lateral, deep posterior, superficial posterior)

muscle volumes, total summed muscle volume for the extrinsic muscles and total summed plantar intrinsic muscle volumes between groups. The average normalized isometric force (N/kg) was computed for each of the four tested motions and utilized to compare groups. Group means and 90% confidence intervals (CIs) were used to compare groups for all dependent variables. Cohen's d effect sizes were also calculated. **Results:** The CAI group had smaller total extrinsic muscle volume compared to healthy controls (CAI = 9.62cm$^3$/mkg, (90% CI: 9.34, 9.91); Healthy = 11.13cm$^3$/mkg (10.92, 11.34), d = 1.53). The CAI group also had smaller muscle volumes of the superficial posterior compartment (CAI = 5.15cm$^3$/mkg (4.74, 5.56); Healthy = 6.21cm$^3$/mkg (5.91, 6.51), d = 1.63) and soleus (CAI = 2.62cm$^3$/mkg (2.40, 2.84); Healthy = 3.26cm$^3$/mkg (3.10, 3.42), d = 1.46). For intrinsic foot muscles, the CAI group had smaller adductor hallucis obliqus (CAI = 0.07cm$^3$/mkg (0.06, 0.08); Healthy = 0.13cm$^3$/mkg (0.12, 0.14), d = 2.33) and flexor hallucis brevis (CAI = 0.06cm$^3$/mkg (0.05, 0.07); Healthy = 0.12cm$^3$/mkg (0.11, 0.13), d = 3.42) muscle volumes when compared to healthy controls. The CAI group had lower strength in eversion (CAI = 1.82N/kg (1.62, 2.01); Healthy = 2.39N/kg (2.17, 2.61), d = 2.03) and dorsiflexion (CAI = 1.97N/kg (1.80, 2.14); Healthy = 2.67N/kg (2.33, 3.02), d = 1.90). No other significant differences were identified for muscle volume or ankle strength between groups. **Conclusions:** CAI patients demonstrate atrophy of intrinsic and extrinsic foot and ankle musculature that was accompanied by lower ankle strength. Clinicians should be aware of the muscle atrophy and strength deficits when prescribing rehabilitation for lateral ankle sprain or CAI patients.

## Examining the Relationship Between Ligament Laxity and Dynamic Stability Among Healthy, Coper, and Unstable Ankles

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**Context:** Individuals with chronic ankle instability (CAI) often report with symptoms of mechanical and/or functional deficits. Mechanical deficits, such as ligament laxity, can be measured using an ankle arthrometer. Functional deficits, such as impairments in stability, can be measured by calculating time-to-stability (TTS) of a jump landing task. While those with CAI report these impairments, the relationship between mechanical and functional deficits is unclear. **Objective:** To examine the relationship between anterior-posterior (AP) TTS and ligament laxity in the AP direction. **Design:** Cross-sectional study. **Setting:** Athletic training research laboratory. **Patients or Other Participants:** 150 NCAA Division I athletes (73 Females, 77 males, age = 19.1 ± 1.7 years; 177.6 ± 11.3cm, 78.9 ± 18.3kg) free from injury at the time of testing were recruited for the study. **Interventions:** Participants were separated into healthy (N = 46), coper (N = 41), and unstable (N = 63) groups by their ankle injury history and Cumberland Ankle Instability Tool score. Mechanical stability, quantified through ligament laxity, in the anterior direction was measured using an ankle arthrometer (Blue Bay Research Inc., Milton, FL). Functional stability was measured from a forward jump with two preparatory steps, hopping over a 15 cm hurdle placed at a distance of 100% of the participant's leg length onto a force plate (Advanced Mechanical Technology Inc., Watertown, MA). Functional stability was quantified by calculating TTS using a 3rd order polynomial line fitting method. **Main Outcome Measures:** Data were analyzed using a correlation to determine the relationship between arthrometer ligament laxity (AL) measures and APTTS among the healthy, coper, and unstable groups. **Results:** No significant correlation was found in the healthy group (APTTS: 1.18 ± 0.27s, AL: 9.61 ± 3.17mm) at r = 0.03, P = 0.180. No significant correlation was found in the coper group (APTTS: 1.19 ± 0.28s, AL: 9.11 ± 2.90mm) at r = -0.105, P = 0.337. No significant correlation was found in the unstable group (APTTS: 1.14 ± 0.27s, AL: 9.32 ± 3.31mm) at r = 0.071, P = 0.971. **Conclusions:** During a forward jump, an individual would utilize the restraints from the anterior talofibular ligament at the ankle to control the forward momentum of the body over the ankle mortise. It would seem that an individual with an increase of laxity in the anterior direction would have a harder time stabilizing in the AP direction during a forward jump. However, the results of this study does not support this thought. Chronic ankle instability is often attributed dichotomously by mechanical and/or functional instability. However, more recent research has reported causes of CAI to include other facets, including perceived instability and recurrent injuries. The results of this study further affirm the notion that CAI is a multifaceted problem. A simple relationship between ligament laxity and dynamic stability cannot identify differences among the healthy, coper, and unstable individuals. Further investigations are necessary to explore other possible attributing factors to CAI.

## Diaphragm Contractility in Individuals With and Without Chronic Ankle Instability

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**Context:** It has been suggested that following lateral ankle sprain, altered afferent inputs from the somatosensory system around the ankle and central changes in sensorimotor control may lead to proximal joint maladaptations to compensate for residual symptoms and decreased function. Specifically, researchers have identified impaired trunk stability in individuals with chronic ankle instability (CAI). The diaphragm muscle contributes to trunk stability by modulating the intra-abdominal pressure. A potential mechanism that could help to explain trunk stability deficits may be related to altered diaphragm function due to supraspinal sensorimotor changes with CAI. This has been observed with other musculoskeletal conditions. However, a study designed specifically to examine the diaphragm contractility in individuals with CAI is lacking. **Objective:** Examine the diaphragm structural integrity in individuals with CAI and healthy controls. **Design:** Single-blinded, case-control. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-seven participants with self-reported CAI (4M, 23F; 22.58 ± 3.33yrs; 168.86 ± 7.67cm; 70.01 ± 13.53kg) and 28 healthy control participants (9M,19F; 21.04 ± 1.88 yrs; 168.50 ± 9.80cm; 66.12 ± 12.39kg) volunteered. **Interventions:** A portable diagnostic ultrasound unit was used to visualize and measure the right and left hemi-diaphragm thickness at the end of resting inspiration and expiration in supine while breathing quietly. A 8-to-13 MHz linear-array transducer was placed transversely over intercostal space between the 8th and 9th ribs at the mid-axillary lines on the right and left sides. The diaphragm movement was imaged and recorded on B-mode ultrasonography. **Main Outcome Measures:** The diaphragm thickness (cm) was measured as the distance from the middle of the pleural line to the peritoneum lines using electronic calipers. The degree of diaphragm contractility was calculated from the mean of three images from the end of resting inspiration (Tinsp) and expiration (Texp) using the following formula: (Tinsp-Texp)/Texp. Independent t-tests were utilized to compare the degree of diaphragm contractility of each side between the CAI and control groups. Significance was set a priori at $P<0.05$. Cohen's d effect sizes with associated 95% confidence interval (CI) were calculated using the pooled standard deviations to determine the magnitude of differences in each dependent variable between groups. **Results:** The CAI group had a smaller degree of left hemi-diaphragm contractility compared to the control group, with a moderate effect size (CAI = 0.21 ± 0.11, Control = 0.29 ± 0.13, t51 = -2.34, P = 0.02 Cohen's d = -0.64, 95% CIs: -1.18, -0.08). There was no between-group difference in the degree of right hemi-diaphragm contractility (CAI = 0.23 ± 0.15, Control = 0.27 ± 0.18, t51 = -1.03, P = 0.31, Cohen's d = -0.28, 95% CIs: -0.82, 0.26). **Conclusions:** Individuals with CAI appear to have altered diaphragm contractility, which may be an illustration of diaphragm dysfunction and central nervous system changes in individuals with CAI. Future investigation is needed to determine if altered contractility of the diaphragm contributes to functional impairments, activity limitations, and participant restrictions commonly observed in patients with CAI.

## Walking Gait Mechanics With Chronic Ankle Instability

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**Context:** Patients with chronic ankle instability (CAI) have been reported to have differences in walking gait mechanics when compared to healthy controls, however no studies have previously measured kinematics, kinetics, and surface electromyographic (sEMG) activity simultaneously. **Objective:** To assess hip, knee and ankle frontal and sagittal plane kinematics and kinetics, and lower leg sEMG measures in patients with chronic ankle instability (CAI) and healthy controls during walking gait. **Design:** Descriptive laboratory study. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** Twenty-four subjects with CAI and 24 healthy controls (CAI: 8 males, 16 females, age = 21.4 ± 3.1 years, previous sprains = 5 ± 4, IdFAI = 23 ± 4, FAAM Sport = 67 ± 16%; Control: 7 males, 17 females, age = 21.7 ± 2.9 years, previous sprains = 0 ± 0, IdFAI = 0 ± 0, FAAM Sport = 100 ± 0%) participated. **Interventions:** Participants walked at a self-selected speed along a 10m walkway across an embedded forceplate. Fifteen steps were analyzed for each participant. **Main Outcome Measures:** An electromagnetic motion analysis system with 10 sensors was used to measure frontal and sagittal plane kinematics and kinetics of the ankle, knee and hip. Surface EMG amplitudes of the anterior tibialis, medial gastrocnemius, and peroneus longus we collected and normalized to mean of muscle activity during quiet standing thus producing a unitless measure. Stride cycles were time normalized to 100 percentage points. Group means and 90% confidence intervals for each dependent variable were compared across the stride cycle. Statistically significant differences were identified during intervals where the group confidence

intervals did not overlap for more than three consecutive percentage points of the stride cycle. Mean differences and standard deviations were generated for regions of significant difference. **Results:** The CAI group demonstrated significantly more ankle inversion positioning compared to the control group across the entire gait cycle (mean difference = 6.6 ± 2.7°). The CAI group was also more plantarflexed during 0-6% (4.6 ± 0.4°), 10-61% (4.6° ± 0.7°), and 70-100% (5.6 ± 0.7°) of the gait cycle. The CAI group also exhibited greater hip flexion from 79-86% (5.0 ± 1.2°), and more knee extension from 96-100% (5.7° ± 0.7°) of the gait cycle. Kinetic results showed decreased eversion moment in the CAI group from 29-38% (0.062° ± 0.008 Nm/kg). No significant differences were found in any of the sEMG measures between groups. **Conclusions:** The CAI group exhibited a more plantarflexed and inverted ankle position across nearly the entire walking gait cycle, while sagittal plane hip and knee kinematics were also altered in the late swing phase. Additionally, diminished eversion moments were found in the CAI group during midstance. These findings provide a more comprehensive understanding of altered gait mechanics in CAI patients than has been previously reported. This information may be used to create more comprehensive gait training interventions for CAI patients.

### Relationships Between Time-to-Stabilization and Isometric Hip Strength in Those With and Without Chronic Ankle Instability

Bolding BA, McCann RS, Terada M, Kosik KB, Crossett ID, Drinkard CP, Gribble PA: University of Kentucky, Lexington, KY

**Context:** Postural control deficiencies following a jump-landing have previously been identified in those with CAI when compared to ankle copers. Functional performance in CAI patients may partially be affected by neuromuscular impairments at the hip joint. Conversely, potential alternative recovery strategies in ankle copers may minimize neuromuscular impairments related to postural control performance. However no previous studies have examined hip muscular function and its association with dynamic postural control after landing in ankle copers and individuals with CAI. **Objective:** Examine the contribution of isometric hip strength to time-to-stabilization (TTS) in individuals with and without CAI. **Design:** Single blinded cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six participants volunteered from the university community. Participants were placed into CAI (14F, 1M; 23.1 ± 3.2 yrs; 166.3 ± 5.9cm; 67.8 ± 8.7kg), Coper (8F, 1M; 25.5 ± 6.7 yrs; 161.8 ± 6.9cm; 58.0 ± 7.8kg), and Control groups (7F, 6M; 21.1 ± 1.8 yrs; 171.2 ± 07.3cm; 72.5 ± 15.8kg) in accordance with published standards. **Interventions:** Participants completed 5 trials of the TTS task. Starting in a double leg stance, the participants jumped to 50% of their maximum vertical jump height and landed on one leg in the center of a force plate. CAI and Coper groups completed the TTS task on their involved limbs, while Controls were tested on a randomly selected limb. Three 5-second trials of isometric hip external rotation (ER), extension (EXT) and abduction (ABD) strength were measured bilaterally with a hand-held dynamometer. **Outcome Measures:** Raw anterior-posterior (AP) and medial-lateral (ML) ground reaction forces were used to calculate AP-TTS and ML-TTS via the sequential estimation method. A resultant vector TTS (RVTTS) was calculated with this equation: RVTTS = $\sqrt{}$(APTTS2 + MLTTS2). Raw peak torque values from each hip strength test were averaged and converted to a normalized torque value (Nm/kg). Backwards linear regression models were used to determine the contribution of hip strength measures to RVTTS variance. Significance was set a priori at $P < 0.05$. **Results:** In Copers, 88% of RVTTS variance was explained by the combination of involved ER and ABD and uninvolved EXT and ER ($R2 = 0.88$, $P = .097$). In CAI, 23.9% of RVTTS variance was explained by the combination of involved and uninvolved EXT ($R2 = 0.239$, $P = .194$). In Controls, 24.8% of RVTTS variance was explained by uninvolved ER ($R2 = 0.248$, $P = .083$). **Conclusions:** In Copers, RVTTS variance was strongly explained by isometric hip strength. In CAI, RVTTS had mild associations with hip strength, which more closely resembled uninjured Controls. Thus Copers may intensify hip strategies in order to achieve postural control, while those with CAI may fail to heighten hip strategies. Therapy for CAI patients may need greater attention to involvement of hip musculature during dynamic postural control tasks.

## Surface Electromyography and Plantar Pressure During Walking in Young Adults With Chronic Ankle Instability

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**Context:** Lateral ankle sprains are common injuries and can manifest into chronic ankle instability (CAI). CAI patients demonstrate alterations in gait including laterally deviated pressure (COP) and changes in muscle activity, but no studies have simultaneously measured muscle activity throughout the entire stride cycle and plantar pressure during stance. **Objective:** To simultaneously measure muscle activation patterns and plantar pressure distribution during walking in young adults with and without CAI. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** 17 CAI (6 males, 11 females, age = 20.0 ± 2.6 years, number of ankle sprains = 5.0 ± 5.6, IdFAI = 21.3 ± 5.2, FAAM Sport = 75.0 ± 6.9%) and 17 healthy (6 male, 11 female, age = 21.8 ± 4.3 years individuals volunteered. **Interventions:** Participants walked on a treadmill at 4.8 km/h while surface electromyography (sEMG) and in-shoe plantar pressure were recorded. **Main Outcome Measures:** Plantar pressure measures (pressure-time integral, peak pressure, time to peak pressure, contact area, contact time) of the entire foot and 9 specific foot regions, and medial-lateral location of COP at 10% intervals were measured during stance. For sEMG, root mean square (RMS) amplitudes throughout the entire stride cycle (10% intervals for stance phase and 25% intervals for swing phase) and area under the RMS curve for 100ms pre-initial contact (IC) and 200ms post-IC for anterior tibialis, peroneus longus, medial gastrocnemius, and gluteus medius were collected. The sEMG measures during gait were normalized to those taken during quiet standing resulting in a unitless measures. Independent t-tests were used to compare dependent variables between groups. Cohen's d effect sizes were also calculated to estimate the magnitude of group differences. **Results:** The CAI group demonstrated significantly more lateral COP than the control group throughout the entire stance phase (mean differences ranged from 2.9 to 7.7 mm, $P < .001$ and $d > 0.9$ for all 10 comparisons). The CAI group also had significantly increased peak pressure (CAI = 172.7 ± 46.3kPa, Healthy = 142.0 ± 27.9kPa, $P = .025$) and pressure-time integral (CAI = 61.3 ± 22.2, Healthy = 48.6 ± 12.4, $P = .049$) under the lateral forefoot compared to the control group. The CAI group had lower anterior tibialis RMS areas (CAI = 7.3 ± 2.2, Healthy = 15.5 ± 9.7, $P < .001$) and significantly higher peroneus longus (CAI = 7.1 ± 3.6, Healthy = 2.9 ± 2.5, $P = .001$), medial gastrocnemius (CAI = 10.3 ± 6.7, Healthy = 2.3 ± 1.8, $P < .001$), and gluteus medius (CAI = 8.9 ± 9.0, Healthy = 1.3 ± 0.3, $P = .003$) activity during100ms pre-IC. The CAI group also had higher gluteus medius sEMG amplitudes during the final 50% of stance and first 25% of swing ($P < .05$). **Conclusions:** The CAI group had large lateral deviations of their COP location throughout the entire stance phase which may place CAI patients at an increased risk of recurrent ankle sprain. The CAI group had increased gluteus medius muscle activation amplitude during late stance through early swing phase which may be a proximal adaptation used to create a wider base of support in preparation for IC. These findings may provide insight into the development of improved gait training interventions in CAI patients.

## Hip Strategies of Ankle Copers and Chronic Ankle Instability Patients During a Single-Leg Landing

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**Context:** Ankle copers are a subpopulation of lateral ankle sprain (LAS) patients with potential adaptive abilities that minimize neuromuscular deficiencies observed in chronic ankle instability (CAI) patients. Increasingly, hip muscular dysfunction is being identified as a site of such impairments in those with CAI. The ability of the hip musculature to eccentrically control hip flexion motion can be important for safe completion of functional tasks, such as a jump-landing. However, no previous studies have investigated the association between hip strength and sagittal plane hip motion during a jump-landing in ankle copers and CAI patients. **Objective:** Determine the associations of isometric hip strength with sagittal plane hip motion during a jump-landing task in ankle copers and CAI patients. **Design:** Single-blinded cohort design. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six members of the university community volunteered, and were separated into CAI (14F, 1M; 23.1 ± 3.2 yrs; 166.3 ± 5.9cm; 67.8 ± 8.7kg), Coper (8F, 1M; 25.5 ± 6.7 yrs; 161.8 ± 6.9cm; 58.0 ± 7.8kg), and Control groups (7F, 6M; 21.1 ± 1.8 yrs; 171.2 ± 07.3cm; 72.5 ± 15.8kg) based on previously established criteria. **Interventions:** Participants completed 5 single-leg landings following a double-limb jump to 50% of maximum vertical jump height. Kinematic data were collected with 10 high-speed digital cameras, 56 retroreflective markers over specific anatomical landmarks, and 3D motion capture software. Participants also completed 3 5-second trials of isometric hip extension (EXT), abduction (ABD), and external rotation (ER) strength using a hand-held dynamometer. All

tests were completed bilaterally. **Main Outcome Measures:** Hip flexion excursion (HFE), defined as the difference between peak post-landing hip flexion angle and hip flexion angle at initial ground contact, was averaged for each limb. For strength tests, raw peak torque, measured in Newtons (N), was averaged, multiplied by moment arm length (m), and divided by body mass (kg) to obtain normalized torque (Nm/kg). Separate backward linear regression models were used to determine the contribution of hip strength to ipsilateral HFE in each group. Significance was set a priori at $P < 0.05$. **Results:** In Copers, 67.8% of HFE variance in the involved limb ($R^2 = 0.678$, $P = 0.012$) and 62.3% in the uninvolved limb ($R^2 = 0.623$, $P = 0.020$) was explained by ABD. In CAI, 31.3% of HFE variance in the involved limb ($R^2 = 0.313$, $P = 0.030$) and 36.5% in the uninvolved limb ($R^2 = 0.365$, $P = 0.017$) was explained by EXT. Controls' HFE variances were not explained significantly by isometric hip strength. **Conclusions:** HFE during landing was related to ABD in Copers and EXT in CAI. Copers and CAI patients may both develop strategies for eccentrically controlling hip flexion motion and limiting landing external moments utilizing hip musculature, but Copers appear to do so to a greater degree and with a greater reliance on abductors. CAI patients may benefit from greater attention to hip extensor strength as a means of attenuating external moments and preventing recurrent injury.

### Potential Association Between Corticomotor Plasticity and Postural Control

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**Context:** CAI is associated with a continuous cycle of self-reported disability, reduced sensorimotor function, and recurrent injury. Examining altered sensorimotor function is crucial in our understanding of the underlying neurophysiological mechanics that may explain patient- (i.e. self-reported disability) and disease- (i.e. diminished postural control) oriented outcomes consistently observed in patients with CAI. Early evidence has highlighted deficits within the corticospinal pathways of the fibularis longus(FL) muscle and its association with self-reported disability using Transcranial Magnetic Stimulation (TMS), signifying a potential reorganization of the suprapsinal sensorimotor system. A novel technique within TMS that may be used to further quantify the amount of this reorganization and potential neural plasticity is mapping of the corticomotor output. However, the TMS mapping technique has not been applied in CAI populations. Understanding this reorganization of the sensorimotor system through TMS mapping may help explain the patient-and disease-oriented factors associated with CAI. **Objective:** Examine the association of corticomotor plasticity of the FL, self-reported disability, and postural control in CAI and Healthy-controls (HC). **Design:** Single-blinded Case Control Study. **Setting:** Research Laboratory. **Patients or Other Participants:** Fourteen CAI patients, (23.3 ± 3.6 years, 170.18 ± 8.37cm, 70.56 ± 11.25kg) and 15 HC (21.18 ± 2.13 years, 170.18 ± 10.49cm, 67.92 ± 9.63kg) volunteered. **Interventions:** Participants completed self-reported disability questionnaires. Static postural control was measured during four, 20-second, single-leg eyes-open postural control trials. TMS was used to map the primary motor cortex of the FL. The average of the three motor evoked potentials (MEP) was normalized to the maximal muscle response. **Main Outcome Measures:** Corticomotor plasticity was determined through 1) size of the corticomotor map area and 2) volume of the corticomotor map. The map area is expressed as the mean number of sites from which normalized MEPs were evoked. The map volume was calculated as the sum of normalized MEP amplitude across scalp sites. Single-leg eyes-open postural control was evaluated by calculating the time-to-boundary (TTB) absolute minimum(s), mean minima(s), and standard deviation of minima(s). Self-reported disability was assessed through the Foot and Ankle Ability Measure Activities of Daily living (FAAM-ADL) and Sports (FAAM-Sports). Independent T-tests were used to assess group differences in each mapping outcome variable (area & volume). Cohen's d effect sizes along with 95% confidence intervals (CI) were calculated using the pooled standard deviations. Pearson product moment correlations were performed between outcome variables in participants with CAI. Significance was set a priori at $P \leq 0.05$. **Results:** CAI corticomotor volume appears to be decreased compared to HC, as it approached significance with a moderate effect size ($P = 0.057$, $d = 0.74$, CI:-0.03,1.47). Corticomotor area and volume were negatively correlated with TTB medial-lateral absolute minimum (Area: $P = 0.030$, $r = -0.514$; Volume: $P = 0.033$, $r = -0.504$) and FAAM-Sport (Area: $P = 0.048$, $r = -0.480$; Volume: $P = 0.019$, $r = -0.580$). **Conclusions:** A potential reorganization within the motor cortex and its association to the patient-and disease-oriented outcomes was observed in individuals with CAI. These data provide particularly novel insight into the sensorimotor plasticity in CAI population.

## Associations Between Hip Strength and Dynamic Postural Control in Those With and Without Chronic Ankle Instability

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**Context:** Chronic ankle instability (CAI) and ankle coper populations commonly perform differently on tests of dynamic postural control. Ankle copers are postulated to have adaptive abilities that limit postural control impairments after initial injury. Previous studies indicate that hip joint movement is associated with performance on tests of dynamic postural control, such as the SEBT. Given hip muscular dysfunction has been identified in CAI patients, an understanding of its contribution to SEBT performance is needed. However, the associations between hip muscular function and SEBT performance have not previously been investigated in CAI and ankle coper populations. **Objective:** To determine to what extent hip strength associates with dynamic postural control in those with and without CAI. **Design:** Single-blinded cohort study. **Setting:** Research laboratory. **Patients or Other Participants:** Forty-three members of the university community volunteered and were separated into CAI (17F, 1M; 22.8 ± 3.0 yrs; 166.5 ± 5.4cm; 68.9 ± 8.8kg), Coper (10F, 2M; 25.2 ± 6.2 yrs; 163.5 ± 6.2cm; 60.8 ± 7.6kg), and Control groups (7M, 6F; 21.1 ± 1.8 yrs; 171.2 ± 7.3cm; 72.5 ± 15.8kg). **Interventions:** Each participant was tested in the SEBT anterior (ANT), posteromedial (PM), and posterolateral (PL) reach directions on the involved limb of CAI and Coper groups and a randomly selected limb in Controls. Bilateral isometric hip extension (EXT), abduction (ABD) and external rotation (ER) strength was measured using a hand-held dynamometer. **Main Outcome Measures:** SEBT reach direction values were normalized as a percentage of total stance leg length (%). Raw peak hip strength values were measured in Newtons (N) and normalized to the length of the moment arm (m) and body mass (kg) to obtain a normalized torque value (Nm/kg). Backwards linear regression models were used to determine to what extent variance in SEBT reach scores were explained by isometric hip strength. Statistical significance was set a priori at $P < 0.05$. **Results:** In the Control group, the combination of involved ER and EXT and uninvolved ABD explained 48.5% of ANT variance ($R2 = 0.485$, $P = 0.099$), uninvolved EXT and ER explained 35% of PM ($R2 = 0.350$, $P = 0.116$) and 35.2% of PL variances ($R2 = 0.352$, $P = 0.114$). In the CAI group, the combination of involved ER and uninvolved EXT explained 28.2% of PM variance ($R2 = 0.282$, $P = 0.083$). Copers' SEBT scores were not explained significantly by isometric hip strength. **Conclusions:** All three groups exhibited unique coordination patterns of hip strength relationship to dynamic postural control, with both groups of ankle injury history patients exhibiting less reliance on hip strength than the models of the Controls. Copers seem to utilize hip strength during the SEBT to a lesser extent than CAI patients. Future studies should attempt to identify the origin of these coordination differences with the aim of promoting optimal strategies in those with CAI.

### Changing Ball-Handling Positions Affects Lower Extremity Moments During Landing

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**Context:** Sports requiring manipulation of objects (e.g. basketball) require athletes to frequently change their trunk and upper extremity placement relative to the lower extremity (LE). Such changes may alter athletes' center of mass (CoM). However, little research has examined if changing upper body positions while holding a standard basketball during a high LE injury-risk movement such as landing subsequently affects LE biomechanics. **Objective:** To examine if changing hand positions during landing affects LE moments. **Design:** Repeated measures. **Setting:** Research Laboratory **Patients or Other Participants:** 30 healthy participants (23.4 ± 4.3 years, 170.7 ± 7.7 cm, 70.2 ± 18.9 kg) **Interventions:** Participants performed 5 landings each from a 45 cm box in 4 different hand placement conditions: 1) Holding a basketball at chest level (CH), 2) Holding a basketball at chest with arms straight in front (FR), 3) Holding a basketball straight up over head (UP), and 4) Placing hands on hips (HIP) without holding a ball (a position commonly used in examining landing biomechanics). LE biomechanics were recorded using a force plate and 3D video tracking system. **Main Outcome Measures:** Peak sagittal Hip, Knee, and Ankle flexor and frontal Knee Abductor moments (Nm/kg) from initial touchdown to lowest point of the vertical CoM displacement were compared across HP conditions using repeated measures ANOVAs with post-hoc pairwise comparisons as appropriate ($p<.05$). **Results:** Participants had differing sagittal Knee (CH = -.55 ± 1.1, FR = -.60 ± 1.2, UP = -.66 ± 0.96, HIP = -.76+077; p = .004), but not Hip (CH = 2.9 ± 1.3, FR = 3.4 ± 1.9, UP = 3.3 ± 1.5, HIP = 3.3 ± 1.5; p = .21), or Ankle (CH = -0.09 ± 0.18, FR = -0.08 ± 1.1, UP = -.08 ± .13, HIP = -.10 ± 0.20; p = .30) flexor moments across the HP conditions. Participants had differing frontal Knee abductor moments (CH = -0.45 ± 0.19, FR = -0.52 ± 0.27, UP = -0.49 ± 0.21, HIP = -0.76 ± 0.77; p = .04), across the different conditions. Specifically, in CH, participants had lower knee moments than in UP (flexor: p = .03; abductor: p = .03), and HIP (flexor: p = .03; abductor: p = .04). **Conclusions:** Changing hand placement during landing alters LE flexor and abductor moments during landing. When landing with arms across the chest, participants' knee flexor and abductor moments were lower than when keeping their hands straight up over the head or on their hips. Decreased knee abductor moments are associated with decreased LE injury risk and vice versa. Thus, holding a ball closer to the chest or on the hips (i.e. closer to overall body CoM), as compared to holding a ball vertically up in the air when taking a jump shot, or coming down holding a ball from a rebound during basketball, may decrease an athletes' injury risk during landing. When combined with prior work noting that upright trunk positions (similar to the UP position in this study) results in high-injury risk alterations in LE moments, our findings suggest that clinicians should incorporate functional hand and trunk movements when designing LE injury prevention programs to decrease LE injury risk during in sports requiring object manipulations.

### Reliability and Validity of the Single-Leg Landing Error Scoring System (SL-LESS) for Lower Extremity Movement Screening

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**Context:** Movement screening assessments are often implemented to identify individuals at high-risk of knee injury in order to prevent the injury and the associated negative long-term consequences. Most established field-based assessments are performed on two legs, while knee injuries usually occur during single-leg stance. Additionally, there is no two-dimensional screening measure to evaluate the movement of multiple body segments in more than one plane during a single-leg task. **Objective:** To determine the reliability and concurrent validity of the novel single-leg LESS (SL-LESS). **Design:** Cross-sectional. **Setting:** University research laboratory. **Patients or Other Participants:** Twenty-eight physically active females (24.79 ± 2.36 years, 1.70 ± 0.07 m, 62.14 ± 9.64 kg) volunteered. Exclusion criteria were a history of, or current, injury to the back or lower extremities or current pregnancy **Interventions:** The LESS protocol and scoring rubric were adapted for a single-leg drop vertical jumps (SLDVJ). Participants completed five SLDVJs from a 20cm high box placed a distance of 25% of the subject's height away from a force plate. Two standard video cameras recorded the jumps and 3D kinematic and kinetic data were recorded simultaneously. An identical data collection occurred at least 48 hours later. **Main Outcome Measures:** The SL-LESS rubric consisted of 11 items that rated errors performed during the SLDVJ. Two trained raters independently scored all participants and one rater scored both sessions. Participants were classified

into groups with scores of 1-2 errors labeled as "good" and ≥4 labeled as "poor". To establish concurrent validity, the ability of the SL-LESS to identify differences in a known ACL injury risk factor, external peak KABD moment was determined. Concurrent validity was evaluated using an independent-samples t tests to compare maximum KAbM between the "good" and "poor" groups. Intraclass correlation coefficients (ICC, model 2,1) were used to determine the test-retest reliability and interrater reliability. Percent agreement and Cohen's kappa statistics were also used to determine agreement of the individual items of the SL-LESS. **Results:** No differences (t20 = -0.61; p = 0.274) were found in maximum KAbM between groups (good = 0.133 ± 0.080 Nm/kgm, poor = 0.153 ± 0.066 Nm/kgm). The SL-LESS demonstrated fair interrater reliability (ICC2,1 = 0.781; 95% CI: 0.581-0.892) and good test-retest reliability (ICC2,1 = 0.850; 95% CI: 0.596-0.938). Individual item agreement ranged from 75.0-100% and kappa statistics indicated significant fair to perfect agreement. **Conclusions:** This was the first study to adapt the LESS for use during a SLDVJ. Results show the instrument has good inter- and intratester reliability, however it was not able to differentiate between individuals with high vs low KAbM, which was chosen as the measure of concurrent validity. This study does, however, provide the basis for a new single-leg, full body screening tool. Revision of the scoring items, as well as including a larger sample size with more variability is the direction for future research.

### Does the Landing Error Scoring System Predict Knee Injury in Elite Youth Athletes?

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**Context:** Previous research has shown that Landing Error Scoring System (LESS) scores can be used as a screening tool to determine ACL injury risk in youth soccer athletes. However, it is unknown if LESS score can be used determine the risk of other types of knee injuries (e.g. PFP, patellar tendinopathy, Osgood-Schlatter disease) that occur during youth sport participation. **Objective:** To determine if LESS scores can identify youth athletes at risk of various different types of knee injury. It was hypothesized that higher LESS scores would be associated with increased injury prevalence and LESS scores would be higher in female athletes. **Design:** Cohort study. **Setting:** Field testing in a gymnasium at an elite sports school. **Patients or Other Participants:** 77 healthy, physically active adolescent athletes (49 males, 28 females; age: 13.0 ± 0.3 years; height: 159.6 ± 9.2 cm; mass: 49.6 ± 9.3 kg) from an Australian Sports Academy across a range of sports. Athletes are offered a spot in the Sports Academy based on fitness and sport-specific performance testing in 6th grade. **Interventions:** Testing for all participants involved a jump-landing task (two practice and two trials), which was videotaped and later scored. Athletes were tracked prospectively throughout the school year for diagnosis of knee injury. T-tests were used to determine differences in LESS scores with injury, across sex, and the % of injured athletes with LESS scores below/above 6. **Main Outcome Measures:** The two jump landing trials were independently scored for "errors" using the LESS by two researchers and the results were averaged. **Results:** Physiotherapists diagnosed 15 athletes with knee injuries during the follow up period. Uninjured participants (6.1 ± 1.9) had slightly lower LESS scores compared to injured participants (6.3 ± 2.0), though not statistically significant (P = 0.710). Contrary to previous findings, there was no difference in LESS between males (6.2 ± 1.8) and females (6.1 ± 2.1, P = 0.928). The percentage of injured athletes with low LESS values (<6, 18.2%) was similar to those with higher values (>6, 20.4%, P = 0.402). **Conclusions:** Despite previous studies linking LESS score and ACL injury, we did not observe an association between LESS and other types of knee injury in adolescents. The overall lack of differences in LESS scores may have been influenced by relatively high scores in general, while similar scores between males and females may be due to maturity status. Consequently, most of these athletes would benefit from improved jump landing technique. While LESS was unable to identify at risk athletes in this preliminary study, in part due to small sample size and total numbers of injuries, future research should track subjects over longer duration with repeat testing and assess other factors that may contribute to knee injury in youth athletes.

## Influence of Pelvic Angle on Hip and Knee Motions During Double and Single Leg Landings in Male and Female Youth Soccer Players

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**Context:** Increased anterior pelvic tilt is suggested to influence static and dynamic lower extremity alignment. Retrospective studies reported associations between greater anterior pelvic tilt and altered lower extremity kinematics that have been theorized to increase the risk of ACL injury. However, no studies have assessed this association in youth athletes across stages of maturation. **Objective:** To determine if greater pelvic angle (PA) is associated with hip and knee kinematics during a jump landing (JL) and single leg hop (SLH) in male and female youth soccer players. **Design:** Cross-sectional. **Setting:** Field Setting. **Patients or Other Participants:** One hundred and sixty four (86M, 78F: 11.0 ± 1.9 yrs, 144.7 ± 16.0 cm, 38.7 ± 10.9 kg) youth soccer players volunteered to participate. **Interventions:** The Pubertal Maturation Observation Scale (PMOS) determined maturation stage. PA was measured bilaterally by a clinician with known reliability (ICC2,k >0.97). Three-dimensional kinematics were assessed bilaterally using electromagnetic motion analysis system during a JL and SLH. For the JL, participants jumped from a 30cm box set 50% of their height away from a force plate and rebound for maximum vertical height. For the SLH, participants stood on one leg and took a hop forward, landing on the same leg (hop distance = 40% of height, minimal vertical height = 5"). **Main Outcome Measures:** Maturation groups: pre-pubertal (44M, 34F: PMOS < 2), pubertal (31M, 27F: PMOS = 2-5), and post-pubertal (11M, 17F: PMOS > 5). PA values were averaged over two measures. Frontal and transverse plane hip and knee peak angles and joint displacements (peak angle minus initial contact) during the deceleration phase [initial contact (vGRF >10N) to max knee flexion] of the JL and SLH tasks were averaged over three trials. The mean values for the right and left limb were used for analyses. Separate Pearson correlations (r) examined the relationship between PA and lower extremity kinematics during each task across maturation for males and females. **Results:** In pre-pubertal males, greater PA (16.7 ± 4.8°) was correlated with less hip adduction (4.3 ± 3.2°, r = -0.055, P = 0.007) and greater knee valgus (-8.8 ± 6.9°, r = 0.353, P = 0.020) displacement during a JL. In post-pubertal males, greater PA (17.5 ± 3.6°) was correlated with less peak hip internal rotation (2.3 ± 8.5°, r = -0.6.33, P = 0.049) and greater peak knee internal rotation (17.7 ± 11.7°, r = 0.692, P = 0.027) during a SLH. PA was not associated with landing kinematics in females or pubertal males (all P > 0.05). **Conclusions:** Greater PA was associated with less hip joint and greater knee joint landing kinematics in pre- and post-pubertal youth male soccer players. As a result of the limited hip motions, the compensated knee motions may contribute to increased risk of ACL injury in youth male athletes. While PA was not associated with landing kinematics in youth female athletes, future studies should continue to examine the role of other static alignments in the incidence of ACL injuries in youth athletes.

## Injury Risk and Agility Performance Correlation Between Female Basketball Players

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**Context:** Objective and safe return to play decisions following lower extremity musculoskeletal injuries are critical to avoid subsequent injury. Performance measures, such as agility tests, are components of sport-specific functional rehabilitation exercises as well as an athlete's evaluation of readiness to return to participation. These types of measures are good indicators of an athlete's functional ability, but may not represent an athlete's level of injury risk. It is unknown how agility test performance correlates with injury risk, as measured by movement technique. **Objective:** To examine the relationship between injury risk and agility performance in females aged 7-17 participating in competitive basketball. **Design:** Cohort design. **Setting:** Field study with a youth female basketball league. **Patients or Other Participants:** Forty-seven female basketball players (age: 13 ± 2 years, height: 164.0 ± 9.9 cm, mass: 55.6 ± 13.4 kg) volunteered to participate. **Interventions:** Participants were tested at the beginning (PRE) of a basketball season. Participants completed 3 trials of a jump-landing task and 2 trials of an agility shuttle run (t-test) in a randomized order. Movement quality during the jump-landing task was graded using the Landing Error Scoring System (LESS) by a single rater at a later date. The LESS is a valid and reliable clinical movement assessment that is predictive of injury risk in youth athletes. Automated electronic timing gates (Brower Timing Systems, Drapper, UT) were used during the t-test. **Main Outcome Measures:** Individual trials

within each task were averaged together for analyses. Correlation analysis were performed between the LESS total score and t-test performance ($\alpha = 0.05$). **Results:** We did not find evidence of an association between LESS and t-test scores ($r2 = 0.2$, 95% CI [-6.02, -4.93], $p > 0.05$, LESS: 6.6 ± 2.1 errors, t-test: 12.09 ± 1.24s). **Conclusions:** These findings suggest that although the t-test is a measure of agility, it may not be an accurate measure of movement control, injury risk and an athlete's readiness to return to play. These findings demonstrate that the t-test should not be utilized as the sole measure of determining an athlete's readiness to return to play. Future research should identify other movement control and agility tests to better evaluate an individual's readiness to return to play following an injury.

## Relationship Between Single Leg Hop Asymmetry, Performance, and Injury Probability: A Moderation Analysis (The FPPE Project)

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**Context:** Despite established relationships between lower extremity (LE) neuromuscular control asymmetry and injury risk, the extent to which this relationship varies as a function of (i.e. is moderated by) LE neuromuscular control performance is unclear. The anterior single leg hop for distance (SLHOP) test has been used to assess LE neuromuscular control asymmetry, performance and injury risk in physically active populations. Identifying if a relationship between SLHOP asymmetry and injury is moderated by SLHOP performance may improve the effectiveness of injury risk screening procedures. **Objective:** Determine if the relationship between SLHOP asymmetry and injury probability is moderated by SLHOP performance. **Design:** Prospective cohort study. **Setting:** High school athletic training facilities. **Patients or Other Participants:** 2,200 male (15.68 ± 1.22 years, 1.76 ± 0.09m, 74.29 ± 15.90kg) and 1,295 female (15.54 ± 1.20 years, 1.65 ± 0.07m, 60.58 ± 10.01kg) high school athletes. **Interventions:** Prior to the start of their competitive sports seasons, participants completed the SLHOP as part of the ongoing Functional Pre-Participation Physical Evaluation (FPPE) project. The FPPE project is a nationwide preseason screen aimed at assessing high school athletes' LE MSK injury risk. SLHOP performance was calculated as the average of the maximum hop distances, normalized to leg length (%LL), for each leg. SLHOP asymmetry was calculated as the difference between the maximum non-normalized hop distances for each leg. The smallest distance of the two legs was subtracted from the largest distance so all asymmetries were positive. **Main Outcome Measures:** Certified Athletic Trainers (AT) using the national surveillance tool, High School Reporting Information Online (RIO), collected LE injury data. An injury was defined as requiring medical care from a physician or AT and resulting in at least one day lost from athletic participation. A logistic regression-based moderation analysis was performed to determine if a relationship between SLHOP asymmetry and injury probability was moderated by SLHOP performance. Significance testing of the interaction between SLHOP asymmetry and performance was used to assess moderation. The Johnson-Neyman technique was used to identify regions in which the conditional effect of SLHOP asymmetry on injury probability was statistically significant. Alpha level was set a priori at $p < 0.05$. **Results:** Certified ATs reported 406 LE injuries. The relationship between SLHOP asymmetry and injury probability was moderated by SLHOP performance (coefficient: -0.0003, 95% CI: -0.0006, -0.0001, $p = 0.025$). The conditional effects of SLHOP asymmetry on injury probability increased as SLHOP performance decreased and were significant for individuals with SLHOP performances below 200.05%LL (conditional odds ratio for every 1cm asymmetry at 200.05% LL: 1.01, 95% CI: 1.001, 1.024, $p = 0.049$). **Conclusions:** The effect of SLHOP asymmetry on injury probability depends on SLHOP performance. Specifically, SLHOP asymmetry may only alter the likelihood of injury if SLHOP performance is below approximately 200%LL. This finding suggests that SLHOP performance should be considered in conjunction with asymmetry when evaluating injury risk.

## A Multimodal Screening Exam Predicts Knee and Ankle Injuries in High School Athletes

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**Context:** High School athletes sustain approximately 2,000,000 sport related injuries per year. The ankle and knee represent 23% and 14% of all injuries, respectively. Various risk factors for injury have been previously identified and include previous injury history, sex, balance, and movement quality during high risk tasks, such as landing from a jump. However, research into these risk factors often report conflicting results. Combining a variety of factors into a single model may yield the most clinically useful information. **Objective:** To examine the value of pre-participation demographic, balance, and movement quality measures and their association with non-contact ankle and knee injuries. **Design:** Prospective. **Setting:** High school. **Patients or Other Participants:** 302 high school athletes (age = 15.6 ± 1.2 years; height = 171.4 ± 9.2 cm; mass = 65.7 ± 11.3 kg, 180 females) from two high schools and four different sports (volleyball, tennis, basketball, soccer). **Interventions:** Participants were screened at the start of their respective high school sport seasons. Screening consisted of an 1) injury history questionnaire, 2) balance, and 3) jump landing assessments. Dynamic balance was assessed bilaterally using the y-balance test in three directions (normalized to limb length). Participants completed practice trials followed by three recorded trials. Three jump landings were performed from a 12-inch high box onto force plates. Frontal and sagittal cameras captured the jumps and were later scored using standardized Landing Error Scoring System (LESS) criteria. A best fit forward stepwise logistic regression model was created to examine the association of these variables with non-contact knee or ankle injuries. An ROC curve was created and Youden's method for optimizing sensitivity and specificity was used to determine the best diagnostic cut-off point of the predicted probability of injury from the model. **Main Outcome Measures:** Y-balance reach distances and asymmetry values, total LESS score, injury history, vertical ground reaction force and between limb asymmetry, and prospective noncontact knee and ankle injuries. **Results:** During the 2014-2015 high school sport season, 18 noncontact ankle and knee injuries were recorded with 284 non-injuries. Four predictors were identified in the model including 1) Anterior reach distance of the right limb (OR = 0.82 (0.72, 0.91), P = .001), 2) previous ankle injury (OR = 11.36 (2.87, 62.94) , P = .002), 3) Grade level (junior [OR = 14.06, P = .039] or senior [OR = 24.37, P = .008]) in standing, and 4) previous knee injury (OR = 7.11, P = .002). The ROC curve analysis calculated a predicted probability cutoff of 0.15 (AUC = 0.89), generating a sensitivity of 81% and specificity of 93%. **Conclusions:** Pre-participation exams are valuable tools in which to identify athletes at high risk of sustaining an injury. The best predictors of future injury included balance, previous injury history, and grade level. Jump landing variables including landing force (peak and between limb asymmetry), and total LESS score were not predictive of lower extremity injury. Cross-validation of injury prediction models is needed.

## A Sagittal-Plane Emphasized Preventive Training Program Reduces Injury Risk in Youth Soccer Athletes

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**Context:** Early intervention with children prior to high school may be critical for improving the long-term adoption of preventive training programs in sport and preventing future injury. There is a gap in knowledge about how to implement preventive training programs in children younger than 14 years old to modify neuromuscular risk factors for injury. Simplifying the instructions provided to children during a program may enhance efficacy and compliance. **Objective:** To compare the effects of a traditional preventive training program (TRAD), a preventive training program with simplified instructions (BASIC), and no program (CON) on landing mechanics in youth soccer athletes under 14 years old. **Design:** Cluster-randomized controlled trial design. **Setting:** Field. **Patients or Other Participants:** 420 youth soccer athletes (n = 200 males: age = 11 ± 3 years, height = 151.5 ± 9.8 cm, mass = 30.8 ± 2.4 kg; n = 220 females: age = 11 ± 3 years, height = 149.0 ± 13.5 cm, mass = 42.4 ± 11.4 kg) volunteered to participate. **Interventions:** Participants were randomized at the team level (29 teams), after stratifying by soccer club, sex, and age, to the TRAD, BASIC, or CON groups. Participants performed three trials of a jump-landing task at the beginning (PRE) and end (POST) of an 8-week soccer season. Two video cameras recorded the task from the front and side of each participant. Landing mechanics were graded using the Landing Error Scoring System (LESS) by a single rater blinded to group at a later date. The LESS is a valid and reliable clinical movement assessment that is predictive of injury risk in youth soccer athletes. A research assistant

implemented the assigned programs to each team 2-3 times per week for the duration of the soccer season. Athletes in the TRAD group received instruction and feedback relative to three planes of motion (eg., "bend your knees", "keep your knees over your toes", "keep your toes pointed straight ahead"). Athletes in the BASIC group only received instruction and feedback related to the sagittal plane (eg. "land low", "bend your knees"). **Main Outcome Measures:** The average LESS score from the three trials at each time point was calculated and used for analyses. A linear mixed effects model clustered by team was used to evaluate differences in LESS score between warm-up groups (TRAD, BASIC, CON) across time points (PRE, POST) (P = 0.05). **Results:** Both preventive training programs reduced LESS scores (BASIC: PRE = 6.54 ± 1.79 errors, POST = 5.62 ± 1.86 errors, P = 0.04; TRAD: PRE = 6.41 ± 1.83 errors, POST = 5.34 ± 1.78 errors, P = 0.004) compared to the control group (PRE = 6.33 ± 1.71 errors, POST = 5.97 ± 1.81 errors). No significant difference existed between the TRAD and BASIC programs (P > 0.05). **Conclusions:** These findings indicate that preventive training programs can injury risk in youth soccer athletes and instructions can be simplified to only emphasize corrections in the sagittal plane. This simplified approach may be easier for youth coaches to utilize and improve program adoption and compliance.

## A Three Week ACL Injury Prevention Program Shows Promise in Improving Landing Mechanics and Balance Performance: Results From a Pilot Study

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**Context:** ACL injury prevention programs (IPPs) have shown to be effective at reducing the risk of injury, particularly if direct supervision of participants is used. The majority of IPPs are for an extended duration, usually 8 weeks in duration. It is unclear whether programs of shorter duration are viable. **Objective:** To implement an ACL IPPs modified from the Dynamic Integrated Movement Enhancement (DIME) program and measure its effects on knee FPPA as well as balance performance. Participants were taught essential movement patterns and performed nine different exercises during each session, including how to control their body position for proper anatomical alignment of the knee, increase hip and knee flexion during cutting and landing activities, and proper landing mechanics. **Design:** Cohort study. **Setting:** University setting. **Patients or Other Participants:** 10 recreational athletes (7 females, 3 males) ages 19.6 ± 3.27 (height: 167.4 ± 4.45cm, weight: 69.55 ± 15.75kg) participated in the study1 dropped out and did not provide post-test data. **Interventions:** We modified our ACL IPP from the DIME program. The program involved initial general aerobic activity followed by each movement included in the DIME program: double leg squat, forward lunge, sideways hop to balance, squat jump, plank, one-leg reach, push-up, box jumps and ice skater. Between each movement, participants engaged in a variety of movement patterns such as running, bounding, zig-zag run, carioca run, etc. The program was designed for use in a standardized, pre-practice warm up. Total duration averaged 20 minutes. The activities were supervised by a total of 5 people during each session. **Main Outcome Measures:** The dependent variables were knee frontal plane projection angle (FPPA) during landing and dynamic balance performance. Landing mechanics were recorded via an iPad 2 and FPPA was analyzed with Dartfish Video Analysis (Dartfish USA, Inc; Alphareta, GA). Participant balance performance was measured with the Star Excursion Balance Test (SEBT) in the anterior, posterior-medial, and posterior-lateral reach directions. The participant's reach was normalized by leg length and reported as a percentage. Paired samples t-test (P = <.05) were used to compare pre and post-test performance data. **Results:** There was a significant difference between the pre (13.5 ± 10.23) and post (8.7 ± 7.3) FPPA (T8 = 2.42, P = .04). There was a significant difference between the pre (79.33 ± 4.62) and post (84.58 ± 7.46) SEBT performance ((T7 = -2.96, P = .02). **Conclusions:** The relatively short duration, ACL IPP shows promise in changing landing mechanics and improving balance. Participants improved both their landing mechanics and balance over the course of the three-week ACL IPP. The results must be interpreted cautiously, however, as the sample size was small and only 9 and 8 participated in the landing mechanic and balance testing, respectively. Moreover, the changes were measured immediately after the program thus the findings are limited to acute changes in landing mechanics and balance.

## The Effect of an Injury Prevention Program Designed to Reduce Medial Knee Displacement in Youth Female Basketball Athletes

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**Context:** Medial knee displacement (MKD) is considered a modifiable risk factor for lower extremity injury and incorporates frontal and transverse plane motion from the knee and hip. Instruction provided to athletes during injury prevention programs (IPPs) often stresses the importance of reducing MKD, but there is not good evidence these programs are effective in reducing MKD. **Objective:** To compare the effectiveness of an IPP designed to reduce MKD and a general movement correction program on MKD and overall landing technique in youth female basketball athletes. **Design:** Cohort. **Setting:** Field Study. **Patients or Other Participants:** Forty-seven competitive female basketball athletes (12 ± 2 years, 165.1 ± 10.2 cm, 56.7 ± 14.1 kg) on eight teams volunteered to participate. **Interventions:** Participants were screened for the presence of MKD at the beginning (PRE) and end (POST) of the season using three tasks: jump-landing task, double leg squat (DLS) and single leg squat (SLS). Tasks were videotaped from the front and side. A single rater blinded to team graded videos at a later date using the LESS, a valid and reliable movement screening tool, and evaluated the DLS and SLS for the presence of MKD using a valid and reliable operational definition. Four teams (n = 19) received an intervention (INT) warm-up that emphasized corrective exercise strategies for MKD when more than 50% of athletes demonstrated MKD during at least one task at PRE. The other 4 teams (n = 28) received a general IPP (CON) designed to improve overall movement control. IPPs were performed prior to practice (2-3x/week) for approximately 12 weeks. **Main Outcome Measures:** Only participants that demonstrated MKD at PRE were used for analyses. Separate independent chi-square analyses were utilized to evaluate the association between group (INT or CON) and MKD presence at POST. A two-way, mixed-model ANOVA was used to compare groups (INT, CON) and time (PRE, POST) on the average LESS score of three trials ($\alpha = 0.05$). **Results:** There was no association between the presence of MKD at POST and group during the jump landing task ($\chi2(1) = 2.21$, $p > 0.05$, # participants with MKD at POST/# participants with MKD at PRE: INT = 14/14(100%), CON = 24/28(86%)), DLS ($\chi2(1) = 0.17$, INT = 3/7(43%), CON = 4/12(33%)), and SLS ($\chi2(1) = 0.37$, $p > 0.05$, INT = 12/17(71%), CON = 22/28(78%)). A main effect for time ($p < 0.001$) was observed (mean difference±SD, [95% CI]: -1.12 ± 1.9 errors, [-1.76, -0.63]). **Conclusions:** Medial knee displacement did not improve with either IPP, including a program specifically designed to address MKD. Athletes did, however, reduce overall injury risk from PRE to POST. Despite MKD being considered a modifiable risk factor, these findings suggest it may prove difficult to modify MKD even with an IPP that was successful at reducing overall injury risk.

# Free Communications, Rapid Fire Oral Presentations: Factors Influencing Head Impact Exposure in Football and Soccer

Saturday, June 25, 2016, 8:15AM-9:00AM, Room 317; Moderator: Julianne Schmidt, PhD, LAT, ATC

### A Comparison of Head Impact Exposure Between Football Practice Types

Myers JL, Swartz EE, Cook SB, Broglio SP, Cantu RC, Ferrara MS, Guskiewicz KM: University of New Hampshire, Durham, NH

**Context:** Head impacts in football are associated with acute and potentially chronic head and neck injury risk. To mitigate this risk, administrators and governing bodies have sought to reduce the number of allowable full-contact practices. While limiting full-contact practices makes intuitive sense, research has reported that head impacts are still common in non-contact sessions and may be of a higher magnitude. These particular impacts may be explained by 'risk compensation' behavior afforded to a helmeted athlete. **Objective:** To compare head impact exposure between practice type in collegiate football. **Design:** Retrospective Cohort. **Setting:** In-season, NCAA FCS Division I football. **Patients or Other Participants:** Twenty-five Division I football players (age = 19 ± 0.8 yrs; height = 72.6 ± 2.1in; weight = 214.1 ± 29.0 lbs) from both offensive and defensive positions (excluding quarterbacks, kickers, and offensive lineman) were recruited from a sample of convenience and monitored for one season. **Interventions:** After providing consent, subjects were assigned an xPatch™ (X2 Biosystems, Inc., Seattle, WA) head impact sensor at the start of pre-season. Prior to each practice, subject attendance was recorded and the xPatch™ was affixed to the subject's mastoid region as per manufacturer's instructions. Subjects complied with designated practice type (independent variable) understood to be full-contact (fully equipped), limited-contact (helmet and shoulder pads), and non-contact (helmet only). Head impact exposures ≥10g threshold of linear acceleration were recorded by the xPatch™ during all practices. Raw impact data were filtered for spurious impacts using X2 Impact Measurement System software followed by visual inspection. Significant main effects and interactions ($P<.05$) were determined using repeated measures ANOVA, followed by dependent t-tests comparing practice type (full vs. limited-contact, full vs. non-contact, limited vs. non-contact) using a post hoc Bonferroni correction. **Main Outcome Measures:** Dependent variables were frequency of head impacts per athlete exposure (AE) and peak linear acceleration (g). **Results:** The season's practice distribution was 37 full-contact, 12 limited-contact, and 28 non-contact sessions. There were significant differences in head impact frequency per AE among practice type ($F = 17.344,21$, $P < 0.001$). Participants had significantly fewer impacts per AE ($P < 0.001$) during non-contact practice (7.8; 95% CI [6,10]) compared to limited-contact (13.4; 95% CI [10,17]) and full-contact (17.0; 95% CI [13,21]) practices, which were also significantly different ($P = 0.027$). The average magnitude of head impacts during non-contact practice (26.9; 95% CI [25.1,28.7]), limited-contact (24.8; 95%CI [23.6,26.1]), and full-contact (24.7; 95% CI [23.6,25.8]) was not found to be different. **Conclusions:** Practices designated as non-contact and helmets only were associated with fewer head impacts compared to other practice types; however the peak linear acceleration of these impacts was the same. Furthermore, these data suggest that the effect of 'risk compensation' behavior related to helmet use may be a factor and the cumulative effect of head impact frequency and magnitude during non-contact practices should not be overlooked. Funding: NATA Foundation.

### The Association Between Neurobehavioral Measures and Head Impact Biomechanics in High School Football Players

Fraser MA, Wasserman EB, Cabell GH, Cross AM, Mihalik JP, Guskiewicz KM: The University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Individuals with elevated aggression, impulsivity, anxiety, and depression are more likely to sustain concussions. However, limited data exist associating neurobehavioral measures and head impact biomechanics. **Objective:** To determine the association between neurobehavioral measures and head impact biomechanics in high school football players. **Design:** Prospective cohort study. **Setting:** High school and research laboratory. **Patients or Other Participants:** 39 football players (16.1 ± 1.1 years) wore helmets instrumented with Head Impact Telemetry System accelerometers during the season. **Interventions:** Preseason neurobehavioral measures of aggression (Buss Perry Aggression Questionnaire, range 29-145), impulsivity (Barrett Impulsiveness Scale – 11, range 30-120), anxiety (Generalized Anxiety Disorder – 7, range 0-21), and depression (Patient Health Questionnaire – 9, range 0-27) were collected. Cumulative aggression-impulsivity and anxiety-depression scores were calculated as the sum of aggression and impulsivity, and anxiety and depression, respectively. **Main Outcome Measures:** Impact magnitude (Linear Acceleration [among hits >10g]) and Head Impact Technology severity profile (HITsp). Linear acceleration magnitude was classified as high (≥60g), moderate (25g to 59.99g), or low (<25g) and analyzed in multilevel proportional odds models. Due to the non-normal distribution of the measures, log transformation of linear acceleration and HITsp was used for linear mixed models. Only video-verified impacts (1164/2538) were included in these analyses. **Results:**

8 individuals graded the video (ICC2,k = 0.991). One-point higher scores in aggression and cumulative aggression-impulsivity resulted in impacts 1.01g (P = 0.03) and 1.01g (P = 0.03) higher in linear acceleration, respectively. One-point lower scores in anxiety resulted in impacts 1.05g (P = 0.01) higher in linear acceleration. One-point higher scores in anxiety were associated with a 23% (OR = 0.777, 95% CI = 0.642, 0.939, P = 0.01) lowers odds of the impact falling into a higher impact magnitude category. HITsp was 1 and 1.05 higher for each 1-point higher score in aggression (P = 0.03) and 1-point lower score in anxiety (P = 0.01), respectively. All other neurobehavioral measures were not significantly associated with linear acceleration or HITsp (P > 0.05 for all). **Conclusions:** Higher aggression and aggression-impulsivity, and lower anxiety were associated with higher average linear acceleration and HITsp. Higher anxiety is associated with reduced odds of experiencing high magnitude impacts. Sport-related concussions typically occur above 60g. Thus, players with increased aggression, increased aggression-impulsivity, or reduced anxiety may be at a higher risk for sustaining a concussion. Preseason neurobehavioral screening may help determine if players should be excluded from specific plays (i.e., special team plays) due to previously reported increased incidence of higher magnitude impacts during those plays.

## Comparison of Concussion Injury Mechanisms and Contact Types Between Youth, High School, and College Football Players

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**Context:** Researchers have previously identified differences in concussion rates and post-concussion outcomes across different competition levels (i.e., youth, high school, and college). Understanding concussion mechanisms contributing to injury across these levels is important so rules and teaching techniques can be specifically developed at each level of football in order to improve safety for all players. **Objective:** To compare concussion mechanisms (player, surface, or equipment contact, or other/unknown) and contact types (blocking, tackling) between youth football (YFB), high school football (HSFB), and college football (CFB). **Design:** Descriptive epidemiology study. **Setting:** YFB (ages 5-14, 118 teams, 310 team-seasons), HSFB (96 teams, 184 team-seasons), and CFB (34 teams, 71 team-seasons). **Patients or Other Participants:** Football players at 3 competition levels. Interventions: Athletic trainers provided athlete exposure (AE) and concussion data to the Youth Football Surveillance System; National Athletic Treatment, Injury and Outcomes Network; and National Collegiate Athletic Association Injury Surveillance Program during the 2012-2014 seasons. **Main Outcome Measures:** Injury proportion ratios (IPR) compared distributions of concussion injury mechanisms and contact types among the competition levels. IPRs with 95% confidence intervals (CIs) that did not include 1.00 were considered statistically significant. **Results:** A total of 1,429 concussions were reported over 1,981,284 AE across all levels (0.72/1000 AE). Player contact was the most common concussion mechanism across all settings (82.7%). The proportion of concussions due to player contact in CFB (88.3%) was higher than in YFB (79.7%, IPR = 1.11; 95% CI: 1.02-1.20) and HSFB (80.5%; IPR =1.10, 95% CI: 1.05-1.15). A significantly greater proportion of YFB concussions (15.4%) were due to surface contact than in both HSFB (8.7%; IPR = 1.76, 95% CI: 1.14-2.72) and CFB (6.6%; IPR = 2.35, 95% CI: 1.38-3.98) concussions. The most common contact types involved in concussion across all levels were tackling (24.4%), being tackled (23.7%), blocking (17.3%), and being blocked (12.0%). Compared to YFB (7.7%), a significantly greater proportion of concussions occurred while blocking in CFB (20.6%; IPR = 2.68, 95% CI: 1.57-4.59) and HSFB (17.7%; IPR = 2.30, 95% CI: 1.36-3.89). A significantly greater proportion of YFB concussions (40.1%) occurred while being tackled as compared to HSFB (23.5%; IPR = 1.71, 95% CI: 1.31-2.24) and CFB (17.0%; IPR = 2.36, 95% CI: 1.70-3.28). Additionally, HSFB players suffered a significantly greater proportion of concussions while being tackled as compared to CFB players (IPR = 1.38, 95% CI: 1.05-1.82). **Conclusions:** The proportion of concussions sustained while being tackled increases as the level of football decreases. It is possible younger athletes have yet to develop appropriate techniques to absorb impacts from other players and the ground. Techniques like appropriate body positioning before the impact, using arms to fend off tacklers, and keeping the head up and out of the tackle need to be teaching points of emphasis for YFB and HSFB coaches. Word Count: 436. Funding for this study was provided by USA Football; the National Athletic Trainers' Association Research and Education Foundation; BioCrossroads in partnership with the Central Indiana Corporate Partnership Foundation; and the National Collegiate Athletic Association.

## The Association Between Body Position, Head Impact Location, and Head Impact Biomechanics in High School Football

Cabell GH, Fraser MA, Cross AM, Wasserman EB, Mihalik JP, Guskiewicz KM: The University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Higher head impact magnitude has been associated with increased sport-related concussion risk in football players. However, the association between a player's body position, head impact location, and head impact biomechanics remains unknown. **Objective:** To determine the association between body position, impact location, and head impact biomechanics. **Design:** Prospective cohort study. **Setting:** Field and research laboratory. **Patients or Other Participants:** High school football players (N = 39; age = 16.1 ± 1.1 years). **Interventions:** Participants wore helmets instrumented with the Head Impact Telemetry System. For 5 games, body position and head impact location were recorded based on video analysis from two camera angles. Body position was scored through involvement of shoulders (yes/no), arms (yes/no), leading with head (yes/no), use of hands/elbows (yes/no), and neck position (neutral-extension, or flexion). Body position was analyzed as a ratio of number of improper techniques out of total possible improper techniques, with higher scores indicating worse performance. Head impact location was categorized as: facemask, top, left/right side, back, body, and unknown. **Main Outcome Measures:** Linear magnitude was recorded during all games. Video-verified linear accelerations >10g were log-transformed due to the data's non-normal distribution (n = 1164 impacts out of 2538 recorded). Additional analyses categorized linear acceleration as follows: ≥60g, 25g to 59.99g, and <25g. Linear mixed models and multilevel proportional odds models were used to examine the association between body position, impact characteristics, and the linear acceleration measures. **Results:** Eight individuals analyzed video (ICC2,k = 0.991). Compared to the worst body position, impacts with proper body position were on average 1.34g ($P < 0.001$) lower. Facemask impacts were 1.21g ($P < 0.001$) lower than top of the head, and 1.15g ($P = 0.007$) higher than left side impacts. Impacts with the worst body position had 3 times the odds of being in a higher impact magnitude category (Odds Ratio (OR) = 2.96, 95% Confidence Interval (CI): 1.48-5.94, $P < 0.01$). Left side impacts had 36% lower odds of higher impact magnitude than facemask impacts (OR = 0.64, 95% CI: 0.44-0.93, $P = 0.02$). Conversely, top impacts had 2 times the odds of higher impact magnitude than facemask impacts (OR = 1.95, 95% CI: 1.46-2.60, $P < 0.001$). **Conclusions:** Impacts sustained to the top of the head and impacts sustained with poor body position had the greatest odds of being a higher magnitude. These findings highlight the importance of players entering collisions in the "heads-up" position and using their upper extremities to protect themselves. In the future, emphasis should be placed upon improving both body and head position in impacts. Coaches should be trained in proper body and head position, and interventions for individual players with poor body and head position should be implemented to decrease high magnitude impact risk in high school football players.

## The Association Between Closing Distance, Body Position and Head Impact Severity in High School Football

Cross AM, Fraser MA, Cabell GH, Wasserman EB, Mihalik JP, Guskiewicz KM: The University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** Longer closing distances prior to impact have been associated with more severe head impacts in college football. Data describing the associations between closing distance, body position, and head impact biomechanics in high school football is lacking. **Objective:** To determine the associations between closing distance, body position, and head impact biomechanics. **Design:** Prospective cohort study. **Setting:** High school and research center. **Patients or Other Participants:** Thirty-nine football players (16.1 ± 1.1 years) wore helmets instrumented with the Head Impact Telemetry System. **Interventions:** For 5 games, closing distance and body position for each head impact were recorded and confirmed from two video camera angles. Closing distance was classified as 'Long' when the striking player and player struck covered a combined distance greater than or equal to 10 yards, or 'Short' (combined distance <10 yards). Body position was scored through involvement of shoulders (yes/no), arms (yes/no), leading with head (yes/no), use of hands/elbows (yes/no), and neck position (neutral-extension, or flexion). Proper technique included driving with the shoulders, use of the arms (elbows or hands), not leading with head, and neutral or extended neck position. Body position was analyzed as a ratio of number of improper techniques out of total possible proper techniques, with higher scores indicating worse performance. Only head impacts for which body position could be determined on video were included in this analysis (N = 1164; 45.8%). **Main Outcome Measures:** Impacts

exceeding 10g were classified as high (≥60g), moderate (25g to 59.99g), or low (<25g). Additionally, magnitude was log-transformed for continuous analyses. Linear mixed models and multilevel proportional odds models were used to examine the association between closing distance, body position, and the linear acceleration measures. **Results:** Eight individuals evaluated video footage (ICC2,k = 0.991). Almost half of the impacts were low magnitude (47.9%), followed by moderate (43.0%), and high (9.1%). 78.6% of analyzed impacts were short distance. On average, short distance impacts were 1.15g lower magnitude compared to long distance impacts ($P < 0.01$), and long distance impacts had 1.7 times the odds of being higher magnitude (Odds Ratio = 1.66, 95% Confidence Interval: 1.21-2.28, $P = 0.003$). When controlling for position played, short distance impacts had better body position compared to long distances ($\beta = -0.051$, $P = 0.03$). Even when controlling for body position, distance ($P = 0.004$) significantly predicted impact magnitude. **Conclusions:** Players who collide while running from greater distances have poor body position and are more likely to sustain severe head impacts. These findings underscore the importance of penalizing offensive and defensive spearing. They also indicate that proper body position needs to be emphasized to players to limit risk of sustaining severe head impacts, especially during longer distance plays. Additionally, modifying these behaviors could potentially reduce the likelihood of sustaining a concussion or cervical spine injury.

## Does Cervical Muscle Strength Influence Head Acceleration in Collegiate Women's Soccer Athletes?

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**Context:** Soccer is one of the fastest growing sports in the United States; however, recently there has been increased concern involving the risk of repeated heading of the soccer ball on brain function. It has been proposed that the purposeful use of the head to advance the ball during soccer can lead to high magnitude/number of impacts over the course of one's career. In an attempt to mitigate this risk of injury, neck strength has been proposed as a modifiable factor to decrease the magnitude of head acceleration soccer athletes are exposed to. **Objective:** To evaluate the relationship of cervical muscle strength and on-field head accelerations in women's soccer. **Design:** Cohort study. **Setting:** NCAA Division-I institution during one season of women's soccer practices/games. **Patients or Other Participants:** Twenty intercollegiate female soccer athletes (age = 19.5 ± 1.0 yr.; height = 167.2 ± 4.6 cm; weight = 59.96 ± 3.2 kg) were recruited for participation. One student-athlete was excluded because she opted-out of wearing the headband accelerometer during the season. **Interventions:** Each athlete was equipped with a Smart Impact Monitor (SIM-G) (Triax Technologies, Norwalk, CT), which was worn throughout each practice/game. The SIM-G is secured via a headband, and 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. Neck strength measures of the anterior neck flexors, anterolateral neck flexors, cervical rotators, posterolateral neck extensors, and upper trapezius were taken using a handheld dynamometer. For data analysis, a log transformation was applied to all linear accelerations. Data were then analyzed using multiple linear regression (direct-entry) of all cervical neck strength measures and the log-transformed acceleration average for each athlete. **Main Outcome Measures:** Dependent variables included average linear acceleration of impacts occurring during practices/games. Independent variables included all cervical neck strength measures. **Results:** A total of 801 impacts occurred across all practices/games with an average acceleration of 19.9 ± 5.1g. The upper trapezius exhibited the highest strength (11.7 ± 3.7kg), followed by the posterolateral extensors (8.8 ± 2.7kg), cervical rotators (7.3 ± 2.2kg), anterolateral neck flexors (7.2 ± 2.3kg), and anterior flexors (7.2 ± 2.3kg). However, the overall association was not statistically significant, $R2 = 0.631$, $p = 0.284$. **Conclusions:** These results indicate that neck strength alone does not predict head accelerations observed on the field during practice/game play. Because the SIM-G monitors all head accelerations that occur during practices and games, including those that may not involve the actual heading of the soccer ball (i.e. body contact with other players or contact with the ground, etc.), it is difficult to draw conclusions on the role of neck strength in purposeful soccer heading. Future research teasing out only those impacts that involve purposeful soccer headers may allow for a better correlational analysis.

## The Effects of Mechanism on Head Impacts in Soccer Athletes

Saunders TD, Le RK, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA, and Purdue University, West Lafayette, IN

**Context:** There has been growing interest in head impacts related to sports participation due to long and short term consequences of head injuries. Although research has found that contact with another player is the main cause of head injuries in soccer, it remains unknown how often head impacts of different mechanisms occur. **Objective:** To compare magnitude and frequency of head impacts between men's and women's intercollegiate Division III soccer players based on head impact mechanisms. **Design:** Descriptive epidemiology study. **Setting:** Soccer fields **Patients or Other Participants:** 31 National Collegiate Athletic Association Division III soccer players (17 women: age = 19.88 ± 1.05 years, height = 163.68 ± 1.96 cm, mass = 61.29 ± 10.96 kg; 14 men: age = 20.28 ± 1.06 years, height = 180.34 ± 2.21 cm, mass = 74.35 ± 19.01 kg). **Interventions:** We collected data using xPatch (X2 Biosystems, Seattle, WA) sensors that were worn over the participants' right mastoid process using an adhesive patch for each game and practice throughout the season. Each exposure was video recorded in order to confirm head impacts and match each with a mechanism. The independent variable of this study was mechanism (head to head, head to body, head to ground, ball to head, goal to head, combination, punch to head, and unknown). **Main Outcome Measures:** Sensors collected linear and angular accelerations and frequency of head impacts. We calculated incidence rates (IRs), incidence rate ratios (IRRs), and 95% confidence intervals (CIs) using Microsoft excel. We used ANOVA instead of MANOVA because the dependent variables were highly correlated (r = .844). The alpha value for all tests was set at $P < .05$. **Results:** There were a total of 860 head impacts verified during 1182 exposures (IR = 727.58, CI = 678.95-776.21) for women and 870 impacts verified during 801 exposures (IR = 1086.14, CI = 1013.97; IRR = 1.49, CI = 1.35-1.64) for men. For males the highest frequency was head to body (IR = 481.61, CI = 435.49-527.72) while for women the highest was ball to head (IR = 916.28, CI = 852.30-980.26; IRR = 1.90, CI = 1.68-2.14). The interaction between sex and mechanism was significant for rotational accelerations ($F4, 1720 = 3.757$, $P = .005$, $\omega^2 = 0.013$) but not for linear accelerations ($F4,1720 = .680$, $P = .606$, $\omega^2 < .001$, $1-\beta = .223$). In addition, there was a main effect for mechanism for rotational accelerations ($F4, 1720 = 9.214$, $P < .001$, $\omega^2 = 0.017$). **Conclusions:** Head impacts occurred more often for men in all categories except ball to head. Head to body is not a permissible contact within the rules of soccer which suggests there should be an increased emphasis on rule enforcement during games and practices.

## Preparedness and Activity of Head Impacts in Intercollegiate Men's and Women's Soccer Athletes

Jackson BC, Rogerson CE, Breedlove KM, Bowman TG: Lynchburg College, Lynchburg, VA, and Purdue University, West Lafayette, IN

**Context:** Previous research in hockey has found that preparedness and activity alter head impact magnitude. It is unknown if a similar occurrence will take place in soccer. **Objective:** To determine differences in the magnitudes and frequencies of head impacts due to sex, preparedness, and impact activity. **Design:** Descriptive epidemiology study. **Setting:** Collegiate soccer fields. **Patients or Other Participants:** 16 female (age: 19 ± 1.05 years, height: 163.68 ± 5.03 cm, mass: 61.36 ± 4.99 kg) and 14 male (age: 20 ± 1.07 years, height: 180.34 ± 5.58 cm, mass: 74.357 ± 8.64 kg) Division III intercollegiate soccer players. **Interventions:** We applied xPatch sensors (X2 Biosystems, Seattle, WA) over the right mastoid process for every practice and game during the fall 2014 season. We watched film to verify and code impacts. Independent variables of the study were sex, preparedness (anticipated with good body position, anticipated with poor body position, and unanticipated), and impact activity (delivered, received, and simultaneous). **Main Outcome Measures:** We compared the effects of sex, preparedness, and activity on linear and angular accelerations using ANOVA because we found a strong correlation between linear and rotational acceleration ($r = .844$, $P < .001$). We calculated incidence rates (IRs) and incidence rate ratios (IRRs) with 95% confidence intervals to determine frequency differences. We established an alpha value of .05 a priori. **Results:** A total of 860 female and 870 male impacts were verified and coded by preparedness and activity during 1182 female (IR = 727.58, CI = 678.95-776.21) and 801 male exposures (IR =

1086.14, CI = 1013.97-1158.32; IRR = 1.49, CI = 1.36-1.64). We found that males were over 2 times more likely to be unprepared for impact (IRR = 2.22, CI = 1.70-2.88). However, we found that males were almost 2 times more likely to be unprepared for impact than females (IRR = 1.9, CI = 1.16-3.11). We also found that females deliver impacts about 4 times more often than males (IRR = 3.85, CI = 3.27-4.54) and males are about 8 times more likely to receive impacts than females (IRR = 8.11, CI = 5.65-11.65). We found an insignificant interaction between sex, preparedness, and activity for both linear ($F_{4,1703}$ = .387, P = .818, $\omega^2 < 0.001$, $1-\beta = .140$), and rotational accelerations ($F_{4, 1703}$ = .951, P = .434, $\omega^2 < 0.001$, $1-\beta$ = .304). **Conclusions:** Male and female intercollegiate soccer players, although exposed to different frequencies of head impacts throughout the year, sustain similar magnitude impacts to the head in terms of preparedness and impact activity. Training interventions should be aimed at improving technique while sustaining impacts as both sexes received impacts while unprepared often.

## Impact Detection Rate Analysis of Four Head Impact Sensors

Campbell KR, Lynall RC, Luck JF, Cutcliffe HC, Kait JR, Kuo C, Camarillo DB, Bass CR, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill, NC; Duke University, Durham, NC; Stanford University, Stanford, CA

**Context:** Head impact sensors provide a biomechanical head injury assessment by measuring the frequency, location, and magnitude of head impacts athletes experience during sport participation. It is important these sensors identify all impacts if we are to understand sub-concussive and concussive injury mechanics. **Objective:** To evaluate four head impact sensors' ability to detect impacts. **Setting:** Laboratory. **Patients or Other Participants:** Three cadaveric head specimens were used. **Interventions:** Impacts were delivered through controlled laboratory drops to the cadaver head specimens wearing a Riddell Speed football helmet. Four impact sensors concurrently measured each drop; the Head Impact Telemetry System (HITS), X2 Biosystems xPatch (xPatch), Triax Technologies Sim-G (Triax), and the gForce Tracker (GFT). Each specimen was dropped onto six locations (facemask, front oblique right, front, occipital, right parietal, and vertex) from 3 drop heights (10, 60, and 100 cm). The HITS and GFT were coupled directly to the inside of the helmet. Two xPatches were adhered over the mastoid process behind each ear. The Triax was coupled to the specimen with a skullcap and positioned over the external occipital protuberance. Our independent variable was sensor type: HITS, right xPatch, left xPatch, Triax, and GFT. **Main Outcome Measures:** Each sensor's detection rate was calculated as the percentage of drops with collected data compared to the total number of drops. A Chi Square analysis assessed the association between sensor type and detection rate. **Results:** There were 72 drops delivered to each specimen (216 total), and there was a significant association between sensor type and detection rate ($\chi^2$ [4] = 38.22, $p < 0.001$). The Triax detected 207 of 216 impacts (95.8%), the GFT detected 188 of 216 impacts (87.0%), and the HITS detected 172 of 216 impacts (79.6%). Data for the right and left xPatch were not collected for 35 and 36 drops, respectively, due to data acquisition issues. These drops were not included when computing impact detection rate for xPatch sensors. Therefore, 137 of 181 impacts (75.7%) were detected by the right xPatch, while the left xPatch detected 86.1% (155/180) of impacts. **Conclusions:** Our data suggest these sensors fail to record the presence of a number of valid impacts in a controlled laboratory setting. Thus, published head impact frequencies may underrepresent true subconcussive exposure during regular participation. Caution should be used when comparing impact frequency results between studies that use different sensor systems. Impact detection rate is only one aspect for evaluating sensor performance. Future studies need to determine sensor accuracy and reliability to measure head impact kinematics. Head impacts must be detected and accurate head impact kinematics are needed if we are to understand the biomechanical inputs to concussion and the role of subconcussive impacts on short- and long-term neurological health.

### Athletic Trainers Spend Most Time on Maintenance and Preventative Care to Keep Athletes on the Field


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**Context:** Non-time loss (NTL) injuries have shown to account for a larger number of injuries as compared to time-loss (TL) injuries that athletic trainers regularly manage. There is limited literature on the amount of effort athletic trainers spend on managing athletes with both types of injuries as well as those receiving preventative care/maintenance treatments. **Objective:** To investigate the number of treatments provided to athletes receiving preventative care/maintenance with full participation status, those with NTL injuries, categorized as limited status, and those with TL injuries as they were not practicing (out status) during off-season baseball. **Design:** Descriptive Epidemiology Study **Setting:** Collegiate Athletic Training Room. **Patients or Other Participants:** 44 NAIA Collegiate Baseball Players (Age = 20 ± 2) **Interventions:** Athlete exposures were recorded over a 55 day off-season training period during fall baseball. Participation status of all baseball athletes was recorded by a member of the research team using one of three categories. The first category was full participation without limitations and received preventative care/maintenance treatments. The second category was limited participation indicating partial participation in practice and was considered to be a non-time loss injury. The third category was out of practice indicating the athlete was completely out of practice due to illness or an injury, noted as a time-loss injury. Treatment data was recorded in the standard manner for this university by recording all treatment interventions into a paper log book. All treatments and participation statuses were entered into an excel spreadsheet for analysis. **Main Outcome Measures:** Athlete exposures and total number of treatments provided by the athletic trainer per participation status of full, limited, and out. Descriptive analysis of data was performed to determine the frequency of treatment and participation status. **Results:** Over the 55 day period, a total of 2,162 potential exposures were possible as two players left the team and four were excluded due to receiving all treatments at an offsite location. The participation status identified 1,934(89%) full athlete exposures, 38(2%) limited athlete exposures and 190(9%) out athlete exposures. A total of 301 treatments were applied with 176 (59%) provided to athletes categorized with full status, 28(9%) to athletes in the limited category, and 97 (32%) to athletes categorized as out. **Conclusions:** Preventative care/maintenance and NTL injuries account for 68% of the treatments performed by an athletic trainer during out of season practice. These results agree with the literature and indicate athletic trainers provide a large amount of treatment in order to keep athletes participating. This study demonstrates that over 90% of the athletes are available for participation throughout off-season practice. Further study is needed to evaluate this during the competitive season.

### Use of Orthopedic Special Tests by Athletic Trainers Who Diagnose Acromioclavicular Sprains: A Report From the Athletic Training Practice-Based Research Network


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**Context:** Acromioclavicular joint (AC) sprains are common in contact sports, including football, and result from falls and direct blows. Appropriate diagnosis and treatment of AC sprains is imperative to reducing recurrence rates. It is unknown which orthopedic special tests athletic trainers (ATs) commonly use to diagnose AC sprains. **Objective:** To describe the reported use of orthopedic special tests by ATs to diagnose AC sprains. **Design:** Retrospective analysis of electronic medical records (EMRs). **Setting:** Thirty-two athletic training clinics in secondary schools (78.1%), collegiate (18.8 %), and other (3.1%) settings across 11 states within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** EMRs of 67 patients (male = 59, female = 8, age = 18.0 ± 2.2 years, height = 174.6 ± 11.2 cm, mass = 77.4 ± 16.4 kg) who were diagnosed with an AC sprain by an AT within the AT-PBRN. **Interventions:** EMRs of patients diagnosed with an AC sprain between October 2009-October 2015 were reviewed. All medical records were created by an AT utilizing a web-based EMR with ICD-9 diagnostic codes (i.e., 840 AC sprain). **Main Outcome Measures:** Summary statistics (percentages and frequencies of reported use) were calculated to describe patient and injury descriptive data, including the reported use of orthopedic special tests for evaluation and diagnosis of an AC sprain. **Results:** The majority of diagnosed AC sprains occurred in males (88%, n = 58), in the sport of football (47.8%, n = 32) and

during in-season games (64.2%, n = 43) due to direct contact/trauma (70.1%, n = 47). ATs reported using an average of 3.2 ± 2.0 (range: 1-10) orthopedic special tests while evaluating and diagnosing an AC sprain. AC joint-specific special tests reported were: AC compression (n = 24, 35.8%; positive = 20, negative = 4), piano key sign (n = 18, 26.9%; positive = 14, negative = 4), active compression/O'Brien's (n = 9, 13.4%; positive = 5, negative = 4), cross-body adduction (n = 8, 11.9%; positive = 8, negative = 0), and traction (n = 8, 11.9%; positive = 4, negative = 4). Other commonly used shoulder tests, not specific to the AC joint, reported were: Hawkins impingement (n = 20, 29.9%; positive = 12, negative = 6, inconclusive = 2), apprehension (n = 20, 29.9%; positive = 4, negative = 16), inferior glide/sulcus (n = 17, 25.4%; positive = 5, negative = 10, inconclusive = 2), Neer impingement (n = 15, 22.4%; positive = 6, negative = 8, inconclusive = 1), and anterior glide (n = 12, 17.9%; positive = 0, negative = 11, inconclusive = 1). No special tests were recorded for 12 (17.9%) patients diagnosed with an AC sprain. **Conclusions:** ATs reported using the AC compression test in conjunction with shoulder stability and impingement tests most frequently in diagnosing patients with an AC sprain. However, current evidence suggests a positive active compression/O'Brien's, cross body adduction, and AC resisted extension test, in isolation or in combination, produces the highest diagnostic accuracy for isolated AC pathology. It appears that ATs are not selecting special tests according to evidence-based recommendations. Educational efforts that focus on clinical-decision making that incorporates clinical utility of orthopedic special tests to improve ATs' efficiency and accuracy in evaluating and diagnosing AC sprains are warranted.

## Assessment Patterns of Athletic Trainers Who Diagnose Knee Sprains: A Report From the Athletic Training Practice-Based Research Network

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**Context:** In evidence-based practice, clinicians should utilize orthopedic special tests with acceptable diagnostic accuracy values. It is unknown if athletic trainers (ATs) utilize orthopedic special tests supported by best evidence for common sport-related injuries, including knee sprains. **Objective:** To describe orthopedic special tests commonly used by ATs to diagnose knee sprains. **Design:** Retrospective analysis of electronic medical records. **Setting:** Sixty-three athletic training clinics (secondary school: n = 53, 84.1%; college: n = 10, 15.9%) across 15 states within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** Two hundred and sixty-three patients (male = 171, female = 92, age = 17.5 ± 2.3 years, height = 172.3 ± 13.6 cm, mass = 76.3 ± 21.0 kg) diagnosed with a knee sprain by an AT. **Interventions:** Medical records within the AT-PBRN were reviewed between October 2009-October 2015. Patient cases were identified using ICD-9 diagnostic codes (844.2: sprained cruciate ligament [ACL/PCL], 844.1: sprained medial collateral ligament [MCL], 844: sprained lateral collateral ligament [LCL]). **Main Outcome Measures:** Summary statistics (frequencies and percentages) were calculated to describe injury demographics, orthopedic tests utilized for evaluation, and test results of the involved side. **Results:** During the study period, 103 ACL/PCL, 120 MCL, and 40 LCL sprains were recorded. For ACL/PCL injuries, ATs used 4.7 ± 2.2 (range: 1-16) special tests with the Lachman (n = 96, 93.2%; positive = 56, negative = 18, inconclusive = 22), valgus stress (n = 79, 76.7%; positive = 15, negative = 59, inconclusive = 5), anterior drawer (n = 76, 73.8%; positive = 39, negative = 19, inconclusive = 18), varus stress (n = 72, 69.9%; positive = 12, negative = 58, inconclusive = 2) and posterior drawer (n = 55, 53.4%; positive = 6, negative = 45, inconclusive = 4) tests being the most commonly recorded tests. ATs reported using 4.8 ± 1.9 (range: 1-9) tests for MCL injuries. The valgus stress (n = 117, 97.5%; positive = 101, negative = 10, inconclusive = 6), Lachman (n = 96, 80.0%; positive = 3, negative = 81, inconclusive = 12), varus stress (n = 88, 73.3%; positive = 2, negative = 85, inconclusive = 1), anterior drawer (n = 75, 62.5%; positive = 0, negative = 65, inconclusive = 10), and posterior drawer (n = 60, 50.0%; positive = 0, negative = 58, inconclusive = 2) tests were the most frequently reported tests for MCL injuries. ATs used 4.6 ± 1.3 (range: 1-7) special tests for LCL injuries with the varus stress (n = 41, 100.0%; positive = 31, negative = 7, inconclusive = 3), valgus stress (n = 34, 85.0%; positive = 2, negative = 32, inconclusive = 0), anterior drawer (n = 29, 72.5%; positive = 0, negative = 25, inconclusive = 4), Lachman (n = 27, 67.5%; positive = 0, negative = 21, inconclusive = 6), and posterior drawer (n = 20, 50.0%; positive = 0, negative = 18, inconclusive = 2) tests being the most often reported tests. **Conclusions:** The most frequently reported special tests for knee sprains were the Lachman, valgus and varus stress, and anterior and posterior drawer tests, regardless of the specific injury diagnosis. Current evidence favors the use of the Lachman test over the anterior drawer test for ACL injuries. There is limited evidence on the diagnostic accuracy of the valgus and varus stress tests and the posterior drawer test for diagnosing collateral and posterior cruciate sprains, respectively. Understanding AT practice patterns regarding clinical tools, such as use of special tests, can help guide educational and research efforts to better support evidence-based practice.

## The Diagnostic Accuracy of Residency vs Entry Level Residency Athletic Trainers in Shoulder and Knee Pathologies

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**Context:** Athletic trainers (AT) are health care providers with strong background in musculoskeletal anatomy and pathologies who collaborate with physicians on a regular basis. ATs work in many settings under the direction of a supervising physician; increasingly AT's are working alongside physicians in the physician practice setting. The Commission on Accreditation of Athletic Training Education (CAATE) has developed athletic training residency standards aimed to advance the knowledge of ATs within specific clinical areas of focus (i.e., prevention, clinical evaluation and diagnosis, immediate care, treatment, or rehabilitation and reconditioning). Many of these residencies are housed within the physician practice setting with a clinical focus in evaluation and diagnosis. According to CAATE standards, athletic training residencies must consist of a 12 month program within a selected clinical area of focus, including evaluations of AT's performance and outcomes. Although evaluation and diagnosis is an educational domain of athletic training, there is no research to date on the diagnostic accuracy of ATs in any setting or at any educational level. **Objective:** To analyze the diagnostic accuracy of ATs who have completed a Post-Professional ATR program or are within the final trimester of their training (RTAT) and those ATs beginning their entry level training (ELRAT). It is hypothesized RTATs will have a higher rate of diagnostic accuracy than ELRATs. **Design:** Prospective analysis study. **Setting:** Physician practice setting. **Patients or Other Participants:** We selected 49 (32-RTAT, 17- ELRAT) "New Patients" with a knee or shoulder pathology with no previous imaging who consented to the study and subsequently underwent advanced diagnostic imaging or surgery. **Interventions:** Independent variables were individual patient knee or shoulder pathology by RTATs and ELRATs. The dependent variable was the patient's MRI or surgical findings. Main outcome measure: RTATs and ELRATs evaluated and recorded patient's primary diagnosis for each patient prior to a physician evaluation. Once the results of the advanced imaging study or surgical findings were available, they were recorded onto the secured data collection system then compared to the AT clinical diagnosis. **Results:** Current data analysis (n = 49) shows that RTATs are 93.5% accurate (30/32) at diagnosing shoulder and knee pathologies, while ERTATs had a diagnostic accuracy of 41% (7/17). **Conclusions:** Those ATs who have completed or are in the final trimester of residency have demonstrated improved clinical diagnosis and evaluation skills and are more accurate than ELRATs. This adds credibility to AT Post-Professional residency programs and the goals of CAATE to advance education of AT's within a specific clinical area of focus.

## Orchard Sports Injury Classification System 10:1 Plus: An End-User Study

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**Context:** Sports injury surveillance classification systems gather information on injury types, rates, mechanisms, and risk factors to objectively assess the risks of sports participation. Sport injuries have been examined thoroughly in previous studies; however, there is a need to create an easy to use, universal system to allow for the comparison of injury and interventions regardless of injury or setting. **Objective:** To establish the level of ease of use and effectiveness of the Orchard Sport Injury Classification System (OSICS) 10.1 Plus for recording injuries and interventions. **Design:** Cross-sectional design. **Setting:** Web-based survey. **Patients or Other Participants:** Three hundred and forty-two (males = 148, females = 192, no response = 2; age = 30.9 ± 9.5y; experience = 9.1 ± 10.5 y) athletic trainers (ATs) in the United States completed the survey. Participants were primarily employed in the secondary school (n = 135) or collegiate setting (n = 171).kj The injury data were collected on 342 patients (males = 246, females = 96). **Interventions:** Participating athletic trainers entered injury and intervention data from one patient into the OSICS 10.1 Plus. The OSICS 10.1 Plus system utilizes the OSICS 10.1 to injury surveillance to document injury and Current Procedural Terminology (CPT) codes to document interventions. Participants were then asked to complete an 18-item end-user evaluation tool to establish demographic information, assess the ease of use and effectiveness of the OSICS 10.1 Plus based on a 5 point Likert scale (1 = strongly disagree, 5 = strongly agree) and open-ended questions to elicit feedback. **Main Outcome Measures:** We analyzed characteristics of central tendency to determine ease of use and effectiveness of the OCISC 10.1 PLUS. **Results:** Participants indicated that

the OSICS Plus is overall easy to use (4.1 ± 0.7pts), easy to enter an injury (4.1 ± 0.8pts), and easy to enter the associated interventions (3.9 ± 0.8pts). Respondents indicated that they neither agreed nor disagreed that the OSICS matched their current injury (3.5 ± 1.0pts) or intervention (3.5 ± 0.9pts) records. A majority of participants indicated that they could find the injury (281/342, 82.2%) and interventions (225/342, 65.8%) of interest. A majority of respondents (205/342, 60.0%) indicated they would consider using OSICS 10.1 Plus for injury surveillance at their institution. However, the open-ended feedback indicated that there is a misunderstanding of the purpose of injury surveillance as opposed to medical documentation. Some participants were looking for the specificity of medical documentation as opposed to injury surveillance. **Conclusions:** Preliminary results of this end-user study indicate that participants agree that OSICS 10.1 Plus is easy to use. The OSICS 10.1 Plus could serve as an effective and useful mechanism for injury surveillance with minor modifications. We, as a profession, need to work to improve regular medical documentation first, as we continue to develop easy to use and effective injury surveillance tools.

## Descriptive Study of Athletic Trainers' Emergency Management Practices for Equipment Intensive Sports

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**Context:** The NATA recently released new clinical practice recommendations from an inter-association task force on the appropriate care of the spine injured athlete. Athletic trainers' current emergency management practices are unknown. **Objective:** To gain information on current and potential future emergency management practices of athletic trainers, especially during care of potentially spine injured athlete-patients wearing equipment. **Design:** Cross-sectional. **Setting:** Online survey. **Patients or Other Participants:** We received completed surveys from 130 participants (65 males, 65 females, age = 35 ± 10 years, 12.5 ± 9.5 years of clinical experience, 7.5 ± 7 years in current positions) out of 1393 randomly selected NATA members in Districts 2 and 3 (9.3% response rate). We used systematic sampling by selecting every 5th Certified non-student member. Participants found employment at secondary schools (60%), colleges (32%), professional sports (3%), or other settings (5%). **Interventions:** We developed an online questionnaire to determine athletic trainers' emergency management practices for football, lacrosse, and hockey. We asked participants questions regarding their current event coverage, emergency action plans, and any anticipated changes due to the proposed guidelines. Six athletic trainers validated the survey content prior to data collection. We used QuestionPro (QuestionPro Inc., Seattle, WA) to collect responses. **Main Outcome Measures:** We asked athletic trainers who work with equipment intensive sports to provide us information related to access to resources (AT personnel, ambulance, EMS providers) for prehospital management of suspected spine injuries. We used descriptive statistics (frequencies, means, medians, modes) to describe the responses. **Results:** 94% were aware of the new recommended guidelines. 95% agreed that athletic trainers were the most qualified to perform equipment removal, however only 62.02% agreed that pre-hospital equipment removal would expedite care and 52.71% agreed that it would create the least spine movement. Participants reported ambulances at games (83.49% football, 47.06% ice-hockey, 17.5% lacrosse). Number of staff ATs present at games had the following ranges ([1-13] football, [0-4] ice-hockey, [0-3] lacrosse); but the mode was only 1. Many respondents will need assistance from EMS to limit spinal motion (66.97% football, 65% lacrosse, 52.94% ice-hockey), however the percentage that practiced equipment removal with their local EMS varied greatly by sport (74.31% football, 64.71% ice-hockey, 52.5% lacrosse). **Conclusions:** Our results support that while athletic trainers believe they are best suited to perform equipment removal, there appears to be concern that pre-hospital equipment removal will not expedite care and minimize spinal motion in the spine. A large percentage of our respondents reported only having 1 athletic trainer present at games in all 3 collision sports, which results in them relying on collaborations with local EMS personnel to manage patient care.

## Athletic Training Students Retain Oxygen Administration Knowledge But Demonstrate Skill Decay Over Six Months

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**Context:** Research suggests skill decay occurs with emergency skills, such as oxygen administration (OA), since the frequency of medical emergencies in clinical settings is low. Identifying the presence and timeline for skill decay allows educators to employ strategies to prevent this occurrence. **Objective:** Evaluate the retention of knowledge and clinical skills associated with OA, specifically nasal cannula (NC) and non-rebreather mask (NrM) usage in athletic training students. **Design:** Cross-sectional study. **Setting:** Two mid-west undergraduate athletic training program laboratories. **Patients or Other Participants:** Twenty-nine athletic training students (males = 11, females = 18; age = 21.03 ± 1.38; sophomores = 8, juniors = 15, seniors = 6) enrolled in professional athletic training programs. **Interventions:** Participants were initially assessed (T1) on OA knowledge and clinical skill. The following week, participants attended an educational session to review previously learned OA knowledge and skills. Participants were re-assessed (T2) on OA knowledge and skills before being randomly assigned to the experimental or control group. The experimental group's knowledge and skills were re-evaluated at 1-month (T3), 3-months (T4), and 6-months (T5). The control group was re-evaluated at 6-months (T5). Knowledge was assessed using 16 multiple-choice questions related to: (1) indications, (2) contraindications, (3) NC/NrM selection, and (4) application strategies. Clinical skills were assessed using a checklist established from the literature and evaluated for content validity by three experts. **Main Outcome Measures:** Descriptive statistics were computed for the dependent variables of OA knowledge and clinical skills scores. Groups served as the independent variable. Repeated measures analysis of variance (ANOVA) with between-subjects (group) and within-subjects (time) effects assessed pre-post changes in knowledge/clinical skills scores. Cronbach's alpha determined internal consistency for the skills assessment. Alpha level was set a priori at $P < .05$. **Results:** The NC and NrM skills assessments demonstrated internal consistency with an alpha coefficient .792 (T1) and .718 (T5) for NC, and .822 (T1) and .670 (T5) for NrM. Repeated-measures ANOVA revealed no significant differences between groups on knowledge ($F_{2,54} = .152$, $P = .859$) and overall clinical skills ($F_{2,54} = .1.515$, $P = .229$). There was a significant main effect for time on knowledge ($F_{2,54} = 65.30$, $P < .001$) where T1 (66.38 ± 11.38) was significantly different than T2 (87.50 ± 7.83) and T5 (84.48 ± 12.23). A significant main effect for time on NC clinical skills ($F_{1.89,50.98} = 112.55$, $P < .001$) found T1 (39.22 ± 22.09) was significantly different than T2 (90.73 ± 9.39) and T5 (81.90 ± 16.22) and T2 was significantly different than T5. A significant main effect for time on NrM clinical skills ($F_{1.55,41.88} = 108.03$, $P < .001$) found T1 (49.18 ± 19.80) was significantly different than T2 (93.83 ± 5.81) and T5 (88.20 ± 11.40) and T2 was significantly different than T5. **Conclusions:** Both groups retained OA knowledge over 6 months, while NC and NrM skills decayed between the intervention and the 6-month follow-up. Regular rehearsal and practice of acute care clinical skills should be integrated into educational programs to avoid decay of skills.

## A Descriptive Investigation on the Effects of Clinical Setting and Years of Experience in the Clinical Management of LAS

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**Context:** Lateral ankle sprains (LASs) are the most common athletic injury, yet there is limited descriptive data on clinical management. A better understanding of management will allow for the identification of factors that may lead to poor outcomes and/or recurrent injuries. **Objective:** Describe the effects of setting and years certified on the clinical management of LASs. **Design:** Cross-sectional **Setting:** Electronic **Patients or Other Participants:** 7888 athletic trainers (ATC) who were members of the NATA categorized as currently working in a high school (HS) or college (C) setting were included in the study. A 22% response rate yielded 1765 responses, 259 responses were excluded as the respondents were not currently working clinically, leaving 1506 available for analysis. Of the 1506 respondents 791 worked in the HS setting and 715 worked in the C setting, respondents had an average of 11.2 ± 9.4 years certificated (YC). **Interventions:** Electronic survey with thirteen yes/no, categorical and Likert-scaled questions focused on the strategies used to treat/rehabilitate LASs. Face validity was determined by a group of athletic trainers and sports injury researchers. Good reliability was established ($r=0.79$) prior to administration of the survey. **Main Outcome Measures:** The independent variables were: Setting (HS/C) and Years Certified (≤5, >5). Frequencies and percentages were calculated for all response. **Results:** The majority (81.8%) of ATCs surveyed altered LAS care based on perceived degree of sprain. Years certified (YC) and a clinical setting had little effect on immobilization and length of immobilization, Grade I LASs are not

typically immobilized (93.1%) Grade 2 LASs are generally immobilized 48 hours (YC ≤ 5: 68%, YC > 5: 77%, HS: 69%, C: 72%), with a walking boot or crutches while the majority of Grade 3 LASs are immobilized for 4 to 7 days (YC ≤ 5:98%,YC > 5:97%, HS: 98%, C: 98%) with walking boot and crutches. (YC ≤ 5:92%, YC > 5:93%, HS: 91%, C: 95%) required athletes to utilize some form of external support when returning to participation. **Conclusion:** Clinical management of LASs is similar across clinical settings and ATC experience levels. These data appear to demonstrate that ATCs follow a clear standard of care for LASs. Future research should attempt to validate this standard of care against real world patient outcomes data as this may help to further explain unsuccessful outcomes and associated pathologies such as Chronic Ankle Instability.

## Common Orthopaedic Special Tests Used for Diagnosing Ankle Sprains in Athletes: A Report From the Athletic Training Practice-Based Research Network

Snyder Valier AR, Huxel Bliven KC, Lam KC: A.T. Still University, Mesa, AZ

**Context:** Ankle sprains are common athletic injuries, making effective evaluation important. Athletic trainers (ATs) use orthopaedic special tests to assist in diagnosing injuries, including ankle sprains, but it is unknown which tests are used most frequently. Understanding AT practice patterns of special test use will assist in knowing if the most common tests are ones with the best diagnostic accuracy. **Objective:** To describe commonly used orthopaedic special tests recorded by ATs in diagnosing athletes with ankle sprains. **Design:** Retrospective analysis of electronic medical records (EMRs). **Setting:** Seventy athletic training clinics in secondary school (n = 60; 85.7%), collegiate (n = 8; 11.4%), and other clinical (n = 2; 2.9%) settings across 14 states within the Athletic Training Practice-Based Research Network. **Patients or Other Participants:** Medical records of 777 male and female patients diagnosed with ankle sprain/strain-unspecified (n = 576; age = 17.0 ± 2.0 years, height = 151.3 ± 58.3 cm, mass = 63.3 ± 25.8 kg), tibiofibular ligament (n = 170; age = 17.2 ± 2.1 years, height = 139.5 ± 67.6 cm, mass = 58.2 ± 31.0 kg), and deltoid ligament (n = 31; age = 18.2 ± 2.4 years, height = 141.5 ± 64.7 cm, mass = 58.2 ± 29.1 kg) injuries. **Interventions:** Medical records of patients diagnosed with a sport-related injury between October 2009-October 2015 were reviewed. All medical records were created by ATs using a web-based EMR with ICD-9 diagnostic codes (ie, 845: sprain/strain–unspecified, 845.03: tibiofibular ligament, 845.01: deltoid ligament). **Main Outcome Measures:** Summary statistics regarding the frequency and number of orthopaedic special tests used in the diagnosis of ankle sprain/strain-unspecified, tibiofibular ligament, and deltoid ligament injuries are reported. **Results:** For sprain/strain-unspecified injuries, ATs recorded 4.4 ± 1.9 (range: 1-16) special tests per evaluation with the anterior drawer (n = 515, 89.4%; positive = 234, negative = 249, inconclusive = 32), inversion stress-talar tilt (n = 458, 79.5%; positive = 224, negative = 213, inconclusive = 21), squeeze (n = 360, 62.5%; positive = 44, negative = 300, inconclusive = 16), eversion stress-talar tilt (n = 353, 61.3%; positive = 49, negative = 286, inconclusive = 18) and bump (n = 335, 58.2%; positive = 28, negative = 296, inconclusive = 11) tests most commonly documented. On average, ATs recorded 4.6 ± 1.9 (range: 1-12) tests to evaluate tibiofibular ligament injuries. The anterior drawer (n = 155, 91.2%; positive = 74, negative = 73, inconclusive = 8), inversion stress-talar tilt (n = 143, 84.1%, positive = 90, negative = 50, inconclusive = 3), bump (n = 120, 70.6%; positive = 10, negative = 106, inconclusive = 4), squeeze (n = 119, 70.0%; positive = 19, negative = 96, inconclusive = 4), and eversion stress-talar tilt (n = 96, 56.5%; positive = 19, negative = 75, inconclusive = 2) were the most frequently documented tests for tibiofibular ligament injuries. ATs recorded 4.3 ± 1.8 (range: 1-7) special tests for deltoid ligament injuries, with the anterior drawer (n = 28, 90.3%; positive = 5, negative = 23, inconclusive = 0), eversion stress-talar tilt (n = 28, 90.3%; positive = 20, negative = 8, inconclusive = 0), inversion stress-talar tilt (n = 19, 61.3%; positive = 5, negative = 14, inconclusive = 0), squeeze (n = 18, 58.1%, positive = 2, negative = 15, inconclusive = 1), and bump (n = 17, 54.8%; positive = 1, negative = 15, inconclusive = 1) tests documented most frequently. **Conclusions:** On average, ATs use 4 orthopaedic special tests when diagnosing ankle sprains, with the anterior drawer, inversion and eversion stress, squeeze, and bump tests being most common. Surprisingly little diagnostic accuracy evidence exists about these tests. Research on the diagnostic accuracy of commonly used orthopaedic special tests is needed.

## Orthopedic Special Tests Used by Athletic Trainers in Diagnosing Glenohumeral Dislocations and Subluxations: A Report From the Athletic Training Practice-Based Research Network

Huxel Bliven KC, Lam KC, Snyder Valier AR: A.T. Still University, Mesa, AZ

**Context:** It is imperative that athletic trainers (ATs) properly diagnose glenohumeral joint (GH) dislocations and subluxations to ensure proper management and treatment. While evidence-based recommendations exist regarding which orthopedic special tests provide the best diagnostic accuracy, it is unknown whether ATs follow the recommendations when evaluating and diagnosing GH dislocations and subluxations. **Objective:** To describe commonly used orthopedic special tests reported by ATs to diagnose GH dislocations and subluxations. **Design:** Electronic medical records (EMRs) were analyzed retrospectively. **Setting:** Eleven athletic training clinics in secondary school (90.9%) and collegiate (9.1 %) settings across eight states within the Athletic Training Practice-Based Research Network (AT-PBRN). **Patients or Other Participants:** EMRs of 66 patients (male=52, female = 14, age = 17.5 ± 2.1 years, height = 174.7 ± 9.9 cm, mass = 75.1 ± 5.7 kg) who were diagnosed with a GH dislocation or subluxation by an AT within the AT-PBRN. **Interventions:** EMRs of patients diagnosed with a GH dislocation or subluxation between October 2009-October 2015 were reviewed. All medical records were created by an AT utilizing a web-based EMR with ICD-9 diagnostic codes (i.e., 831.00 Dislocation/Subluxation). **Main Outcome Measures:** Summary statistics (percentages and frequencies of reported use) were calculated to describe patient and injury descriptive data, including the reported use of orthopedic special tests for evaluation and diagnosis of GH dislocations and subluxations. **Results:** The majority of diagnosed GH dislocations and subluxations occurred in males (78.8%, n = 52), in the sport of football (53.0%, n = 35) and during in-season games (42.4%, n = 28) and practices (37.9%, n = 25). Common mechanisms of injury were contact (62.15%, n = 41), falls (19.7%, n = 13), and non-contact (15.2%, n = 10). ATs reported using an average of 3.4 ± 2.8 (range: 1-16) orthopedic special tests while diagnosing a GH dislocation or subluxation. The most common orthopedic special tests reported included: Apprehension (n = 40, 60.6%; positive = 30, negative = 9, inconclusive = 1), inferior glide/sulcus (n = 30, 45.5%; positive = 8, negative = 21, inconclusive = 1), anterior glide (n = 25, 37.9%; positive = 9, negative = 12, inconclusive = 4), posterior glide (n = 22, 33.3%; positive = 8, negative = 10, inconclusive = 4), relocation (n = 18, 27.3%; positive = 13, negative = 5), and Hawkins impingement (n = 17, 25.8%; positive = 7, negative = 10). No special tests were recorded for 17 (25.8%) patients diagnosed with a GH dislocation or subluxation. **Conclusions:** ATs use approximately three special tests in their evaluation of GH dislocations and subluxations. The apprehension test was the most commonly reported special test used by ATs in diagnosing a GH dislocation or subluxation, which corresponds with the frequency of use reported shoulder and elbow surgeons. While the apprehension test has good clinical utility for confirming an anterior GH dislocation or subluxation, using the combination of apprehension and relocation tests for anterior instability is recommended. Clinical utility measures for posterior instability is limited. Educational efforts should focus on encouraging the use of special tests with high diagnostic accuracy, including test combinations such as apprehension and relocation, in diagnosing anterior GH dislocations and subluxations.

### Approaches to Utilizing Evidence-Based Practice by Athletic Training Students During Clinical Education


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**Context:** The field of athletic training is constantly evolving. Knowledge of evidence-based practice (EBP) as a means for providing patient care has become a focus of athletic trainers nationally. Athletic training programs are required to instruct their students in not only evidence-based techniques, but also the steps associated with utilizing evidence properly when making clinical decisions. The question remains, however, as to whether the evidence based concepts and practices are being reinforced during clinical education. **Objective:** To examine the approaches utilized by athletic training students in regard to EBP. **Design:** Qualitative study utilizing journaling and grounded theory. **Setting:** A CAATE-accredited undergraduate athletic training program. **Patients or Other Participants:** Twelve senior-level athletic training students with prior experience in literature searching and review. **Data Collection and Analysis:** All participants were asked to document an experience where the EBP processes were utilized in order to optimize patient care. Participants were asked to document their clinical question and outcomes using the Patient, Intervention, Comparison, Outcome (PICO) format, to identify resources utilized to inform treatment decisions, and to identify the level of evidence for the utilized resources. Data were analyzed via a general inductive approach in order to uncover the most dominant themes. Data analysis took place in three distinctive steps including examining transcripts to gain a sense of the data, breaking down data into discrete parts, and identifying major categories. To ensure trustworthiness of the data, the researchers negotiated over the coding scheme until we came to agreement, completed peer review, and performed stakeholder checks. **Results:** Most participants documented patient cases that were either general medical, post surgical, or chronic in nature with prolonged recovery. Resources obtained were primarily from peer-reviewed journals. Specific content included case studies, randomized controlled trials, and systematic reviews. The athletic training students were proficient at identifying the level of evidence for the resource, correctly identifying the level of evidence 75% of the time. One deficiency was in the external validity of the resources obtained, as most of the studies were performed on non-athletic populations. **Conclusions:** The results of the study provide insight into how athletic training students are infusing evidence-based practice into their clinical experiences. It is encouraging that the students are aware of the quality of research being utilized to inform clinical decisions, and are seeking out information from peer-reviewed sources. The participants were able to clearly document patient cases and interventions using the PICO format when prompted; however, it remains unclear how often athletic training students are utilizing the PICO format when providing patient care. Also, it appears that athletic training students need to be more cognizant of the applicability of certain peer-reviewed literature to their own specific clinical settings.

### The Inclusion of Emotional Intelligence Competencies in Professional Athletic Training Education Programs


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**Context:** The concept of emotional intelligence (EI) is gaining popularity in scholarly, corporate, and healthcare settings; however, little is known about the inclusion of emotional intelligence in athletic training education. **Objective:** To determine whether emotional intelligence competencies are incorporated in the curriculum of professional athletic training education programs. **Design:** Cross sectional design involving online survey research. **Setting:** All 364 Commission on Accreditation of Athletic Training Education (CAATE) accredited professional athletic training education program directors were invited to participate in an online survey for this study. **Patients or Other Participants:** An invitation including the link to the online survey was sent to all 364 professional athletic training education program directors. 44 individuals began the survey and 42 completed the survey for a return rate of 12%. **Interventions:** Researchers designed a survey based upon Daniel Goleman's model of emotional intelligence containing four sections reflecting the four competencies of EI: self-awareness, self-management, social awareness, and relationship management. Responses were rated on a five-point Likert scale of never = 0, rarely = 1, sometimes = 2, very often = 3, or always = 4. The survey was administered via an online survey data collection tool (surveymonkey.com). The survey was validated using clinical coordinators from the researcher's respective undergraduate programs. Feedback was

obtained and the survey was restructured accordingly. **Main Outcome Measures:** Dependent variables consisted of the four sections of the survey reflecting emotional intelligence competencies: self-awareness, self-management, social awareness, and relationship management. Independent variables consisted of familiarity with emotional intelligence, previous training in EI, education level, age range, years BOC certified, and years as a program director. Scores for each section were averaged and data was analyzed using independent samples t-test as well as one-way ANOVA. **Results:** An independent samples t-test comparing participants who had heard of emotional intelligence ($2.53 \pm 0.73$) with those who had not ($1.64 \pm 0.62$) was significantly different ($t40 = 2.60$, $p = .01$) for the relationship management competency. ANOVA testing revealed a significant difference ($p < .01$) between program directors' age range and all four EI competencies showing that older program directors incorporated all four emotional intelligence competencies more often than their younger counterparts. **Conclusions:** Program directors with awareness of EI incorporated its characteristics in their professional athletic training education curriculum more often than those who do not. Older program directors also included emotional intelligence competencies in their professional athletic training education programs significantly more often than younger program directors.

## Graduate Assistant Athletic Trainers' Perceptions of Their Professional Preparation

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

**Context:** The professional preparation of newly credentialed athletic trainers has been passionately debated. Understanding how newly credentialed athletic trainers feel they are prepared will help enhance professional preparation. **Objective:** Explore graduate assistant athletic trainers' perceptions of their professional preparation for their role. **Design:** Phenomenological **Setting:** Phone interviews with graduate assistant athletic trainers in the collegiate setting. **Patients or Other Participants:** 19 collegiate graduate assistants (15 female, 4 male; average age $23 \pm 0.15$ years; NCAA Division I: 13, II: 3, III: 2, NAIA: 2; post-professional athletic training program: 6). Data saturation guided the number of participants. Participants were recruited via an email from the National Athletic Trainers' Association database sent to all certified students. **Data Collection and Analysis:** Data were collected via phone interviews, which were audio recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via member checks and peer debriefing. **Results:** Three themes emerged that described the perceptions of professional preparation of graduate assistant athletic trainers in the collegiate setting: 1) didactic education, 2) clinical experience, and 3) academic and clinical incongruence. Overall, participants felt academically prepared for their role, but preparedness was often dependent on curricular sequence, program length, and academic rigor of their professional program. Participants felt more prepared if their courses built upon each other with program sequencing (e.g., mastered anatomy before evaluation) and courses were rigorous. Clinical experiences greatly influenced professional preparation; however, institutional characteristics, clinical education philosophy, and the preceptor impacted the quality of the experience. Participants at non-NCAA Division I settings felt they had more hands-on patient care opportunities than participants in Division I. Participants felt prepared when they had active learning opportunities clinically and if their preceptors viewed the students' role as educational and challenged them to practice skills and make decisions, as opposed to providing labor. Incongruence existed when students were exposed to all the competencies during didactic education, but never gained experience with some skills clinically (e.g., rehabilitation, documenting injuries, communicating with coaches and physicians). Participants acknowledged they did not gain experience in all areas because certain situations did not present themselves during clinical education (e.g., conflict resolution, administration). Although participants were exposed to topics didactically, they felt would have been more prepared if they had gained hands-on experience with rehabilitation, administration, communication, and making decisions in the clinical setting. **Conclusions:** Athletic training students are being exposed to a variety of learning experiences academically, but do not gain clinical experience if situations do not arise or preceptors do not allow active participation. To ensure new athletic trainers are prepared, academic programs need to ensure rigor and place students with preceptors who provide active learning opportunities.

## Athletic Training Students' Academic Preparation in Healthcare Documentation

Brugge AM: University of Minnesota-Duluth, Duluth, MN, and The College of St. Scholastica, Duluth, MN

**Context:** Documentation is fundamental to all patient encounters across health professions. Athletic training education currently delineates five competencies and one clinical integration proficiency specific to documentation knowledge, skills and abilities. To date, there is little research on athletic training students' (ATS) preparation in performing patient documentation. **Objective:** To describe how final-year ATS report having received instruction, having rehearsed, and been assessed on the documentation-related competencies in athletic training. **Design:** Survey research was conducted to ascertain ATS reports of preparation in documentation in didactic, laboratory, and clinical education. This investigation received University of Minnesota IRB approval as an exempt study. **Setting:** An electronic survey was distributed to final-year ATS across all NATA districts in October 2014. **Patients or Other Participants:** A total of 1,094 final-year ATS enrolled in professional programs accredited by the CAATE during the fall of 2014 were solicited to participate via athletic training program directors. This convenience sample led to a 16.9% response rate. The greatest percentage (29.2%) of participants were attending institutions in NATA District IV. Among participants, 21.1% opted not to identify their professional program degree level, 11.3% were enrolled in post-baccalaureate professional programs, and 67.6% were bachelor's degree students. **Interventions:** The survey instrument was developed by the researcher, designed to correlate with education competencies, and examined for content validity by a panel of experts. Face validity was performed with 14 final-year ATS prior to a pilot study with 40 participants. The instrument consisted of 43 items; 7 demographic items, 15 items related to instruction, rehearsal, and assessment activities in didactic and laboratory education, 19 items pertaining to documentation experiences in clinical education, and 2 open-end questions. **Main Outcomes Measures:** SPSS® (v.20) was used to analyze descriptive statistics across various survey items. **Results:** ATS report having received instruction on SOAP notes (99.5%), HIPAA (99.5%), and medical terminology (95.1%) at high levels. However, 76.1% reported not having practiced using CPT and ICD codes, and correctly defining common third-party reimbursement abbreviations was limited (CPT = 28.3%, ICD = 24.5%, and NPI = 18.1%). Only 8.8% correctly identified the CPT code for an athletic training evaluation, and 8.1% reported instruction on the HITECH Act of 2009. Reporting of third-party reimbursement activities delineated in the HA-11 and HA-12 competencies indicated 7.4% had educational experiences related to communicating with insurers and 7.4% reported educational experiences on billing for medical services. **Conclusions:** Final-year ATS report appropriate levels of instruction, rehearsal, and assessment of their knowledge, skills, and abilities in medical terminology, writing SOAP notes, and the security, privacy, and confidentiality of medical records. Foundational knowledge in the use of procedural and diagnostic coding and performance of third party reimbursement activities may be lacking in athletic training professional programs.

## Clinical Reasoning Abilities of Professional Students and Certified Post Professional Students Using the Diagnostic Thinking in Athletic Training Inventory: Does Educational Program Type Matter?

Geisler PR, McKeon P, Kicklighter T, Heinerichs S: Ithaca College, Ithaca, NY; Lee University, Cleveland, TN; West Chester University, West Chester, PA

**Context:** Clinical reasoning (CR) is an aspect of medical cognition that's well recognized as essential for clinical diagnostic problem solving, yet measuring CR remains difficult because valid tools for assessing CR in various practitioners are scarce, especially using AT subjects. The Diagnostic Thinking Inventory for Athletic Training (DTI-AT) is a valid and promising tool for measuring CR abilities but has not yet been tested in different AT populations to discern differences in CR abilities due to educational background, clinical experiences, or concept familiarity. **Objective:** To administer the DTI-AT to different levels of AT students in order to assess differences in clinical reasoning based on mode of formal educational and experiences (entry-level or post-professional). **Design:** Cross sectional survey. **Setting:** Senior students in CAATE accredited bachelor's programs; last year master's students in CAATE accredited entry-level programs, and last year students in post-professional master's programs. Only undergraduate programs with current 3-year aggregate, >90% first time BOC pass rate were invited to be part of the undergraduate group in order to limit our undergraduate sample to high performance programs. **Patients or Other Participants:** We invited directors of entry-level and post-professional AT education programs in the United States to invite final year students to participate. Participation was voluntary, and secured via program director invitation after random

program selection and geographic representation. **Interventions:** Each participant completed the online, 41-item Likert scale DTI-AT in anonymous fashion, at their leisure and at the completion of their last semester of program. **Main Outcome Measures:** The DTI-AT produces 3 scores relative to clinical reasoning skills: Total diagnostic thinking (DT, max score = 246), structure of memory (SOM, max score = 120) and flexibility in thinking (FIT, max score = 126). The independent variable was group (entry-level vs. post-professional). Separate independent t-tests were used to assess group differences on the 3 DTI-AT scores. Alpha level was set a priori at $p \leq 0.05$. **Results:** 89 students (76 entry-level, 13 post-professional) completed the DTI-AT inventory. Post-professional students scored significantly higher on overall DT (post-professional: 187.2 ± 15.2, entry-level: 179.0 ± 13.7, $p = 0.05$) and FIT (post-professional: 95.0 ± 7.8, entry-level: 87.7 ± 8.2, $p < 0.01$), but not on SOM (post-professional: 92.2 ± 8.4, entry-level: 91.2 ± 8.3, $p = 0.73$). **Conclusions:** Both SOM (organized, linked, experiential case knowledge) and FIT (ability to problem solve using different strategies) are strong indicators of higher-level clinical reasoning and hallmarks of expert clinicians' thinking. Of the 2 subscales, FIT is more dependent upon clinical exposure/experience, particularly regarding independent problem solving and reflection, while SOM is more dependent upon how knowledge is learned, organized and made meaningful. Given their increased clinical experiences, our certified post professional students showed higher overall levels of DT and higher FIT than did entry level students, yet almost identical SOM scores as their younger counterparts; indicating that independent and more intensive clinical exposures may be more important for developing DT & FIT, and that educational content and delivery may be similar amongst the different programs.

## Perceived Benefits of a Graduate Level Model in Athletic Training Education

Barrett JL, Mazerolle SM, Bowman TG: University of Connecticut, Storrs, CT, and Lynchburg College, Lynchburg, VA

**Context:** Educational reform has occurred previously in athletic training. Moving to a graduate degree model has been decided as the next change as a means to better align with other healthcare programs. Additional reasons for the transition were to improve the status of athletic training within the larger healthcare community, provide improved quality of care to patients as well as recruiting and retaining a more mature and committed student. The advantages to this model, however, are not well understood. **Objective:** Understand the perceived benefits of the graduate model as viewed by those currently vested in such a program. **Design:** Qualitative study. **Setting:** Professional Masters Athletic Training Programs (PM ATPs). **Patients or Other Participants:** 29 (13 athletic training faculty and program directors, 16 students) participated in our study. The students were 25 ± 3 years old, and had an average self-reported GPA of 3.8 ± .2. Program directors and faculty on average were 45 ± 9 years old and had 22 ± 8 years of experience as athletic trainers along with 12 ± 7 years of experience in athletic training education. **Data Collection and Analysis:** We collected data through an online questionnaire (Qualtrics) based upon their role in their PM ATP. Data was evaluated using an inductive approach to systematically review the data. We identified codes initially and then grouped them into categories leading into emergent themes. Participant recruitment ceased once saturation was met. Peer review and multiple analyst triangulations along with multiple stakeholder triangulation were completed to secure rigor in our findings. **Results:** Inductive analysis revealed 5 benefits of the PM ATP model. 1) Early and Full Immersion into Clinical Education allows students to prepare for their roles as athletic trainers, 2) Faculty stress the Importance of Inter-professional Education by engaging students in the larger scope of healthcare through purposeful interactions, 3) Expecting prior Foundational Knowledge allows Focused Education Training at the graduate level due to a lack of competition between general requirements and athletic training curriculum, 4) Increased Professional Commitment to the athletic training profession occurs since students do not use athletic training as a stepping-stone to other careers 5) Higher Student Maturity facilitates deeper learning as students are mature and focused. **Conclusions:** The perceived benefits of the PM ATP model are multifactorial and our findings mirror what has been suggested as to why a transition is necessary and ultimately decided upon. As experienced by our participants, some challenges faced within the bachelor's model appear to be avoidable. Fundamentally, the PM student can gain experiences that may not be offered at the undergraduate level due to valuable clinical education experiences that do not compete with general education. As programs begin to transition, it is important for them to maintain their autonomy while learning from current PM ATPs.

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

Hankemeier DA, Welch Bacon CE, Van Lunen BL: Ball State University, Muncie, IN; A.T. Still University, Mesa, AZ; Old Dominion University, Norfolk, VA

**Context:** Several healthcare competencies have been identified for all healthcare professionals to implement into patient care. These competency areas of evidence-based practice (EBP), healthcare informatics (HCI), quality improvement (QI), patient-centered care (PCC), professionalism (PROF) and interprofessional education and collaborative practice (IPECP) are required at the post-professional level, while very few are required in professional athletic training programs. Students studying athletic training should be able to implement these competencies once they transition to professional practice. **Objective:** To compare perceived ability levels within competency areas between students enrolled in professional undergraduate (UG) and entry-level masters (ELM) Commission on Accreditation of Athletic Training Education athletic training (AT) programs. **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 AT programs. **Interventions:** The survey consisted of a section for each competency. Concepts (range: 8-18) were described within each competency that related to the definition of the competency. Participants rated their perceived ability to implement each concept of each competency in their clinical practice on a 4-point Likert scale of strongly disagree (1), disagree (2), agree (3), and strongly agree (4). Reliability of the ability scale was established prior to data collection and was extremely high ($\alpha$ = .955). **Main Outcome Measures:** Composite ability scores were calculated by adding all values and then averaging the scores back to the Likert scale. Higher scores indicated participants' perceived higher ability levels in each competency. The independent variable was AT program type (UG, ELM) and dependent variables were participants' responses. Between-group differences were assessed with Mann-Whitney U tests ($P<.05$). **Results:** Overall, participants "agreed" with their ability to implement concepts into clinical practice (QI = 3.41/4.0 ± .35, PROF = 3.53/4.0 ± .30, HCI = 3.04/4.0 ± .44, IPECP = 3.25/4.0 ± .46, EBP = 3.36/4.0 ± .37, PCC = 3.30/4.0 ± .44). Significant differences were found between UG and ELM students with ELM exhibiting higher perceived abilities for QI (UG = 3.39/4.0 ± .35, ELM = 3.49/4.0 ± .34, U = 84756.0, P = .018), PROF (UG = 3.52/4.0 ± .30, ELM = 3.60/4.0 ± .28, U = 91188.5, P = .002), EBP (UG = 3.34/4.0 ± .36, ELM = 3.47/4.0 ± .35, U = 85440.0, P < .001). There was no significant difference for HI (UG = 3.03/4.0 ± .44, ELM = 3.08/4.0 ± .39, U = 101024.0, P = .205), IPECP (UG = 3.24/4.0 ± .45, ELM = 3.29/4.0 ± .46, U = 102144.0, P = .145), or PCC (UG = 3.29/4.0 ± .41, ELM = 3.35/4.0 ± .40, U = 99596.5, P = .082). **Conclusions:** Final-term students in ELM AT programs perceive themselves as having greater ability to implement the competency areas of QI, PROF and EBP in clinical practice when compared to final-term students in UG AT programs. Opportunities should be provided for students to demonstrate their ability to address the competencies of HI, IPECP, and PCC. As athletic training education transitions to an ELM degree, it is essential that knowledge and skills related to all competencies are fostered so students feel comfortable in their abilities to implement the competencies in clinical practice. Funded by the National Athletic Trainers' Association Research and Education Foundation

Learning Objectives:
At the conclusion of this session, participants will be able to:
Identify each of the healthcare competencies and how to implement them into clinical practice.
Identify the differences between the perceived abilities of undergraduate and graduate athletic training students when implementing the healthcare competencies into clinical practice.
Discover methods that can improve implementation of healthcare informatics, interprofessional education and collaborative practice, and patient centered care.

References:
1. Morris TM & Hancock DR. Institute of medicine core competencies as a foundation for nursing program evaluation. Nurs Educ Res. 2013;34(1):29-33.
2. Institute of Medicine (IOM). Health Professions Education: A Bridge to Quality. Washington, DC: National Academy Press; 2003.

# Free Communications, Rapid Fire Oral Presentations: School Personnel Concussion Knowledge and Interventions

Saturday, June 25, 2016, 1:30PM-3:00PM, Room 317; Moderator: Richelle Williams, MS, ATC

### The Effect of a School-Related Cognitive Activity Intervention on Recovery Following Concussion in High School Athletes

Littleton AC, Guskiewicz KM, Mihalik JP, Register-Mihalik JK, Marshall SW, Gioia GA: Towson University, Towson, MD; University of North Carolina at Chapel Hill, Chapel Hill, NC; Children's National Health System, Washington, DC

**Context:** Cognitive rest is suggested following concussion, yet the effect of limiting cognitive activity on recovery is unclear. **Objective:** To characterize the effect of a guided cognitive activity intervention (standard-of-care vs. intervention) on recovery time and patient satisfaction following concussion, and to determine if sex, age, concussion history, average daily cognitive and physical activity, symptoms at the time of injury, and premorbid conditions predict concussion recovery time. **Design:** Cluster-randomized trial. **Setting:** High school. **Patients or Other Participants:** Forty high school athletes with diagnosed concussions were enrolled in the study (20 standard-of-care, 20 intervention; 27 males, 13 females; age = 15.7 ± 1.1 yrs; height = 175.3 ± 9.1 cm; mass = 69.5 ± 34.2 kg). **Interventions:** Participants from four high schools were administered concussion baseline testing for symptom, neurocognition, postural control, and vision measures. Initially, two schools were randomly assigned to the standard-of-care group and two schools were assigned to the intervention group. After the minimum number of participants for the standard-of-care group was attained, the standard-of-care schools were converted to intervention schools. All participants recorded demographic information (sex, age, concussion history, premorbid conditions) and their physical and cognitive activity from the time of injury until they were deemed recovered. Intervention group participants received daily guidance on how much school-related cognitive activity to complete, while the standard-of-care group followed instructions they were provided by their healthcare providers. **Main Outcome Measures:** Recovery time, defined as days from time of injury until the participant maintained a baseline symptom score for 24 hours and performed greater than 95% of baseline performance on all clinical measures; and patient satisfaction, measured by the overall score on an adaptation of the Patient Satisfaction Questionnaire (PSQ-18). We used a survival analysis employing Kaplan-Meier curves with log-rank tests to analyze our primary aim, and several univariate cox proportional hazard models for our second aim (a priori $\alpha = 0.05$). **Results:** There were no statistically significant differences between the standard-of-care and intervention groups in recovery time (standard-of-care = 9.1 ± 4.4 days, intervention = 11.5 ± 5.0 days; P = 0.12) or patient satisfaction (standard-of-care = 1.8 ± 0.4, intervention = 1.8 ± 0.3; t33 = 0.24,P = 0.53; we were missing patient satisfaction surveys for 5 participants). None of the following variables were predictors of recovery: sex, age, previous concussion history, average daily cognitive activity, average daily physical activity, symptoms at the time of injury or premorbid conditions (P > 0.05 for all). **Conclusions:** This study adds to a small but growing body of literature suggesting there may be no clear therapeutic benefit of cognitive rest. Larger trials are needed before definitive recommendations for practice can be established.

### The Influence of Athletic Trainer Employment on School Administrators' Perceived Knowledge, Confidence, and Importance of Adolescent Concussion

Johnson RS, Valovich McLeod TC, Kasamatsu TM, Register-Mihalik JK, Erickson CD, Welch Bacon CE: A.T. Still University, Mesa, AZ; California State University, Fullerton, CA; University of North Carolina at Chapel Hill, Chapel Hill, NC

**Context:** School administrators (SA) play an important role in implementing proper academic adjustments (AA) for students with sport-related concussions (SRC) and in hiring athletic trainers (AT). Little is known whether access to an AT influences SAs' perceived importance, knowledge, and confidence of adolescent concussions. **Objective:** To determine whether access to an AT influences SAs' perceived importance, knowledge, and confidence in knowledge regarding adolescent concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 532 SAs (68.7% response rate; 308 superintendents, 224 principals, age = 52.3 ± 7.7, school administrator experience = 8.11 ± 6.1 years) from a convenience sample of 770 school administrators from 29 states. **Interventions:** Participants were solicited via email to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC) survey. The BAKPAC consisted of 20 4-point Likert-scale items to assess participants' perceived importance (6), knowledge (7), and confidence in their knowledge (7) for several topics related to concussion. Separate versions of the survey were tailored to superintendents (BAKPAC-SP) and principals (BAKPAC-PR), respectively. **Main Outcome Measures:** The dependent variables were participants' responses to the 20 Likert-scale items.

A higher score indicated participants had a higher perceived knowledge level, higher confidence in their knowledge, and perceived the concepts to be more important. Composite knowledge and confidence scores were achieved by totaling all values and then calculating the average back to the Likert scale (total divided by 4). Descriptive statistics were utilized to describe overall importance, knowledge, and confidence while Mann Whitney U tests ($P<.05$) were used to determine group differences. **Results:** Respondents included 364 SAs with access to an AT (SAwAT) and 168 without access (SAwoAT). SAwAT agreed-to-strongly agreed (3.5/4.0 ± 0.68, P = .001) that cognitive activities should be limited following a SRC, while SAwoAT agreed (3.3/4.0 ± 0.76). SAwAT agreed they were knowledgeable about AA available (3.0/4.0 ± 0.75, P = .008) and return-to-play (RTP) criteria (3.1/4.0 ± 0.72, P = .013) following a SRC, and disagreed-to-agreed they were knowledgeable about return-to-learn (RTL) criteria (2.8/4.0 ± 0.83, P < .001). SAwoAT disagreed-to-agreed to they were knowledgeable about AA available (2.8/4.0 ± .85) and RTP criteria (2.9/4.0 ± 0.84) following a SRC, and disagreed they were knowledgeable about RTL criteria (2.5/4.0 ± 0.91). Both groups were only minimally or moderately confident in their knowledge, SAwATs were more confident in their knowledge about AA available (2.9/4.0 ± 0.76, P = .003), RTL criteria (2.7/4.0 ± 0.83, P = .002), and RTP criteria (3.0/4.0 ± 0.76, P = .013) following a SRC compared to SAwoATs (AA = 2.86 ± 0.86; RTL = 2.5/4.0 ± 0.89; RTP = 2.8/4.0 ± 0.82). SAwATs also had significantly higher composite concussion knowledge (3.0/4.0 ± 0.54, P = .003) than SAwoATs (2.8 ± 0.62). **Conclusions:** SAs that had ATs employed at their schools agreed more strongly that they were knowledgeable about and were more confident in their knowledge regarding AA, RTL, and RTP criteria post-SRC compared to SAs that did not have an AT employed. These findings highlight the importance of having an AT employed in the secondary school setting.

## Interscholastic Athletes Have Favorable Attitudes Towards Concussion Reporting Upon Completion of a Concussion Education Program

Sanchez M, Cardenas JF, Welch Bacon CE, Bay RC, Christopherson RM, Valovich McLeod TC: A.T. Still University, Mesa, AZ; Barrow Neurological Institute, Phoenix, AZ; Arizona State University, Tempe, AZ

**Context:** Numerous efforts have been taken to improve the knowledge and awareness of sport-related concussion among adolescents. These efforts, including those outlined in state laws, interscholastic association policies, and from agencies like the Centers for Disease Control and Prevention aim to increase knowledge with the ultimate goal of changing behavior to improve concussion reporting. While numerous studies have aimed to evaluate the effectiveness of concussion education programs, fewer studies have assessed post-education attitudes. **Objective:** To describe attitudes towards concussion among interscholastic athletes following a concussion education program. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** Adolescents participating in interscholastic athletics, between 2011-2014, in the state of Arizona (67,207 males, 55,171 females, age = 14.7 ± 1.1 years, grade = 9.6 ± .94 level). **Interventions:** Participants completed the Barrow Brainbook concussion education course, which was comprised of a pre-assessment, interactive online educational program, and post-assessment. Barrow Brainbook is the mandated concussion education course required for interscholastic athletes in the state. Part of the post-assessment included 16 scenario-based questions gauging attitudes towards concussion. **Main Outcome Measures:** The dependent variables were participants' responses to the scenario-based questions. Responses were scored on a 5-point Likert scale with strongly agree = 5, neutral = 3, strongly disagree = 1. Descriptive statistics (mean ± SD) were reported. **Results:** Participants disagreed-to-strongly disagreed that performance should be the same following concussion (1.58/5.0 ± .85), concussions don't happen in their sport (1.86/5.0 ± 1.09), getting your bell rung is a badge of honor (1.73/5.0 ± .91), concussion can't be treated (1.86/5.0 ± .95), and athletes have a responsibility to the game even if it means playing with symptoms (1.53/5.0 ± .86). Participants responded neutral-to-agree that they leave it up to the coach or athletic trainer to determine if they are well enough to play (3.45/5.0 ± 1.38), pressure to win can sometimes stress you to the point where it is not fun to play (3.61/5.0 ± 1.10), and that concussions can change your personality (3.73/5.0 ± .98). Participants agreed-to-strongly agreed that they would report a teammate shaking out the cobwebs to their coach (4.59/5.0 ± .68), taking out a star athlete with a suspected concussion is appropriate (4.54/5.0 ± 1.00), a teammate complaining of a headache after a bad fall likely has a concussion (4.18/5.0 ± .77), they knew when to leave a game when injured (4.32/5.0 ± .84), feeling nauseous and woozy after a hit were likely signs of a concussion (4.33/5.0 ± .77), they would seek care for just suspecting a concussion (4.53/5.0 ± .65), they would tell a coach if they suspected a teammate had a concussion (4.60/5.0 ± .61) and as a team captain they have a responsibility to ensure equipment is on properly (4.58/5.0 ± .65). **Conclusions:** Following an educational program, interscholastic athletes generally had favorable attitudes towards concussion. While these findings are promising, continued efforts should be put forth in developing effective educational interventions that instill favorable attitudes and foster behavioral changes that result in increased symptom reporting.

## Concussion Knowledge and Attitudes of North Carolina Head Football Coaches

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**Context:** Sport-related concussions are prevalent among high school sports, especially football. **Objective:** The purpose of this study was to investigate the knowledge and attitudes toward concussions head high school football coaches in North Carolina possess. **Design:** Descriptive cohort design **Setting:** North Carolina high school football. **Patients or Other Participants:** Eighty-seven head high school football coaches in North Carolina. There was a 24.6% (87/353) response rate. The average age of the participants was 46 years and the average years of coaching experience was 20.3 years. **Interventions:** The Rosenbaum Concussion Knowledge and Attitudes Survey-Coaches section (RoCKAS-CH) was used to measure the concussion knowledge and attitudes in the head coach population. Qualtrics software was used to administer the survey online. **Main Outcome Measures:** The survey was divided into four sections: demographics, concussion knowledge index, concussion attitudes index, and a symptoms list. Descriptive statistics were calculated for the participants' age, years of coaching football, Concussion Attitudes Index, Concussion Knowledge Index, and symptoms list. An independent samples t-test was performed to determine if there were any statistical differences between coaches having an athletic trainer with concussion knowledge. **Results:** Sixty-five percent of coaches (50/77) indicated they had access to a full-time athletic trainer while 35% (27/77) had no access to an athletic trainer. Two common misconceptions were reported by the participants: 1) After a concussion occurs, brain imaging (e.g. CAT scan, MRI, x-ray, etc.) typically shows visible physical damage (e.g. bruise, blood clot) to the brain (44/73, 60%), which was not significantly affected with the presence of an athletic trainer [$t(68) = 1.507$, $p = 0.128$)]. A "bell-ringer or ding" is a concussion (44/73, 60%), which was not significantly different based on the presence of an athletic trainer [$t(67) = 0.375$, $p = 0.708$]. The coaches indicated many safe attitudes toward concussions like athletic trainers should make the return to play decisions (58/61, 95%). However, the coaches revealed their acknowledgement of risky behaviors. Eleven of 63 coaches indicated they would continue playing while having a headache resulting from a concussion (17.4%). In response to the question whether athletes that are knocked unconscious should go to the emergency room, 7 of 62 answered they do not (11.2%). Coaches were able to identify commonly reported concussion symptoms like headache (62/62, 100%) and sensitivity to light (61/62, 98%). The most commonly answered distractor questions were reduced breathing rate (11/62, 18%) and panic attacks (14/62, 23%). **Conclusions:** This study demonstrated there is an overall moderate understanding of concussions as well as a general safe attitude among NC high school football coaches. The findings of this study that many common misconceptions among coaches about concussions still exist suggest the inherent need for appropriate medical coverage on football sidelines.

## Differences in High School Athletes' Knowledge of Concussion and Reporting Behaviors in High Schools With and Without an Athletic Trainer

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**Context:** Increased sport participation and sport-related concussion incidence has led to an emphasis of having an appropriate medical professional available to high school athletes. The medical professional best suited to provide medical care to high school athletes is a certified athletic trainer (AT). Access to an AT may influence the reporting of sport-related concussion in the high school athletic population; however, little is known about how the presence of an AT affects concussion knowledge, recognition and reporting. **Objective:** To evaluate knowledge of concussion and reporting behaviors in high school athletes with and without an AT. **Design:** cross-sectional study **Setting:** Participants completed a one-time paper and pencil survey. **Patients or Other Participants:** 715 high school athletes (503 male, 212 female) from 14 high schools. Seven schools had an AT and 7 schools did not have an AT. **Interventions:** A validated knowledge of concussion survey consisted of 83 questions including demographics, concussion history, concussion knowledge, and reasons why an athlete would not report their concussion to an authoritative figure. Athlete knowledge of concussion was assessed through a series of 35 questions in which participants were asked to recognize signs and symptoms of concussion, identify complications related to multiple concussions, and answer questions pertaining to general knowledge of concussion. Total knowledge was calculated by summing the number of correct answers out of 35. Scores could range from 0 to 35 with a score closer to 35 representing

greater concussion knowledge. The independent variable was AT access (AT/No AT). **Main Outcome Measures:** The proportion of athletes who correctly identified signs and symptoms of concussion, knowledge of concussion and reasons why high school athletes would not disclose a potential concussive injury across AT access. Frequency statistics, independent t-tests, and a linear regression were conducted to analyze data. **Results:** Of the 715 participants, 61.3% (n = 438) had access to an AT and 38.7% (n = 277) did not have AT access. The under-reporting of concussion among high school athletes was 55%. The top reason high school athletes did not report a potential concussive injury was not thinking the injury was serious enough to warrant medical attention (33.7%). Athletes with access to an AT have more knowledge of concussion than athletes that do not have access to an AT ($t(2, 713) = 4.77$, $p = 0.00$). Results from the linear regression investigating the presence of an AT indicated no statistical significance ($p = 0.08$) on reporting behaviors. **Conclusions:** The NATA has reported that only 42% of high schools in the United States have access to an AT. Results from this study indicate that high school athletes with access to an AT have more concussion knowledge. Moreover, the presence of an AT could decrease unreported concussions.

## Physician Assistants' Familiarity and Perceptions of Academic Adjustments for Adolescent Athletes Following Sport-Related Concussion

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**Context:** Physician assistants (PA) often provide care for adolescents following a sport-related concussion and therefore should be considered as members of the concussion management team. However, not all PAs have connections with secondary schools or interaction with athletic trainers (AT), and it is unclear how often they prescribe cognitive rest as part of concussion management. Furthermore, little is known about PAs' awareness and perceptions of academic adjustments (AA) available for concussed adolescents. **Objective:** To determine whether PAs' association with an AT influences familiarity and perceptions of AA following a sport-related concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 191 PAs (9.6% response rate) from a convenience sample of PAs across 34 states (49 males, 58 females, 84 missing, age = 47.1 ± 11.4years, PA experience = 15.8 ± 10.5years). **Interventions:** Participants were solicited via email to complete the Physician Assistants' Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC-PA) survey. The BAKPAC-PA consisted of several multipart questions to assess PAs' familiarity, perceptions, and utilization regarding various aspects of AA. The independent variable was PA association with an AT (PA-AT, PA-noAT). **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:** Only 18.8% of respondents reported access to an AT (n = 21), while 81.3% did not (n = 91). While there was no significant group difference, PAs agreed-to-strongly agreed that concussions affect school performance (3.8/4.0 ± 0.57), and agreed that PAs (3.6/4.0 ± 0.61), ATs (3.3/4.0 ± 0.76), school nurses (3.2/4.0 ± 0.83), and physicians (3.7/4.0 ± 0.57) each have a role in implementing AA. PA-ATs were minimally-to-moderately familiar with AA (2.8/4.0 ± 0.89,P = .019) and minimally familiar with 504 plans (2.2/4.0 ± 0.97, P = .009), while PA-noATs were only minimally familiar with AA (2.2/4.0 ± 0.95) and not at all familiar with 504 plans (1.5/4.0 ± 1.17). Furthermore, 65.4% of PA-ATs (n = 17) personally encountered a patient who experienced a decrease in academic performance (P = .012) compared to 27.9% of PA-noATs (n = 46). 38.5% of PA-ATs (n = 10, P = .001) always or almost always prescribe AA, compared to only 11.5% of PA-noATs (n = 19). In fact, 29.1% of PA-noATs (n = 48) never prescribe AA for concussed adolescents. Finally 57.7% of PA-ATs (n = 15) reported having patients receive AA following a concussion (P = .042), compared to only 23.0% of PA-noATs (n = 38); 15.8% of PA-noATs (n = 26) did not know if patients under their care received AA following a concussion. **Conclusions:** PAs recognize that all healthcare professionals have a role in AA. Additionally, PAs who have access to an AT appear to have greater familiarity with AA and prescribe AA for concussed adolescents more frequently. ATs should cultivate new relationships with PAs and work in conjunction with PAs to ensure patients are appropriately prescribed AA as part of the management plan.

## A Comparison of Health Care Professionals' Perceptions and Familiarity of Academic Adjustments for Adolescents Following a Concussion

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**Context:** Various healthcare professionals (HCP), including athletic trainers (AT), school nurses (SN), physicians (PHYS) and physician assistants (PA), provide collaborative care for adolescents following a concussion. Current best practices suggest that HCPs should incorporate cognitive rest as a part of concussion management and should prescribe academic adjustments (AA), including individualized education plans (IEP) and 504-plans, when warranted. However, in order to effectively prescribe cognitive rest for concussed adolescents, it is essential to ensure all HCPs are familiar with and perceive the value of AA. **Objective:** To compare HCPs' perceptions of and familiarity with AA for adolescents following a concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 2,209 participants (421 male, 1,269 females, 519 missing, age = 46.0 ± 17.2) from a convenience sample of 22,286 HCPs (9.9% response rate). **Interventions:** Participants were solicited via email to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussions (BAKPAC) survey. The BAKPAC consisted of several multipart questions to assess HCPs' familiarity and perceptions regarding AA. Separate versions of the survey were tailored to each HCP group (BAKPAC-AT, BAKPAC-SN, BAKPAC-PHYS, BAKPAC-PA) respectively. The independent variable was HCP group with four levels (AT, SN, PHYS, PA). **Main Outcome Measures:** The dependent variables were participants' responses to the AA questions. Descriptive statistics were utilized to describe overall familiarity and perceptions while Kruskal-Wallis H tests ($P < .05$) and Mann Whitney U tests with a Bonferroni adjustment ($P < .0125$) were used to determine group differences. **Results:** Overall, HCPs agree that concussions can affect school performance (3.6/4.0 ± 1.2), concussed adolescents are eligible for consideration under the Americans with Disabilities Act (ADA; 3.0/4.0 ± 1.2), and that an AT has a role in the implementation of AA (3.0/4.0 ± 1.2). 57.3% of HCPs reported that they have managed a concussed adolescent who experienced decreased school performance and 61% had patients receive AA following concussion. Familiarity with IEPs ($P \leq .001$) and 504-plans ($P \leq .001$) differed among groups. SNs were most familiar with IEPs (3.5/4.0 ± .71) and 504-plans (3.5/4.0 ± .73), followed by PHYSs (IEP = 2.8/4.0 ± 1.4, 504-plan = 2.1/4.0 ± 1.3), PAs (IEP = 2.3/4.0 ± 1.0, 504-plan = 1.7/4.0 ± 1.0), and ATs (IEP = 2.1/4.0 ± 1.4, 504-plan = 1.8/4.0 ± 1.3). Perceptions regarding the effect of concussion on school performance ($P \leq .001$), concussed adolescents eligibility for consideration under the ADA ($P \leq .001$), and the role of an AT in implementing AA ($P \leq .001$) also differed among HCPs. **Conclusions:** While HCPs agree that concussions can affect school performance, familiarity with the different modes of AA is somewhat minimal. As a concussion management team, HCPs should work collaboratively to ensure proper concussion management is achieved, including the incorporation of AA. Results from this study provide evidence that continuing education opportunities on concussion management are needed and more specifically should focus on various implementation strategies for AA. Additionally, HCPs should collaboratively discuss AA, the existing AA programs available, and the implementation process.

## Public School Teachers' and Administrators' Understanding of Concussion Management in the Classroom

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**Context:** Concussion management is a multifaceted process requiring a teamed approach to care throughout recovery. Teachers and school administrators (SA) are important stakeholders on the concussion management team. Yet, no research describes teachers' and SAs' understanding of concussion or their perceptions about the implementation of return-to-learn (RTL) guidelines. **Objective:** To understand teachers' and SAs' concussion knowledge and perceptions about implementing RTL guidelines. **Design:** Qualitative study. **Setting:** Large metropolitan public school system. **Patients or Other Participants:** Teachers (n = 15, 11 ± 7 years experience) and SA (n = 6, 12 ± 6 years experience). **Data Collection and Analysis:** Interviews were conducted using a semi-structured guide by the lead researcher. Interview audio was recorded and transcribed verbatim. Data were analyzed using an analytic induction and constant comparison approach. Final themes were determined upon agreement among the research team. Data triangulation and trustworthiness were assured using participant interpretation member checks, inclusion of multiple researchers, and prolonged engagement (>4 years) working with the school system. **Results:** Four major themes emerged: 1) different and unequal knowledge, 2) school context, 3) personal experience, and 4) external pressures. First, different expertise among stakeholders creates unequal knowledge within the concussion management team. Teachers expressed feeling ill equipped and lacking confidence to implement RTL or make academic adjustments without specific instructions from a physician. Second, teachers articulated that communication

between teachers about a student's RTL was limited unless the case was long term. Teachers accordingly are unaware of and found it challenging to properly calibrate and adjust the total academic workload assigned to the student. Third, teachers not coaching a sport at the school were less familiar with concussion overall than teachers who coach a sport. Teacher-coaches had increased exposure to concussion education than non-coaching classroom teachers. Fourth, teachers having a personal experience with concussion were more sympathetic toward students' needs. However, teachers acknowledged feeling pressed to provide and monitor a concussed student's individual RTL needs amidst numerous competing demands and large class sizes. Administrators complimented the school's concussion policy and communication efforts to inform the student's teachers, however expressed minimal understanding of challenges that teachers described regarding implementing RTL guidelines. **Conclusions:** Our findings demonstrate that teachers and SAs care about students and their learning while recovering from concussion. However, it was noted that the daily realities of the contemporary public school context complicate teachers' and SAs' capacity to consistently and effectively implement RTL guidelines. We learned that teachers and SAs understand that concussions are a serious health issue. Yet teachers did not feel proficient in making academic adjustments and desired meaningful and efficient communication strategies with other teachers, SAs and physicians to facilitate proper care for a students recovering from concussion in the classroom. Supported by the Potomac Health Foundation.

## School Nurses' Perceived Role in Communication and Collaboration as a Member of the Concussion Management Team at the Secondary School Level

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**Context:** A comprehensive concussion program, in which both the school nurse (SN) and athletic trainer (AT) have an integral role, is essential for successful management of concussion at the secondary school level. Depending on the responsibilities of a particular SN, they may work in tandem with an AT and/or other school staff members as a concussion management team (CMT), where collaboration and communication is vital. In most schools, SNs are the only healthcare professional present during the school day, while most ATs are at the school in the afternoon. These alternate schedules further highlight the potential for miscommunication between members of the CMT. To date, there is limited information discussing SNs' role in the CMT, and how their communication and collaboration affect the perceived success of concussion management. **Objective:** To explore SNs' perceived role in communication and collaboration with ATs and other members of the CMT at the secondary school level. **Design:** A consensual qualitative research tradition was used for this qualitative investigation. **Setting:** Individual phone interviews were conducted for all participants. **Patients or Other Participants:** 24 SN (24 females; age = 53.0 ± 6.21years; SN experience = 14.4 ± 6.1 years), representing 16 states were interviewed. Participants were recruited with criterion sampling. **Data Collection and Analysis:** One semi-structured phone interview was conducted with each participant. Upon transcription, a 4-person research team coded the data into themes and categories. Each researcher independently coded the data, and then the team met to reach a final consensus ensuring accuracy and representativeness of the data. Triangulation of the data was ensured by the use of multiple researchers, participant member-checking, and the use of an internal auditor. **Results:** Participants reported that they communicate with several individuals including school personnel, external healthcare providers (for collaboration and referral), and parents for concussion management. The SNs also reported communication with the school AT if the school had access to an AT. However, in some instances, SNs discussed a lack of communication with multiple CMT members including the AT and other school personnel. The participants frequently reported having roles in concussion assessment and daily follow-up, facilitation of the management plan, serving as a liaison between medical staff and school staff, and being a resource for parents throughout the injury recovery process. **Conclusions:** SNs' role in concussion management involves communication with school personnel and other healthcare providers. Consistent communication between the SN and other members of the CMT including the AT, parents, and athletes is essential to ensure comprehensive concussion management at the secondary school level. Miscommunication may hinder recovery and even lead to potential liability concerns. The SN has a unique role to facilitate this communication with all parties and the ability to impact successful concussion management.

## School Nurses' Perceptions of the Academic Management Team for Student-Athletes Following a Sport-Related Concussion

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**Context:** Following sport-related concussion, both cognitive and physical rest are imperative aspects of injury management. The inclusion of academic adjustments (AA) and the formation of an academic management team provide a mechanism to manage academic issues. The school nurse (SN) is often the only other healthcare professional, besides the athletic trainer (AT), employed in the secondary school. While these healthcare providers should work collaboratively to manage concussive injuries, little is known regarding SNs' involvement in the implementation of AA for concussed student-athletes. **Objective:** To explore SNs' perceptions of the academic management team for student-athletes following a sport-related concussion in the secondary school setting. **Design:** The emergent design of this qualitative investigation was modeled after the consensual qualitative research approach. A semi-structured interview protocol was used to allow for flexibility in accordance with the emergent design. To solicit participants, a criterion sampling method was utilized. **Setting:** Individual phone interviews were conducted for all participants. **Patients or Other Participants:** 15 SNs employed in the secondary school setting (15 females; age = 55.9 ± 5.81 years; SN experience = 15.3 ± 5.89 years), representing 9 states, were interviewed. **Data Collection and Analysis:** One individual phone interview was conducted with each participant. 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 participant member-checking, use of multiple researchers, and an internal auditor. **Results:** SNs identified several components regarding the academic management team that are essential to include in the concussion management process. Particularly, participants perceived that in addition to the SN, the academic management team should include at a minimum, an AT, physician, school counselor, and respective teachers. Additionally, SNs' discussed the individual role and responsibilities, and perceived concussion-related education levels, of each member of the academic management team. Finally, participants discussed their perceptions of their own role and responsibilities as a member of the AA management team for concussed student-athletes. **Conclusions:** The inclusion of an academic management team to aid the recovery following a sport-related concussion is vital to ensure proper care for the student-athlete. As the sole healthcare providers in many secondary schools, the SN and AT must effectively collaborate to ensure student-athletes are allowed sufficient cognitive rest via the incorporation of academic adjustments during the recovery process. The AT and the SN as well as other members of the academic management team need to be communicative throughout the entire recovery period. Collaboration and communication within all members of the management team ensures proper concussion management and individualized care for the injured student-athlete.

## Perceptions of Academic Adjustments Following Adolescent Concussion: Comparison of School Administrators With and Without Access to Athletic Trainers

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**Context:** School administrators (SAs), athletic trainers (ATs), and other school professionals play unique roles within the school-based interdisciplinary concussion management team. It is unclear if access to an AT influences implementation of academic adjustments (AA) and SAs' perceived role in this process following concussion in student-athletes. **Objective:** To examine SAs' perceptions and implementation of AA following concussion. **Design:** Cross-sectional. **Setting:** Self-reported online survey. **Patients or Other Participants:** 532 SAs (308 superintendents, 224 principals; years of experience = 8.11 ± 6.1 years) across 29 states were recruited from a convenience sample of 770 (68.7% response rate). There were 364 SAs with access to an AT (SAwAT) and 168 without access to an AT (SAwoAT). **Interventions:** SAs were contacted via email and requested to complete the Beliefs, Attitudes, and Knowledge of Pediatric Athletes with Concussion (BAKPAC) survey. The BAKPAC was comprised of several 4-point Likert-scale and closed-ended items to explore SAs' perceptions of their role in and current implementation of AA following concussion. Separate survey versions were tailored to superintendents (BAKPAC-SP) and principals (BAKPAC-PR). **Main Outcome Measures:** Dependent variables were participants' responses to 9 Likert-scale items (ie, higher scores indicated stronger agreement with perceived role in implementing AA) and items regarding AA implementation

and personnel involved. Descriptive statistics were calculated to describe perceptions and implementation of AA, while Mann Whitney U and Chi-Square tests ($P < .05$) were used to identify group differences. Item responses were not required; therefore, total responses are reported. **Results:** Overall, SAs agreed-to-strongly agreed (3.8/4.0 ± 0.43) a concussion could affect school performance. Following concussion, 64.0% (326/509) of SAs reported AA were provided, 19.8% (101/509) were unsure, and 16.1% (82/509) reported AA were not provided. More SAwAT (73.3%, 239/326) reported AA were provided to student-athletes following concussion than SAwoAT (26.7%, 87/326) ($\chi^2_2 = 18.23$, $N = 509$, $P < .001$). More SAwAT reported having an established academic team (78.7%, 185/235) than SAwoAT (21.3%, 50/235) ($\chi^2_1 = 24.363$, $N = 478$, $P < .001$). Most commonly identified personnel involved in the academic team included: parent (38.5%, 205/532), teacher (37.6%, 200/532), and principal (37.0%, 197/532). Coaches (28.4%, 151/532) were perceived to be involved in the academic team more often than ATs (24.4%, 130/532). Regarding AA implementation, SAwAT agreed-to-strongly agreed teachers (3.6/4.0 ± 0.56, $P = .049$) and guidance counselors (3.4/4.0 ± 0.60, $P = .048$) have a role, whereas SAwoAT agreed teachers (3.5/4.0 ± 0.54) and guidance counselors (3.3/4.0 ± 0.63) have a role. Both groups agreed principals (3.5/4.0 ± 0.59, $P = .627$), superintendents (3.0/4.0 ± 0.71, $P = .890$), and ATs (3.0/4.0 ± 0.74, $P = .138$) have a role in AA implementation; however, no differences were found between groups. **Conclusions:** AT employment was associated with more SAs who reported AA provided to student-athletes following concussion and who reported existence of an established academic support team. Athletic trainers were not commonly perceived to be involved in the academic team; therefore, continued communication and relationship building among ATs, SAs, and school professionals is encouraged.

## The Utilization and Effectiveness of Physical and Cognitive Rest Following Concussion: A Systematic Review of the Literature

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**Context:** While the majority of concussion position and consensus statements provide recommendations for physical and cognitive rest, these guidelines are vague and do not provide information on the specifics (eg, timing, duration, type) related to physical and cognitive rest. **Objective:** To systematically review the literature to determine how often rest is utilized by healthcare providers and whether rest reduces the severity and duration of concussion-related impairments. **Data Sources:** An electronic search was conducted in 6 databases including the Cochrane Clinical trials, EBSCO-CINAHL, EBSCO-Sport Discus, Educational Resources Information Center, Ovid – MEDLINE, and PubMed. Search terms included: brain concussion AND -academic accommodations, -cognitive rest, -rest; concuss AND -sports-AND-academic, -sports-AND-rest, -sports-AND-return-to-learn, -sports-AND-return-to-play; mild traumatic brain injury AND -rest, -cognitive rest, -return-to-activity, -return-to-play; recurrent concussion-AND-sport. Hand searches were also performed. **Study Selection:** After removal of duplicates, initial screen of titles and abstracts was completed independently by 3 authors, followed by full text review. A meeting was held to discuss any articles for which consensus on inclusion was not obtained at each step. Articles were included if they were published in English, original research, and evaluated the utilization or effectiveness of physical and/or cognitive rest. Narrative reviews, editorials, critically appraised topics, commentaries, abstracts, animal research and original research that did not address the primary clinical questions were excluded. **Data Extraction:** The initial search yielded 2851 articles, with 1239 undergoing title/abstract screen. Full-text review was completed for 143 articles with 19 meeting study criteria and included. Study design, patient, participant, subject sample, instrumentation and/or interventions utilized, outcome measures, main results, and conclusions were extracted, as appropriate. A Standard data collection form was used. Strength of recommendation (SOR) as outlined by the Oxford Centre for Evidence-Based Medicine was assigned to the body of literature. **Data Synthesis:** Articles were categorized based on their ability to answer one of the clinical questions of interest and the conclusions were summarized using a qualitative synthesis of the findings. Data were not appropriate for meta-analysis due to the observational nature of many included studies and heterogeneity of the patients, participants, interventions and outcomes. **Conclusions:** The review identified that physical and cognitive rest are underutilized by healthcare providers (SOR = B) and that moderate physical and cognitive rest may facilitate recovery during the initial days after concussion (SOR=B). However, the evidence regarding the best approach to rest is mixed and inconclusive. High quality, prospective studies evaluating the influence of rest, early light exercise, and other treatment options are needed to provide an evidence-based roadmap for managing sport-related concussion. Until additional research has been published, it is prudent for clinicians to approach concussion management and return-to-activity in a conservative manner that evaluates the clinical presentation as well as the needs of each individual patient.

## Return-to-Learn Following Sport Concussion: A Survey of Current Practice of Athletic Trainers

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**Context:** The management sport concussion (SC) has been historically grounded on consensus-based return-to-play (RTP) guidelines, however, current RTP guidelines are primarily based on physical rest. Recent recommendations have emphasized cognitive rest to supplement RTP guidelines, yet remain based on limited empirical data. Due to the increased emphasis, Certified Athletic Trainers (ATs) have been tasked with facilitating cognitive rest for concussed student-athletes. **Objective:** To investigate the clinical practice of secondary school and collegiate ATs in terms of return-to-learn (RTL) concepts following a SC. **Design:** Cross-sectional, survey based. **Setting:** Online. **Patients or Other Participants:** Participants consisted of 729 (67.3%) secondary school and 354 (32.7%) collegiate ATs. **Interventions:** A random sample of (10%) from the National Athletic Trainers' Association (NATA) Membership database (n = 4,000) were invited to participate in the current study via email. Participants were randomly selected to equally represent each NATA District and state. Respondents were allotted six weeks to complete the survey instrument via SurveyMonkey™. **Main Outcome Measures:** Four domains consisting of RTL (1) current knowledge, (2) current practice, (3) available resources, and (4) demographics were assessed using descriptive statistics. **Results:** Our overall response rate was 27% (1,083/4,000). The majority of high school ATs worked full time at a public high school as a head athletic trainer (84.9%). Collegiate respondents were primarily head (43.2%) or assistant (41.2%) ATs. In terms of knowledge, approximately 41.2% of total respondents correctly indicated the absence of evidence-based guidelines for RTL. Additionally, 14.7% of respondents felt that ATs were not allowed to recommend academic accommodations during the recovery from SC. In terms of current practice, 73.9% of total respondents identified having an established RTL policy. Interestingly, a greater proportion of secondary school ATs (77.9%) reported having an established RTL policy compared to collegiate ATs (65.5%). Although 92.0% of total surveyed respondents were aware of the NCAA RTL guidelines, only 38% reported employing them in their clinical practice. In regards to resources, the majority of ATs at the high school (97.1%) and collegiate (82.2%) setting had access to a mental health professional(s) (e.g. school counselor or disability resource office). Despite their availability, 21.4% of high school and 37.0% of collegiate ATs reported never accessing these resource(s) to care for concussed student-athletes. **Conclusions:** Our results identified variations in the implementation of RTL policies and cognitive recovery following SC at the high school and collegiate level of sport. These data suggest that despite the absence of empirical evidence, the majority of surveyed ATs, regardless of practice setting, have some form of cognitive rest in their concussion management protocol.

# Free Communications, Rapid Fire Oral Presentations: The PROs of Patient Reported Outcomes

Saturday, June 25, 2016, 3:15PM-4:30PM, Room 317; Moderator: Megan Houston, PhD, ATC

### Commonly Used Patient-Reported Outcome Measures in Athletic Training

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**Context:** Although patient-reported outcome measures (PROMs) are important for patient-centered care and establishing patient-oriented evidence, most athletic trainers (ATs) struggle to incorporate these tools into clinical practice and research. An understanding of common PROMs successfully implemented by ATs who use PROMs (AT-USE) and reasons for disuse by ATs who do not use PROMs (AT-DIS) may help guide educational and research efforts to improve PROM usage by ATs. Objective: To identify commonly used PROMs by AT-USE and describe reasons for disuse by AT-DIS. **Design:** Survey. **Setting:** Online survey. **Patients or Other Participants:** A convenience sample of ATs who worked in the high school, college/university, clinic/hospital, industrial, and military/government settings were surveyed. **Interventions:** Participants completed an electronic survey that was developed by PROM experts and validated prior to release. The 58-item survey was split into two question sets. AT-USE were asked to identify PROMs they use (generic, single-item, region-specific) and completed 10 Likert-style questions regarding PROM selection criteria. AT-DIS were asked to complete 19 Likert-style questions about their reasons for not using PROMs. **Main Outcome Measures:** Dependent variables were the endorsements of questions. Endorsements were confirmed when a rating of "agree" or "strongly agree" was selected by participants. Data are reported as percentage endorsed (%). **Results:** Of the 1077 individuals who accessed the survey, 827 completed the survey (completion rate = 76.8%; age = 35.7 ± 10.5 years; female = 56%; years certified = 46% 6-20 years; college/university setting = 41%) and were classified as AT-USE (20.9%) or AT-DIS (79.1%). Most AT-USE reported incorporating generic (52.8%), single-item (66.1%) and region-specific (87.4%) PROMs into practice for the knee (62.6%), foot/ankle (54.6%), and shoulder/elbow (54.6%). The most frequently used PROMs were the Numeric Pain Rating Scale (48.9%), Lower Extremity Functional Scale (35.6%), Disability of the Arm, Shoulder, and Hand (33.3%), Foot and Ankle Ability Measure (23.6%), and Global Rating of Change (21.3%). AT-USE reported that the most important criteria for selecting PROMs were that the measure was: easy for patients to understand (97.7%), valid and reliable (95.9%), appropriate for the conditions treated (88.3%), easy for clinicians to understand and interpret (86.6%), and able to be completed quickly (86.0%). The common reasons cited by AT-DIS for PROM disuse were: inadequate clinic support or structure (47.4%), patient completion time too great (46.1%), clinician scoring and interpretation time too great (45.7%), questions irrelevant to patients (25.8%), low benefit-to-effort ratio (25.5%), and scores difficult to interpret (25.1%). **Conclusions:** Our findings indicate that most ATs do not use PROMs, with time constraints being a primary barrier. AT-USE generally utilize single-item and region-specific measures that tend to capture changes in pain and function. Continuing education efforts should identify strategies to overcome time constraint issues. Development of PROMs relevant to high functioning patients may be needed to consider these factors.

### Influence of History of Shoulder Injury on Perceived and Demonstrable Physical Capability

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**Context:** To account for both a patient's perceived and demonstrable ability to perform sport-specific activities (physical capability), subjective and objective measures of physical capability have been developed to determine the degree of impairment following injury. The clinical goal of returning the individual to pre-injured activity level cannot be definitively confirmed as no pre-injured information exists thus, decisions to cease treatment and/or return a patient to activity is limited. **Objective:** To compare perceived and demonstrable physical capability between athletes with and without a recent history of shoulder injury (past 12 months) prior to an athletic season. We hypothesized that a history of injury would negatively affect all measures. **Design:** Cross sectional study **Setting:** Pre-participation physical examinations at physician offices and athletic facilities. **Patients or Other Participants:** 299 collegiate athletes (age: 18 ± 2 years, height: 177 ± 10cm, weight: 75 ± 13kg, male: 178, female: 121). **Interventions:** Participants were administered a history of injury questionnaire along with the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC) and performed the closed kinetic chain upper extremity stability test (CKCUEST) after receiving medical clearance to participate in their sport. **Main Outcome Measures:** Differences in KJOC score between athletes with and without a history of shoulder injury in the past 12 months and differences CKCUEST performance. Median values and range of scores are reported from non-parametric analyses. Sexes were

analyzed separately due to previously reported strength differences. **Results:** 8 females reported shoulder injury in the past 12 months and perceived their level of physical capability via the KJOC (66, range 24-100) to be significantly lower than the 113 females (99, range 43-100) with no shoulder injury ($p = .01$). 14 males reported previous shoulder injury and perceived their level of physical capability (66, range 55-100) to be lower than the 164 males (99, range 50-100) with no shoulder injury ($p < .001$). There were no differences in CKCUEST performance between athletes with or without a recent shoulder injury in either sex (females: injured = 19 touches, range: 16-29 vs. uninjured = 20 touches, range: 12-30, $p = .58$; males: injured = 24 touches, range: 20-32 vs. uninjured = 25 touches, range: 16-34, $p = .98$). **Conclusions:** Although all athletes were medically qualified to participate in their respective sport, those athletes with a recent shoulder injury had a perception of physical capability which was less than optimal. While history of shoulder injury negatively impacted self-perceived capability to perform in sport, physical performance of the CKCUEST was not affected by the previous injury. This suggests that patient perception of physical capability is more sensitive than objective performance of tasks which highlights the importance placed on patient opinion. Capturing patient self-reported information may help facilitate monitoring or intervention prior to the start of the competitive season to overcome self-perceived deficits in physical capability.

## The Relationship of Three Generic Patient Reported Outcomes in Physically Active Patients With Lower Extremity Injury

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**Context:** It is essential to capture the patient's values, experiences, and perspectives when providing patient care to assess the impact of musculoskeletal injury on health-related quality of life (HRQOL) and to determine treatment effectiveness from the patient's perspective. Generic patient-reported outcome instruments (PROs) are tools designed to capture HRQOL outcomes and contribute to the development of patient-oriented evidence. At this time multiple generic PROs are used in clinical practice, and the identification of one instrument to utilize consistently with all patients could enhance the generalizability of patient-oriented evidence. **Objective:** To determine the relationship between three generic PROs: the modified Disablement in the Physically Active Scale (mDPA), the PROMIS Bank v.1.2-Physical Function (PROMIS), and the Short-Form 12 (SF-12) in physically active patients seeking treatment for a lower extremity health condition. **Design:** Cross-sectional. **Setting:** Healthcare clinics. **Patients or Other Participants:** A total of 45 patients (age = 21 ± 2.7 years, height = 70.0 ± 3.1cms, weight = 79.2 ± 18.0kgs) participated. Patients were included if they self-reported participation in >90 minutes of physical activity per week and were seeking treatment for a lower extremity health condition. **Interventions:** Following consent, the patients completed one demographic questionnaire and the three generic PROs, which were collected electronically. **Main Outcome Measures:** The mDPA is comprised of two summary components, the mDPA-Mental and mDPA-Physical; higher scores represent greater disability and decreased HRQOL. The SF-12 is comprised of two composite scores, the SF-12 Mental (SF-12MCS) and SF-12 Physical (SF-12PCS). The PROMIS is a computer adaptive test that selects questions based on the patient's previous responses. The SF-12 subscales and PROMIS are scored using a norm-based algorithm with a population mean of 50; lower scores indicate decreased HRQOL. The dependent variables were scores on the mDPA-Mental, mDPA-Physical, SF-12MCS, SF-12PCS and the PROMIS. Separate Spearman's rank correlations (r) and the coefficient of determination (r2) were performed to determine the relationship between all PROs. Alpha was set a-priori $p < 0.05$. **Results:** Moderate-to-strong, significant correlations were identified between the PROMIS and all other scales (SF-12 PCS: $r = 0.750$, $r2 = 0.563$; SF-12 Mental: $r = 0.593$, $r2 = 0.352$; DPA-Mental: $r = -0.586$, $r2 = 0.343$; and DPA-Physical: $r = -0.766$, $r2 = 0.587$). Moderate-to-strong, significant correlations were also identified between the DPA-Mental and all other subscales (SF-12 PCS: $r = -0.557$, $r2 = 0.310$; SF-12 MCS: $r = -0.555$, $r2 = 0.308$; and DPA-Physical: $r = 0.465$, $r2 = 0.216$). Finally, a strong significant correlation was identified between the DPA-Physical and the SF-12 PCS ($r = -0.686$, $r2 = 0.471$) but not for the SF-12 MCS ($r = -0.307$, $r2 = 0.094$). **Conclusions:** When measuring physical function the PROMIS, mDPA and SF-12 subscales are strongly correlated. However, the PROMIS was also moderately correlated with the SF-12 Mental and DPA-Mental suggesting this instrument provided the most comprehensive assessment of function in this study. Overall, these results demonstrate each instrument is useful in physically active adults with lower extremity injuries and are measuring similar constructs. To determine which instrument should be used in physically active populations, clinicians and researchers should explore the psychometric properties, responsiveness and patient acceptability before selecting one instrument for use across all patients.

## Minimal Clinically Important Differences for the Knee Injury and Osteoarthritis Outcomes Score (KOOS) Among Knee Surgical Patients

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**Context:** The Knee Injury and Osteoarthritis Outcomes Score (KOOS) has become a commonly used patient reported outcome measure for a variety of knee pathologies. Minimal clinically important difference (MCID) values for the KOOS have been suggested to be between 8 and 10 points, largely based on expert opinion or MCID values for other patient reported outcome measures. However, these values have not been well investigated among a variety of knee surgical patients. **Objective:** Our purpose was to determine MCID values for the KOOS among knee surgical patients. **Design:** Retrospective Case-Series **Setting:** Outpatient Sports Medicine Clinic Patient Outcomes Registry **Patients or Other Participants:** Data for 148 patients (59 male, 89 female; mean age = 30 ± 12 yrs; mean time since surgery = 1.3 ± 0.5 years.) with preoperative KOOS scores and a minimum of 1-year follow-up from orthopaedic knee surgery to address ligament (n = 35), meniscus (n = 21), articular cartilage (n = 83), and patellofemoral pathologies (n = 91). **Interventions:** All patients were enrolled prospectively into an ongoing patient outcomes database and completed patient reported outcome measures, including the KOOS, pre-operatively and annually following knee surgery. Additionally, at follow-up patients also completed a 15 point Global Rating of Change (GROC). **Main Outcome Measures:** Those patients reporting a GROC score of 4 ("moderately better") or better were considered to have experienced a meaningful improvement. For each patient a pre-post change score was calculated for each KOOS subscale. MCID values were identified using receiver-operator characteristic (ROC) curves of the sensitivity and 1-specificity of the KOOS change scores for predicting a meaningful improvement on the GROC. The pre-post KOOS change scores with the highest combined sensitivity and specificity were identified as the MCID values. **Results:** The Area-Under-the-Curve (AUC) was significantly greater than 0.5 ($p < .05$) for all ROCs. The MCID for the KOOS Symptoms subscale was 9 (AUC = 0.68, $p < 0.001$; sensitivity = 0.87, specificity = 0.45). The MCID for the KOOS Pain subscale was 13 (AUC = 0.70, $p < 0.001$; sensitivity = 0.72, specificity = 0.59). The MCID for the KOOS Activities of Daily Living subscale was 18 (AUC = 0.70, $p < 0.001$; sensitivity = 0.62, specificity = 0.70). The MCID for the KOOS Sports & Recreation subscale was 23 (AUC = 0.69, $p < 0.001$; sensitivity = 0.79, specificity = 0.54), and the MCID for the KOOS Quality of Life subscale was 22 (AUC = 0.75, $p < 0.001$; sensitivity = 0.74, specificity = 0.68). **Conclusions:** With the exception of the KOOS Symptom subscale, the MCID values presented here exceed the 8-10 point range previously proposed for the KOOS on the basis of expert opinion. Specifically, the present investigation demonstrates that knee surgical patients may require large improvements in pain and sports and recreation related knee function in order to perceive a moderate improvement in overall knee function following ligament, meniscal, articular cartilage, or patellofemoral related knee surgery. Future investigations should explore KOOS MCID values in specific patient populations (age, activity-level, pathology, etc.).

## Relationship Between Subjective and Clinical Measures of Knee Function in Patients After Anterior Cruciate Ligament Reconstruction

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**Context:** Joint injury and surgical reconstruction, particularly of the ACL, increases the risk of post-traumatic osteoarthritis (PTOA). While radiographic evidence of PTOA appears 10-15 years post-injury, clinical symptoms may not clearly align with imaging results. Thus, it's important to determine the association between objective clinical measures of knee function and patient-reported symptoms to gain a comprehensive understanding of function in these individuals. This may allow for enhanced identification of PTOA, which may lead to better treatment options and the possibility of targeted prevention for those classified as high-risk. **Objective:** Investigate relationships between patient-reported measures and objective clinical measures of knee function among individuals with a history of ACL reconstruction. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four physically active individuals (13M, 11F, age: 26.5 ± 7.2 years, mass: 78.1 ± 16.4kg, height: 173.7 ± 9.6cm) with a history of a single, unilateral ACL reconstruction (8.1 ± 1.4years since surgery). **Interventions:** Participants completed two patient-reported outcome questionnaires: Knee Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee Subjective Knee Form (IKDC), as well as the Tegner Activity Scale. An isokinetic dynamometer was used to assess bilateral quadriceps and hamstring strength during concentric and eccentric contractions at 60 and 180°/s. Anterior knee laxity (LAX) was measured bilaterally using a knee arthrometer at three loads (67, 89, and 133N). Knee function was assessed bilaterally via a single-hop for distance

(SH) and triple-hop for distance (TH). **Main Outcome Measures:** Each subjective measure (IKDC, KOOS total and subscales, Tegner) was scored according to published guidelines. Peak torques were assessed and normalized to body weight (Nmkg-1). The longest distance recorded for each hop test was used for analysis. The average LAX across three trials was calculated for each leg, then difference in laxity (involved-uninvolved) was calculated. Limb symmetry indices (LSI's) were calculated as (involved leg/uninvolved leg) for all strength and hop tests. Pearson-product correlations were calculated between each clinical measure (difference in laxity, strength LSIs, hop test LSIs) and each subjective measure (IKDC, KOOS total and subscales, Tegner) to assess for relationships between variables ($\alpha \leq 0.05$). **Results:** Our results yielded one significant relationship between Laxity@67N and the KOOS Sport/Recreation subscale (LAX67N = 1.8 ± 1.7mm, KOOSsport/rec = 87.1 ± 10.7, r = 0.41, p = 0.05). Otherwise, no other significant correlations between subjective and clinical measures of knee function were found. **Conclusions:** One significant relationship was discovered between laxity @67N and KOOSsport/rec subscore, suggesting that individuals with a higher KOOSsport/rec score may be more physically active and may place greater strain on the graft. Subjective and objective measures appear to be unique and measure different constructs and both should be used during patient assessment to obtain a comprehensive evaluation of function. Further research should examine older participants as well as those with moderate-to-advanced PTOA to better understand any relationship between objective clinical measures and subjective reports of function.

## Recovery of Psychological Readiness May Differ Between Genders Following ACL Reconstruction in Adolescent Athletes

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**Context:** Injury to the anterior cruciate ligament (ACL) is a traumatic event that can generate an emotional response in adolescent athletes. Equally emotional is the preparation to return to sport (RTS) and the potential risk of re-injury. These psychological factors have been identified as possible limiting factor to a successful rehabilitation. Understanding if adolescent male and female athletes have similar psychological recovery courses would be beneficial for clinical care. **Objective:** To determine if clinical outcomes of subjective knee function and psychological readiness differ between genders following ACL reconstruction surgery in adolescent athletes. **Design:** Retrospective review. **Setting:** Outpatient clinic. **Patients or Other Participants:** A total of 45 adolescent athletes (23 females) who underwent ACL reconstruction surgery, completed clinical measures at their six-month follow-up appointment and successfully returned back to unrestricted sport were included in this analysis. No significant differences were found between males and females for age (16.2 ± 1.5 years, 16.3 ± 2.2 years) and average RTS timing (7.3 ± 2.0 month, 7.3 ± 1.8 months). **Interventions: Main Outcome Measures:** Subjective knee function was assessed with the validated International Knee Documentation Committee (IKDC) Subjective Form. Psychological readiness was assessed with the validated ACL-Return to Sport after Injury (ACL-RSI) scale. Formal clearance to resume unrestricted sport was obtained from clinic notes. A mixed effects random intercept regression model with type III effects was used to determine both the differences between the gender groups as well as the association between scores and return to play. **Results:** No significant difference was found between IKDC scores for male (88 ± 10) and female (87 ± 10) athletes. A trend was identified that female athletes demonstrated lower ACL-RSI scores (males 81 ± 14, females 72 ± 17, P = .063). A statistical difference was found between gender, clinical outcome score, and RTS timing. In females, higher ACL-RSI scores (P = .002, $\beta$ = -0.06) and higher IKDC scores (P = .013, $\beta$ = -0.09) were associated with an earlier RTS. This association was not found in male athletes. **Conclusions:** Although both male and female adolescent athletes felt their knee would function well during sport, the results of this study suggest there may be differences in psychological readiness between genders. Adolescent male athletes demonstrated an overall stronger psychological readiness to return to sport at six-months following ACL reconstruction; however an association was not found between clinical outcomes scores and RTS timing. Conversely, better scores on the ACL-RSI and IKDC were associated with an earlier return to sport in adolescent female athletes. Further investigations are warranted to investigate the psychological hurdles that face each gender when trying to return to sport following ACL reconstruction in order to create beneficial rehabilitation models.

## Functional and Psychological Readiness Outcomes Can Help Predict Return to Sport Following ACL Reconstruction in Adolescent Athletes

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**Context:** Sports medicine providers use an assortment of objective and subjective clinical measures to help determine when an athlete is safe to return to sport (RTS) following after ACL reconstruction surgery. A better understanding of the utility of these clinical measures in an adolescent population would be beneficial for clinical care. **Objective:** To determine if functional outcomes and psychological readiness were associated with timing of RTS following ACL reconstruction surgery in adolescent athletes. **Design:** Retrospective review. **Setting:** Outpatient clinic. **Patients or Other Participants:** A total of 37 adolescent athletes who underwent ACL reconstruction surgery (20 males, average age 15.9 ± 1.9 years, 37 hamstring grafts) and completed clinical measures at their 6 month follow-up appointment were included. **Main Outcome Measures:** Clinical measures included functional outcomes of strength measured by isometric knee-flexion/extension peak torque deficits between the surgical and contralateral knee, performed at 60° of knee flexion, and the pediatric International Knee Documentation Committee (Pedi-IKDC) Subjective Form. Psychological readiness was assessed with the validated ACL-Return to Sport after Injury (ACL-RSI) scale. The associations between the subjective measures and isokinetic strength and return to play time were analyzed using a mixed effects random intercept linear regression model. Associations with a p-value of 0.05 or less were considered statistically significant. **Results:** Patients returned back to sport an average of 7.2 ± 1.9 months after surgery. A significant association was found between isometric extension peak torque deficits and Pedi-IKCD scores (P = .004) and ACL-RSI scores (P < .001). Patients with a deficit of greater than 20% had significantly lower Pedi-IKDC scores (67.2 ± 12.4) and ACL-RSI scores (49.1 ± 12.6) than patients with a deficit of 10-20% (Pedi-IKDC score 89.3 + 8.7, ACL-RSI score 75.5 ± 14.3) and those patients with a deficit less than 10% (Pedi-IKDC score 86.5 ± 15.6, ACL-RSI score 80.4 ± 17.3). No significant association was found between isometric flexion peak torque deficits and subjective scores. A significant association was found between RTS and Pedi-IKDC scores (P = .007) and ACL-RSI scores (P = .02). Patients with a Pedi-IKDC score of less than 80 had a significantly longer time until RTS (9.6 ± 1.9 months) than patients with a score between 80-90 (7.2 ± 1.6 months) and a score greater than 90 (6.4 ± 1.4 months). Patients with an ACL-RSI score of less than 70 had a significantly longer time until RTS (8.4 ± 1.8 months) than patients with a score of 70 or greater (6.7 ± 1.7 months). No significant association was found between RTS and isometric knee-flexion/extension peak torque deficits (P = .72, P = .07). **Conclusion:** Although restoration of lower extremity strength is needed for an athlete to safely return back to sports, subjective outcomes of knee function and psychological readiness may be more helpful in predicting RTS timing after ACL reconstruction in adolescent patients. At the conclusion of the program, participants will be able to summarize the importance of using not only objective but also subjective clinical information was assessing an adolescent athlete's ability to return to sport after ACL reconstruction surgery.

## Effects of Rehabilitation Attendance on Three Month Patient Reported Outcome Measures in Articular Cartilage Restoration Patients

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**Context:** Articular cartilage restoration patients have a unique long-term post-surgical rehabilitation. During rehabilitation there is a necessary balance between allowing the restoration heal while loading the joint. The first 3 months post surgery are critical due to weight bearing progression, achievement of full ROM, and protection of the graft. However, healthcare providers are frequently faced with inconsistent rehabilitation attendance within this patient population. Differences in patients' self-report of recovery may explain this inconsistency in rehabilitation compliance, particularly variations in attendance to prescribed rehabilitation among articular cartilage patients. **Objective:** To assess if there is a difference in patient reported outcome measures (PROMs) between a high physical therapy attendance group and a low physical therapy attendance group. We hypothesized that the group with lower attendance would have higher PROMs 3-months post-surgery because patients who report being better able to perform activities of daily living would be less likely to attend therapy. **Design:** Prospective longitudinal. **Setting:** Outpatient physical therapy clinics. **Patients or Other Participants:** Fifteen patients undergoing articular cartilage restoration (Males = 6 Females = 9, Age 27 + 10 yrs, BMI 28.94 + 6.12) were enrolled in the study. Defects were located on the lateral femoral condyle (n = 6), medial femoral condyle (n = 7), patellofemoral joint (n = 1), or multiple (n = 1). Surgical procedures performed were osteochondral allograft

transplantation (n = 9), autologous chondrocyte implantation (n = 5), and particulated juvenile cartilage implantation (n = 1). **Interventions:** Physical therapy information was collected during each patient's, first post-operative appointment with the treating physician. Physical therapy clinics were contacted and provided with a standard intake form to document attendance biweekly. Patient attendance was categorized as high attendance or low attendance. Low attendance was defined as failure to attend past 1 month post-surgery and high attendance was designated as continuing therapy beyond 1 month post-surgery. **Main Outcome Measures:** Patients completed the International Knee Documentation Committee Subjective Knee Form (IKDC), Knee Injury and Osteoarthritis Outcomes Score (KOOS), and a pain Visual Analog Scale (VAS) at 3 months post-operative. Independent t-tests were used to compare PROM scores between groups. Change scores (post-operative–pre-operative) were calculated for each PRO to determine minimal detectable change (MDC) and minimally clinically important difference (MCID). **Results:** No statistical differences ($p > 0.05$) were found between the low-attendance (<1month) (n = 7) and the high-attendance (>1month) (n = 8) groups for any dependent variable. The results were as follows <1month mean + SD, >1month mean + SD: KOOS symptoms 59 + 28, 56 + 17; KOOS pain 74 + 25, 70 + 23; KOOSADL 83 + 27, 73 + 24; KOOS SportRec 36 + 34, 31 + 40; KOOSQOL 38 + 18, 38 + 22; IKDC 49 + 20, 41 + 17; VAS 4.38 + 3.63, 3.78 + 3.32, respectively. **Conclusions:** The lack of statistical significance suggests that at 3months post-operative all patients had similar PROMs regardless of therapy attendance. However, while not statistically significant the difference in group means for the KOOSADL did exceed both the MDC and the MCID. Therefore, while statistical differences were not found, clinical differences in activities of daily living may be present between patients with low-attendance and those with high-attendance.

## Functional Performance and Self-Reported Function Among Competitive Male Collegiate Basketball Players With History of Ankle Sprain

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**Context:** Single leg functional performance and self-reported functions have been reported to be diminished in individuals with chronic ankle instability among general population. However, little evidence is available for competitive athletes with such condition. **Objective:** To investigate if functional performance and self-reported function deficits are present in male collegiate basketball players with history of ankle sprain. **Design:** cross-sectional **Setting:** Collegiate athletic training facility. **Patients or Other Participants:** Thirty individuals with history of at least one ankle sprain within the previous year (Sprain) (height = 181.5 ± 7.9 cm, mass = 74.7 ± 9.6 kg, age = 19.5 ± 1.2 years), 25 individuals with a history of ankle sprain but not within the previous year (Coper) (height = 179 ± 7.9 cm, mass = 73.3 ± 5.8 kg, age = 19.7 ± 1.3 years), and 40 control individuals without a history of ankle sprain (Control) (height = 179 ± 9.0 cm, mass = 72.4 ± 8.6 kg, age = 18.9 ± 3.7 years) participated in the study. **Interventions:** Subjects performed two single leg functional performance tests of Square hop test (SQ) and Side Hop test (SH). **Main Outcome Measures:** The means of 2 trials for SQ and SH were recorded (in seconds). Subjects also filled out the ADL and Sports subscales of the FAAM (FAAM ADL and FAAM SP). One-way factorial ANOVA was performed with Turkey's post hoc analysis for both measures. Alpha for all analyses was set at $p < .05$. **Results:** We found no significant difference among the groups for SQ (Sprain = 12.7 ± 2.8, Coper = 12.4 ± 2.0, Control = 12.6 ± 1.7, p = .89) or SH (Sprain = 7.1 ± 1.5, Coper = 6.9 ± 1.0, Control = 7.0 ± .9, p = .84). On the other hand, we found significant differences among the groups for FAAM ADL (Sprain = 98.1 ± 4.0%, Coper = 99.7 ± 1.4%, Control = 99.6 ± 1.3%, p = .03) and FAAM SP (Sprain = 93.8 ± 12.1%, Coper = 99.1 ± 2.5%, Control = 99.1 ± 3.8%, p = .01). Sprain group had significantly lower FAAM SP scores than Coper and control groups ($p > .05$). Post hoc analysis did not reach a significant level for the FAAM ADL. **Conclusions:** Male collegiate basketball players with a recent history of ankle sprain have significantly lower sports-related self-reported functions but not single leg functional performance deficits.

## Impact of Previous Ankle Sprain on Ankle Function and Quality of Life in Adolescent Athletes

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**Context:** Ankle sprain injuries are the most common injury that occurs in adolescent sports. The immediate (short-term) disablement associated with an ankle sprain is well known. However, the long term impact that ankle sprains have on ankle function and quality of life of active adolescent athletes has not been widely reported. **Objective:** To determine the impact that a previous ankle sprain has on ankle function, functional ankle instability and quality of life in healthy adolescent athletes. **Design:** Cross sectional study. **Setting:** Data were collected during the summer of 2015 at a series of schools, camps and club team competitions **Patients or Other Participants:** A convenience sample of N = 1,002 healthy (able to fully participate) adolescent athletes (females = 51%, males = 49%; age = 15.6 + 1.6 yrs.). **Interventions:** Subjects completed a survey (paper, in-person) consisting of validated self-report measures that included the Foot and Ankle Ability Measure (FAAM), Foot and Ankle Ability Measure-Sport (FAAM-Sport), Identification of Functional Ankle Instability (IdFAI), and The Pediatric Quality of Life 4.0 (PedsQL). Subjects also answered questions regarding whether they had sustained any ankle sprain injuries that caused them to seek medical attention and miss time from their sport. **Main Outcome Measures:** The dependent variable included history of previous ankle sprain (PAS). Outcomes scores were compared between subjects with PAS and subjects with no history of ankle sprain (NoPAS). Wilcoxon Rank Sum tests were used to compare the (median, [25th, 75t IQR]) FAAM and FAAM-Sport. T-tests were used to compare the (Mean + SD) PedsQL Psychosocial and Physical Health summary and Total PedsQL scores. All differences were assessed with $p < 0.05$. **Results:** Two hundred sixty three subjects (26%) sustained an injury to one (n = 218, 22%) or both (n = 44, 4%) ankles. The time since the PAS occurrence was 18.1 + 15.3 months. Functional ankle instability (IdFAI score >11) was reported by the PAS subjects in one (n = 208, 94%) or both (n = 29, 65%,) ankles. Subjects with PAS had lower ($p < 0.001$) scores for the FAAM (PAS = 96.4 [83.6,100], NoPAS = 100 [100,100] and FAAM-Sport (PAS = 90.6 [75.5.,100], NoPAS = 100 [100,100]. There was no difference ($p = 0.201$) in the PedsQL psychosocial summary score (PAS = 91.8 + 10.7, NoPAS = 90.7 + 11.8). Subjects with PAS had lower ($p < 0.001$) scores for the PedsQL physical health summary (PAS = 88.8 + 14.5, NoPAS = 94.8 + 8.1) and lower ($p < 0.001$) total PedsQL score (PAS = 90.1 + 10.7, NoPAS = 92.8 + 8.9). **Conclusions:** Ankle sprain injuries cause significant long term negative impacts (high prevalence of ankle instability, lower ankle function and quality of life) in adolescent athletes. Sports medicine professionals need to recognize the long term consequences of ankle sprains to advocate for widespread implementation of injury prevention methods in adolescent athletes.

## Patient Reported Outcomes Over the Course of a Competitive Basketball Season in Participants With and Without a Previous Knee Injury History

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**Context:** Athletes who participate in sports with rapid acceleration and deceleration movements, and high impact biomechanical forces are at an increased risk for developing osteoarthritis (OA). Furthermore, prior joint injury is also a recognized risk factor for knee OA. While sport participation and joint injury are separate risk factors, the combination of the two determinants may further confound OA development and progression. Patient reported outcomes (PRO) utilization can potentially identify early symptoms prior to OA development. There is limited research in the sports medicine field regarding prospective PROs, specifically in athletes who have sustained a previous joint injury and have returned to continuous high impact sports. **Objective:** To examine knee PROs over a competitive basketball season, and to compare PROs between basketball athletes with a knee injury history (INJ) versus no previous injury (CON). **Design:** Prospective Cohort Study. **Setting:** Division II University **Patients or Other Participants:** Twenty-nine NCAA Division II men's and women's basketball players between the ages of 18 to 24 participated in the study. INJ participants (n = 10; M = 3/F = 7) self-reported a history of a significant knee injury, and CON participants (n = 19; M = 10/F = 9) denied any significant knee injury history. **Interventions:** The independent variables were knee injury history (INJ vs CON). Participants completed the Knee Osteoarthritis Outcome Score (KOOS) on a biweekly basis throughout the season. The primary aims were analyzed using separate 2 (group) x 8 (time) analysis

of variance (ANOVA) with repeated measures for time, as well as multiple independent t-tests. A priori statistical significance was defined as $P < 0.05$. **Main Outcome Measures:** Dependent variables were PRO scores in the 5 KOOS subscales (pain, activities of daily living [ADL] function, symptoms, sports and recreation function, and knee related quality of life [QOL]) at 8 biweekly time points during the season,. Covariates that were considered were height, weight, and participation minutes (i.e. practices and games). **Results:** Significant group-by-time interaction effects were found for KOOS sport/recreation ($F4.2,114.4 = 3.326$, $P = 0.011$) and QOL ($F2.9,80.6 = 3.076$, $P = 0.032$). Significant main effects for time were found for KOOS symptoms ($F4.5,122.8 = 2.448$, $P = 0.043$), sport/recreation ($F4.2,114.4 = 6.103$, $P < 0.001$), and QOL ($F2.9,80.6 = 4.767$, $P = 0.004$). INJ participants reported significantly poorer scores for all KOOS subscales (pain:73.1 ± 20.2; symptoms: 63.9 ± 25.9; ADL: 81.6 ± 19.0; sport/recreation: 58.0 ± 24.9; QOL: 56.9 ± 24.8) in comparison to CON participants (pain: 93.7 ± 8.4; symptoms: 90.0 ± 11.7; ADL: 96.7 ± 4.6; sport/recreation: 89.2 ± 11.6; QOL: 89.9 ± 11.3) when competitions started ($P = 0.002$). **Conclusions:** These findings indicate that athletes with a knee injury history are reporting poorer outcome scores at various points over the course of the season. These scores affect them both with basketball activity and with their overall QOL. This may be related to an increased risk for possible OA development. These findings suggest that athletes with a previous knee injury history may benefit from interventions like rest or modified activity to help prolong the health of their knees.

### Perceptions of Athletic Trainers by Interscholastic Student-Athletes

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**Context:** AT public relations programs exist at the national and state levels. Various perceptions about ATs exist and have been studied in a variety of practice settings; however, there is little research available that identifies the perceptions of interscholastic school student-athletes who receive care from an AT. **Objective:** To identify the perceptions of interscholastic student-athletes who receive AT services about the role, qualifications, educational requirements, and responsibilities of ATs. **Design:** A cross-sectional design. **Setting:** Two public interscholastic athletic programs located in Connecticut. **Patients or Other Participants:** Interscholastic athletic participants at two public high schools with at least one season of athletic participation on any level (freshman, junior varsity, or varsity) were recruited. A sample of 160 participants was used; 70 females and 90 males with a mean age of 16.44 (±1.34) years were surveyed. **Interventions:** A survey was designed based on the BOC Practice Analysis and publically accessible NATA public relations documents. The survey was reviewed by two ATs, each with over 15 years of experience, for content and construct validity. The survey was pilot tested on freshman AT students. **Main Outcome Measures:** Descriptive statistics from the survey were utilized to provide quantitative data related to interscholastic student-athletes' perceptions of the role, qualifications, educational requirements, and responsibilities of ATs. **Results:** Participants reported that personal trainers (40%) and physical therapists (70%) were considered analogous to ATs, while a super majority agreed that ATs are healthcare providers (87%). Certification and/licensure (93%) and a bachelor's degree (31%) were considered requirements to qualify to practice as an AT. Participants believed that coursework for an AT included a course in physical therapy (100%), injury assessment (100%), strength and conditioning (94%), emergency care (94%), therapeutic exercise (81%), anatomy and physiology (69%), injury prevention (69%), healthcare administration (69%), therapeutic modalities (50%), biomechanics (50%), and nutrition (44%). Participants reported that practice settings for AT included secondary schools (100%), colleges (93%), professional sports (93%), military (60%), performing arts (47%), physician offices (47%), hospitals (47%), public safety (30%), and industrial settings (20%). Participants believed an AT's responsibility included determine return to play (100%), educate about safety (100%), tape/wrap (93%), evaluate concussions (93%), provide immediate care (93%), review pre-participation screening data (87%), evaluate injuries (87%), document care (53%), perform rehabilitation (47%), monitor environmental conditions (47%), and prevent illnesses (27%). **Conclusions:** While public perception differentiating personal and athletic trainers has improved, there are still misconceptions about the difference between ATs and physical therapists, the qualifications to practice athletic training, educational requirements within AT curricula, and responsibilities of ATs. This study demonstrates the need for improved grassroots education to current patients by individual athletic trainers and improved access to athletic trainers to other interscholastic athletic participants within interscholastic athletic departments already employing ATs.

### Head Impact Characteristics Based on Player Position in Collegiate Soccer Athletes

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**Context:** Previous studies have found differences between player position and head impact frequency in competitive football and hockey. There is a paucity of research on competitive soccer. Soccer game play is the same between the sexes, and therefore offers an interesting comparison of head impacts. **Objective:** To determine the magnitude and frequency of head impacts in National Collegiate Athletic Association (NCAA) Division III soccer athletes based on player position and type of play. **Design:** Descriptive epidemiology study. **Setting:** Soccer fields. **Patients or Other Participants:** Our sample included 13 men's soccer athletes (20 ± 1.1 years old, 180.3 ± 5.6 cm, 74.4 ± 8.6 kg) and 16 women's soccer athletes (20 ± 1.1 years old, 163.7 ± 4.9 cm, 61.2 ± 4.9 kg). **Interventions:** Accelerations of head impacts were recorded by an xPatch Sensor (X2 Biosystems Inc. Seattle, WA) adhered over each participant's right mastoid process during each exposure during the fall 2014 season. Impacts were coded by sex, player position, and type of play (offense, defense, transition). Exposures were filmed to verify impacts. **Main Outcome Measures:** XPatch sensors stored frequency and linear and rotational accelerations of head impacts over 10 g. We calculated incidence rates (IRs) and incidence rate ratios (IRRs) with 95% confidence intervals (CIs) to determine frequency differences. We used ANOVAs to compare the linear and angular accelerations between player position, sex, and type of play. **Results:** Male soccer players had a higher overall incidence rate than

females. Across player position, male and female soccer defenders sustained the most head impacts males IR = 18.9, 95% CI = 16.84-20.83; females IR = 9.64, 95% CI = 8.36-10.92; IRR = 1.95, 95% CI = 1.64-2.31. The least amount of impacts for both sexes was found to be the goalkeeper position males IR = 5.72, 95% CI = 4.35-7.09; females IR = 2.75, 95% CI = 1.60-3.89; IRR = 2.08, 95% CI = 1.20-3.37. Both male and female soccer athletes were most likely to sustain a head impact while engaging in offensive play, male IR = 5.39, 95% CI = 4.90-5.88, however, females were more likely IR = 6.60, 95% CI = 6.06-7.15; IRR = 1.2, 95% CI = 1.08-1.38.We found a non-statistically significant interaction between sex, player position, and type of play for both linear ($F_{5,1701} = .990$, $P = .422$, $\omega^2 < .001$, $1-\beta = .358$) and rotational accelerations ($F_{5,1701} = 1.607$, $P = .155$, $\omega^2 < .001$, $1-\beta = .565$). **Conclusions:** We speculate that differences in impact frequency between the sexes can be attributed to the fact that males are more aggressive and will fight for possession of the ball close to goal. Our results indicate head impact magnitudes between the sexes are similar.

## Relationship Between Navicular Drop and Lower Extremity Kinematics During Functional Tasks Across Sex and Maturation

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**Context:** Previous studies have examined the relationship between excessive pronation and lower extremity joint motion, but have been limited to adult populations. Retrospective studies observed that excessive pronation is related to ACL injuries due to altered movement patterns during dynamic activity. Considering that ACL injuries begin to occur in the maturing youth athlete, there is a need to understand this relationship across sex and maturation stage. **Objective:** To examine the relationship between clinical assessment of pronation and lower extremity kinematics during a jump landing (JL) and a single leg hop (SLH) across sex and maturation in youth soccer players. **Design:** Cross-sectional. **Setting:** Field Setting. **Patients or Other Participants:** One hundred and sixty four (86M, 78F: 11.0 ± 1.9 yrs, 144.7 ± 16.0 cm, 38.7 ± 10.9 kg) youth soccer players participated. **Interventions:** The validated Pubertal Maturation Observation Scale (PMOS) determined maturation stage. Navicular drop (ND) was measured bilaterally by a clinician with known reliability (ICC2, $k > 0.97$). Three-dimensional kinematics were assessed bilaterally using an electromagnetic motion analysis system during a JL and SLH. The JL required participants to jump from a 30cm box set 50% of the their height from a force plate and rebound for maximum vertical height. SLH trials began while standing on one leg, taking a hop 40% of their height forward over a minimum height of 5", and landing on the same leg. **Main Outcome Measures:** Maturation groups: pre-pubertal (44M, 34F: PMOS < 2), pubertal (31M, 27F: PMOS = 2-5), and post-pubertal (11M, 17F: PMOS > 5). ND values were averaged over two measures. Hip and knee peak angles and joint displacements in the frontal and transverse planes during the deceleration phase [peak knee flexion minus initial contact (vGRF ≥ 10N)] of the JL and SLH tasks were averaged over three trials and used for analyses. The mean left and right values were used for analyses. Separate Pearson correlations (r) examined the relationship between ND and joint kinematics during JL and SLH across maturation stages for males and females. **Results:** In pre-pubertal males, ND (8.2 ± 3.8mm) was correlated with peak knee valgus in JL (-11.5 ± 9.0°, $r = 0.412$, $P = 0.006$) and SLH (-9.5 ± 8.0°, $r = 0.402$, $P = 0.007$), and peak knee internal rotation (11.7 ± 11.8°, $r = 0.336$, $P = 0.027$) and displacement (10.2 ± 8.1°, $r = 0.338$, $P = 0.027$) in JL. In pubertal males, ND (6.4 ± 3.7mm) was correlated with hip adduction displacement (14.4 ± 4.5°, $r = 0.404$, $P = 0.033$) in SLH, peak knee internal rotation in JL (2.6 ± 14.6°, $r = 0.414$, $P = 0.032$) and SLH (13.0 ± 12.9°, $r = 0.477$, $P = 0.010$), and peak knee external rotation (-2.8 ± 8.9°, $r = 0.458$, $P = 0.016$) in JL. There were no significant correlations in post-pubertal males or in females. **Conclusions:** In males, ND was associated with frontal and transverse plane knee kinematics across maturation. However, ND was not associated with lower extremity kinematics in female youth athletes. Understanding these relationships is important for identifying risk factors for knee injuries and in developing effective interventions.

## A Comparison of Cooling Times With and Without Football Equipment Following Exercise Induced Hyperthermia

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**Context:** Exertional heat stroke (EHS) is one of the three leading causes of sudden death in sport, however it is 100% survivable when proper recognition and management protocols are implemented. When managing EHS, core body temperature (Tcore) should be lowered to less than 39°F within 30 minutes of collapse and cold water immersion (CWI) is the most effective way to accomplish this. Current protocols recommend removal of all equipment and clothing prior to immersion to enhance cooling. This can be a tedious process and could possibly affect patient morbidity and mortality by causing a delay in cooling. However, comparisons in total cooling time with and without equipment removal have not been assessed. **Objective:** To compare time to immersion and overall cooling times with and without football equipment removal following exercise induced hyperthermia. **Design:** A randomized and counterbalanced cross over design. **Setting:** Research laboratory. **Patients or Other Participants:** Six healthy collegiate football athletes (age = 21.2 ± 0.75 y, height = 187.5 ± 7.08 cm, mass = 106.4 ± 21.5 kg) without a history of diagnosed EHS or any contraindication to CWI participated. **Interventions:** Each participant reported to the laboratory on two occasions separated by seven days. On each occasion they performed a bout of exercise on a stationary cycle in a climate controlled chamber maintained at 35°C while wearing a typical football uniform with full equipment until they achieved a Tcore of 39.5°C. Once the target temperature was achieved, the participants were fully immersed in water maintained at 10°C either with or without the clothing and equipment removed by clinicians until a Tcore of 38.4°C was achieved. The helmet was removed in both conditions to allow for immediate airway access. When the participants returned for the second session, identical procedures were followed using the remaining condition. **Main Outcome Measures:** Tcore was assessed using a rectal thermometer (DataTherm® II Continuous Temperature Monitor) and was used to determine baseline temperature, achievement of target temperatures and to determine cooling rates. The time from exercise target temperature (diagnosis) to immersion, from immersion to cooling target temperature and total times were used to compare cooling times and rates between the two conditions. **Results:** A significant difference ($t5 = 16.32$, $p = .001$) in the time it took to immerse the subjects in the cold tub was observed as it took longer to immerse the subjects during the equipment removal condition (170.87 ± 13.93 s) than during the non-removal condition (63.02 ± 18.84 s). However, no differences were noted when comparing the cooling time ($t5 = .840$, $p = .439$), overall treatment time ($t5 = .516$, $p = .628$) and the cooling rate ($t5 = 1.41$, $p = .217$). **Conclusions:** The results do not suggest the need to change current protocols. However, if there is difficulty in equipment removal, CWI should not be delayed and the patient should be immersed with the equipment on.

### An Intrapelvic Hematoma Resulting From an Iliac Crest Contusion in a 21 year-old Collegiate Football Player: A Case Report

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**Background:** A 21 year-old collegiate male football quarterback with no pertinent medical history complained of moderate left hip pain after being tackled during a game. The patient presented with minimal ecchymosis over an approximate two-inch square superior to the midline of the left iliac crest. After completing a week of treatment, rehabilitation, and a return to play progression, the patient played in the following game. Prior to the game, he was padded for protection. During the second half, he started to feel nauseous as well as extreme pain and tightness in his left lower abdomen. At this point, the original swelling had increased and diffused into the scrotum. The patient did not recall any specific mechanism during this game causing the increase in symptoms. **Differential Diagnosis:** Left external or internal oblique strain, contusion, avulsion fracture from the ileum, iliac crest fracture, iliac crest contusion, splenic injury, or abdominal hematoma. **Treatment:** The patient had negative x-rays for a fracture originally. While sitting out during the second game, he experienced an increase in pain levels, and swelling in the involved side. This resulted in transportation to the emergency department for further evaluation deemed necessary by athletic trainer and team physician. A CT scan with IV contrast, done in the emergency department, revealed a hematoma approximately 11 centimeters in size with release of contrast revealing active bleeding adjacent to the left iliacus muscle. The patient was hospitalized for three days. Ten days after the original CT scan, another CT scan was completed, revealing extension of the hematoma to 13.4 centimeters in size, extending intrapelvically. There was also a defect within the left transversus abdominis and internal oblique musculature that was avulsed from the ilium. Once released from the hospital, the patient received daily treatment in the athletic training facility consisting of ice, pulsed ultrasound, vibration stimulation, pulsed laser, and electrical stimulation. The patient's hemoglobin levels were followed during the course of treatment resulting in one blood transfusion completed during the second week. The patient fully returned to play after one month post-injury. **Uniqueness:** The patient was initially diagnosed with a left iliac crest contusion ("hip pointer"), a common injury after a blow to the iliac crest. The athlete's worsened hematoma was believed to be caused by multiple blows to the involved side during the second game. The rapid deterioration of the patient's status made the situation emergent. **Conclusions:** Athletic trainers evaluate iliac crest contusions in football regularly. It is important to follow up on these injuries because they can be worse than first assumed. An intrapelvic hematoma can worsen to not only limit participation and ADL, but ultimately result in death if not cared for properly with further evaluation and imaging. While the direct cause is unknown, it is hypothesized that the patient's re-aggravation of the oblique wall damage was worsened due to high-level activity and sustained minor blows during the course of the second game. It may be necessary to let these injuries completely resolve and/or investigate them further prior to returning the patient back to a contact sport, rather than risking the possibility of severe complications. Properly padding the injured area could not prevent the deterioration of this injury. During the return to play progression, simulating game-like contacts, especially for a quarterback, could possibly have revealed this injury. There are many muscular attachments on the iliac crest that cannot be overlooked by the athletic trainer during initial evaluations of hip injuries. Ordering an MRI may be of use in the future to evaluate any persistent soft tissue damage. A follow-up CT scan could also be completed if there is any level of concern regarding a muscle herniation.

### The Investigation of Oculomotor and Postural Control Deficits 24-48 Hours Post-Concussion

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**Context:** Oculomotor and postural control deficits both occur in over 30% of concussed athletes. However, little research quantitatively explores oculomotor and postural control deficits collectively post-concussion. **Objective:** To investigate anti-saccades (AS), reflexive gaze deviations away from a fixed area of interest (AOI), and center of pressure peak excursion velocity (CoP) between NCAA Division I athletes 24-48 hours post-concussion (PC) and healthy NCAA Division I athletes (NC) during a dynamic postural control task, the Nintendo WiiFit Soccer Heading game (WS). **Design:** Prospective cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** A convenience sample of 5 PC (2 female, 3 male; age: 19.8 ± 0.8 years) and 5 matched NC (2 female, 3 male; age: 18.5 ± 0.8 years) were recruited for this study. NC were matched to PC based on age, gender, and sport position. **Interventions:** All participants in this study performed 2 trials of the 60-second WS while wearing a monocular eye tracking device (240Hz). While playing the WS, the participants were instructed to not deviate their gaze away from the center AOI while swaying their body in a mediolateral (ML) direction to move their avatar in a similar fashion to head soccer balls coming down the center, left, and right of the screen. No anteroposterior (AP) head movement is necessary to head the soccer balls; the avatar's head just needs to make contact with the soccer balls to head them. The WiiFit board was placed on top of AMTI force plates (1000Hz) to calculate the CoP in both AP and ML directions. **Main Outcome Measures:** One-way ANOVAs were ran to determine significant differences in AS, AS duration, average AS duration, WS CoP AP, and WS CoP ML. **Results:** AS ($p=0.036$) were significantly greater in the PC group (17.9 ± 8.7) when compared to the NC group (6.6 ± 5.5), AS duration ($p=0.020$) was significantly greater in the PC group (12.9 ± 8.7 sec) when compared to the NC group (1.2 ± 1.4 sec), and average AS duration ($p<0.001$) was significantly greater in the PC group (0.47 ± 0.1 sec) when compared to the NC group (0.14 ± 0.06 sec). WS CoP AP ($p=0.475$) was not significantly different in the PC group (3.56±2.88 mm/s) when compared to the NC group (2.54±0.99 mm/s) and WS CoP ML ($p=0.285$ mm/s) was not significantly different in the PC group (1.67±1.76 mm/s) when compared to the NC group (0.75±0.37). **Conclusions:** These results suggest detectable oculomotor control deficits post-concussion in the absence of detectable postural control deficits. These deficits may indicate that PC do not have sufficient gaze stability to adequately navigate through their environment immediately post-injury. Future research needs to track oculomotor control deficits longitudinally and further compare oculomotor control with postural control measures.

### Preliminary Examination of the Validity of the Quick-FAAM in Physically Active Patients With an Acute Foot or Ankle Injury

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**Context:** The Quick-Foot and Ankle Ability Measure (Quick-FAAM) is a 12-item region specific patient reported outcome (PRO) derived from the original Foot and Ankle Ability Measure (FAAM). The Quick-FAAM contains items from both the FAAM-Activities of Daily Living (FAAM-ADL) and FAAM-Sport subscales and was developed to reduce administration and scoring time. The Quick-FAAM has demonstrated excellent internal consistency and a strong correlation to the original FAAM in people with chronic ankle instability. However, the validity of the instrument has yet to be determined in patients seeking treatment for acute foot or ankle conditions. **Objective:** To determine the convergent and divergent validity of the Quick-FAAM in physically active patients seeking treatment for an ankle or foot condition. **Design:** Cross-sectional. **Setting:** Athletic training clinics. **Patients or Other Participants:** Twenty physically active patients (19.9 ± 1.8 years, 69.6 ± 3.6cm, 83.1 ± 24.4kg) seeking treatment for an ankle or foot condition. Interventions: Following consent, the patients completed a demographic questionnaire and electronic administrations of the Quick-FAAM, FAAM-ADL, FAAM-Sport, the modified Disablement in the Physically Active Scale (mDPA) and the Short-Form 12 (SF-12). **Main Outcome Measures:** The Quick-FAAM is a 12-item region-specific PRO that assesses the patients' level of function. It was derived from the original FAAM, which consists of an ADL (21 items) and a Sport (8 items) subscale. For all FAAM measures, lower scores represented decreased HRQL. The SF-12 is comprised of two composite scores, the SF-12 Mental (SF-12MCS) and SF-12 Physical (SF-12PCS). The SF-12

subscales are scored using a norm-based algorithm with a population mean of 50; lower scores indicate decreased HRQL. The mDPA is a 16-item generic PRO with two summary components, the mDPA-Mental and the mDPA-Physical. Higher scores on the DPA represent decreased HRQL. The dependent variables were scores on the Quick-FAAM, FAAM, mDPA-Mental, mDPA-Physical,SF-12MCS, and the SF-12PCS. Separate Spearman's rank correlations (r) and the coefficient of determination (r2) were performed to determine the relationship between the Quick-FAAM and the other PROs. Alpha was set a priori $p < 0.05$. **Results:** The Quick-FAAM demonstrated good convergent validity by exhibiting strong correlations with the SF-12PCS ($r = 0.891$, $r2 = 0.794$, $p < 0.001$), mDPA-Physical ($r = -0.795$, $r2 = -0.632$ , $p < 0.001$), and the FAAM ($r = 0.919$, $r2 = 0.845$, $p < 0.001$) . The Quick-FAAM demonstrated good divergent validity by exhibiting weak correlations with the mDPA-Mental ($r = -0.347$, $r2 = -0.120$, $p = 0.134$) and the SF-12MCS ($r = 0.306$, $r2 = 0.093$, $p = 0.217$). **Conclusions:** When measuring physical function, the Quick-FAAM, SF-12PCS, mDPA-Physical, and the original FAAM were strongly correlated. Additionally, the Quick-FAAM was weakly correlated with the SF-12MCS and mDPA-Mental which suggests that the Quick-FAAM is measuring different constructs. This data provides preliminary evidence that the Quick-FAAM is a valid instrument for physically active adults with an acute ankle or foot condition. Future research is needed to examine the reliability and responsiveness of the Quick-FAAM in this patient population.

### A Randomized Control Trial Investigating the Effects of Three Different 4-Week Ankle Rehabilitation Programs on Hopping Ability in Patients With Chronic Ankle Instability

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**Context:** Various rehabilitation exercises have been used to reduce residual symptoms and decreased function that are associated with Chronic Ankle Instability (CAI). Research has shown that resistance band and wobble board programs are effective; however, utilizing both exercises together has not been evaluated. **Objective:** To determine the effectiveness of three 4-week rehabilitation programs on individuals who suffer from CAI. **Setting:** Research Laboratory **Patients or Other Participants:** Thirty-seven patients with "giving way" and a history of ankle sprains (i.e. CAI) were randomized into four groups: wobble board, resistance band, combination and control. The wobble board group consisted of 8 patients (166.42 ± 8.93cm, 71.03 ± 22.68kg, 23.88 ± 4.09 yrs), the resistance band group consisted of 10 patients (157.27 ± 26.18cm, 81.68 ± 22.62kg, 22.50 ± 1.08 yrs), the combination group consisted of 10 patients (168.28 ± 9.21cm, 73.54 ± 19.01kg, 23.00 ± 4.03 yrs), and the control group consisted of 9 patients (169.66 ± 5.31cm, 79.03 ± 21.77kg, 24.11 ± 4.40 yrs). **Interventions:** Baseline measurements included two counterbalanced hop tests. Figure of eight hop test (FET) required patients to hop in a figure-of-8 pattern over a 5 meter distance as fast as possible for 2 repetitions, and side-hop test (SHT) required patients to hop 30cm side-to-side fast as possible for 10 repetitions. Two trials were completed for each hop test. The rehabilitation programs consisted of 3 sessions a week for 4 weeks. For resistance band group sessions consisted of 3 sets of 10 repetitions of ankle plantarflexion, dorsiflexion, inversion and eversion. Wobble board group sessions consisted of 5 trials of clockwise/counterclockwise rotations changing direction every 10 seconds during each 40 second trial. Combination group completed both resistance band and wobble board programs during each session and control group did not complete any exercises. After four weeks, baseline measurements were repeated. Two 4x2 repeated measure ANOVAs were used for data analysis ($\alpha = .05$). Tukey's HSD post-hoc tests were conducted on significant interactions. **Main Outcome Measures:** Dependent measures were fastest time for both FET and SHT, and shorter time to complete indicated improved performance for both tests. **Results:** Main effects for time were significant for both FET ($P < 0.0001$) and SHT ($P < 0.0001$). Main effects for group were not significant for either FET ($P = 0.056$) or SHT ($P = 0.141$). Significant group by time interactions were found for both FET ($F1,33 = 4.03$, $P = .015$) and SHT ($F1,33 = 4.78$, $P = .007$). Post-hoc testing showed an improvement in FET from pre to post measures for both the wobble board and combination groups ($P < 0.01$) and the resistance band group ($P < 0.05$), whereas the control group remained the same. Post hoc testing for SHT also showed that the resistance band group ($P<0.01$) improved from pre to post measures whereas the control, wobble board and combination groups did not. **Conclusions:** The four week combination program did not improve functional hopping ability compared to an isolated wobble board or resistance band program for individuals suffering from CAI.

### Effect of Pre-Operative Quadriceps Strength on 3-month Outcomes in Articular Cartilage Repair and Restoration Patients

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**Context:** Articular cartilage post-operative rehabilitation requires a long non-weight-bearing period contributing to post-operative quadriceps atrophy. Limited research has focused on quadriceps strength in these patients. In ACL patients high quadriceps strength preoperatively has been found to result in better functional outcomes post-operatively. **Objective:** Our purpose was to evaluate if preoperative isometric quadriceps strength affects 3-month post-operative outcomes. We hypothesized that patients with high-strength would have better post-operative outcomes. **Design:** Prospective Longitudinal. **Setting:** Orthopeadic Sports Medicine Clinic. **Patients or Other Participants:** Six Males and nine Females (Age 27 + 10 yrs, BMI 28.94 + 6.12) undergoing articular cartilage repair/restoration participated. Defects were located in the Lateral femoral condyle = 6, Medial femoral condyle = 7, Patellofemoral Joint = 1, or Multiple = 1. Osteochondral Allograft Transplantation (n = 9), Autologous Chondrocyte Implantation (n = 5), and Juvenile particulated cartilage transplant (n = 1) were performed. **Interventions:** Three 5-second isometric MVICs of the quadriceps were performed bilaterally. Pre-operative limb symmetry index (LSI = involved peak torque/uninvolved peak torque) was calculated. Patients were categorized as low-strength (<80% LSI) (n = 9) or high-strength (>80% LSI) (n = 6). **Main Outcome Measures:** Pre-operative and 3-months post-operative patients completed patient reported outcomes (KOOS, IKDC) and the Y-Balance Test (YBT). Participants performed 3-repetitions on the YBT on the surgical and healthy limb. Three trials were averaged. Due to non-normal distributions

a Mann-Whitney-U test was used to compare dependent variables (YBT, KOOS, IKDC) between low-strength and high-strength groups. Change scores (post-operative–pre-operative) were calculated for each PRO to determine minimal detectable change(MDC) and minimally clinically important difference (MCID). **Results:** No statistical differences ($p > 0.05$) were found between the low-strength and the high-strength groups for any dependent variable. Median (IQR) are listed as LSI > 80%, LSI < 80%, respectively. KOOSpain 72 (52-87), 75 (53-96), KOOSsymptoms 43 (35-69), 64 (49-84), KOOSADL 78 (58-93), 91 (51-99), KOOSSportRec 18 (10-51), 18 (0-81), KOOSQOL 35 (18-40), 50 (25-60), IKDC 39 (28-58), 46 (29-70), YBT-anteriorsurgical 55.37 (51.55-60.52), 52.64 (36.6-62.48), YBT-posteriomedialsurgical 85.43 (80.78-95.77), 93.81 (69.95-101.46), YBT-posteriorlateralsurgical 81.33 (71.68-87.84), 79.96 (68.49-93.62). The IKDC difference between groups (7 points) exceeded the MCID (6 points), but not the MDC (15.6 points). The group differences for KOOSsymptoms (21 points), KOOSADL (13 points), KOOSQOL (15 points) exceeded both the MDC (pain6, symptoms5, ADL7, SportRec12, QOL7 points) and the MCID (8-10 points). **Conclusions:** There was no statistical difference between groups for PROs or YBT measures. However, in the low-strength group KOOSsymptoms, KOOSADL, KOOSQOL, and IKDC medians were better when compared to the high-strength group at 3-months post-operative. Furthermore, the difference between group medians for the KOOSsymptoms, KOOSADL, KOOSQOL, and IKDC exceeded the MCID. These differences suggest that clinical differences between the groups may exist. This is evident by function in the high-strength groups' PRO being influenced more than the low-strength group. This may be due to those patients with greater quadriceps strength being more adversely affected by the extended non-weight bearing period than the weaker group.

## Athletic Training Educators' Use and Perceptions of Simulations and Standardized Patients

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**Context:** Simulations and standardized patient (SP) encounters are becoming more prevalent in athletic training to teach and evaluate student performance. Little is known regarding the perceptions and use of simulations and SPs in athletic training education. **Objective:** To explore how athletic training educators are utilizing simulations and/or standardized patients and their associated perceptions of these strategies. **Design:** Focus groups. **Setting:** District athletic training educators' conference. **Patients or Other Participants:** 21 athletic training educators (6 males and 15 females, 39.4 ± 7.96 years). **Data Collection and Analysis:** Three focus groups occurred using a semi-structured interview guide. Focus groups were audio recorded and were transcribed verbatim. Data were analyzed using a general inductive approach. Trustworthiness was established via member checking, peer debriefing and multiple-analyst triangulation. **Results:** All participants utilized simulations but only six (29%) utilized SPs. Four overarching themes were identified: 1) standardized patient encounters, 2) simulations, 3) valued educational experiences, and 4) barriers. Participants utilized SPs to teach and evaluate students at the middle and end of the semester. Simulations were conducted individually and with students in groups. Group simulations utilized classroom and/or lab time to efficiently engage the students in teamwork activities (e.g., spine boarding, communication). Individual simulations were used to evaluate specific clinical skills (e.g., history taking, performing selective tissue tests). Both simulations and SP encounters were seen as valued educational experiences used to teach and/or evaluate communication, acute care, non-orthopedic (e.g., chest or abdominal auscultation, managing breathing difficulties) and orthopedic (e.g., musculoskeletal evaluation) skills. Participants reported using simulations and SP encounters to prepare students for commonly seen conditions such as an ankle sprain as well as emergency situations (e.g., cardiac arrest) that are critical but infrequent. Barriers to the implementation of simulations and/or SPs included restraints on faculty time, access to resources, and financial cost. For those using SPs, identified barriers included the time to create a case, training and retraining SPs, reviewing videos and grading encounters. Time involved in creating the simulation and preparing and operating a simulator were barriers to simulations. The physical and financial resources available to participants varied with not all having access to simulators, SPs, or the facilities to house such encounters. **Conclusions:** Simulations and SP encounters are being used to prepare students for a variety of patient encounters. Faculty should consider identifying resources needed to implement simulations and SP encounters and discuss those with administrators. Institutions could consider providing some faculty with release time to create and utilize simulations and SP encounters. The barriers to implementation should be considered when determining the use of simulations and SP encounters within an individual athletic training program.

## Functional Performance Tests That Identify Adolescent Athletes With Risk of Lateral Ankle Sprains

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**Context:** Lateral ankle sprains are common among adolescent athletes, and approximately 31% of young athletes will develop Chronic Ankle Instability (CAI) after an initial ankle sprain. However, it is unclear which functional performance tests (FPTs) are predictors of developing CAI in adolescents. Identifying the clinical utility of FPTs and establishing cutoff scores could be useful in developing effective preventive interventions. **Objective:** Determine the accuracy of FPTs in identifying risk of future lateral ankle sprain(s) and establish specific cutoff scores identifying adolescent athletes who will go on to have lateral ankle sprain(s). **Design:** Prospective cohort study. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Fifty-two participants from a junior soccer club (27 males: age 15.6 ± 1.3 yrs, height 166.7 ± 7.4cm, mass 61.9 ± 8.3kg, BMI% 67.5 ± 20.5%; 25 females, age 15.8 ± 1.4 yrs, height 158.9 ± 4.9cm, mass 52.0 ± 4.5kg, BMI% 51.1 ± 19.8%) were recruited and then tracked for 8 months. Twelve participants had ≥one lateral ankle sprain diagnosed by a medical provider causing them to miss ≥one full day of practice or competition and were classified as injured. Forty participants had no injury and were classified as uninjured. **Interventions:** Participants performed the anterior (AN), posterior-medial (PM), and posterior-lateral (PL) reach directions of the Star Excursion Balance Test (SEBT) and the Single-Leg-Hop Test (SLHT) before the 8-month tracking period. All tests were measured by a single rater (ICC2,1 > 0.89). **Main Outcome Measures:** The SEBT measures were averaged across three trials and normalized to leg length (%).The SLHT was the fastest time to completion (sec) between two trials. Sensitivity (Sn) and 1-specificity (1-Sp) values were calculated for each measure. Area under the curve (AUC) from receiver operating characteristic (ROC) and cutoff scores using Youden's Index (J) were calculated to estimate the utility of each FPT ($\alpha = 0.05$). Positive (LR+) and negative (LR-) likelihood ratios and odds ratios (OR) were also calculated to determine if those with and without lateral ankle sprain occurrence could be distinguished using cutoff scores. **Results:** There were no significant differences in age, height, or BMI% ($p > 0.05$) between the groups but the injured group had significantly greater mass ($p = 0.03$). Significant AUC values and cutoff scores were found for the PM (AUC = 0.77; 95% CI 0.60, 0.94; $p = 0.005$; Sn = 0.83; 1-Sp = 0.28; cutoff = 75.6%; J = 0.56; LR+ = 3.03; LR- = 0.23; OR = 13.18), the PL (AUC = 0.80; 95% CI 0.67, 0.93; $p = 0.002$; Sn = 0.92; 1-Sp = 0.40; cutoff = 70.6%; J = 0.52; LR+ = 2.29; LR- = 0.14; OR = 16.50) reach direction of the SEBT, and the SLHT (AUC = 0.73; 95% CI 0.52, 0.94; $p = 0.018$; Sn = 0.67; 1-Sp = 0.08; cutoff = 15.4sec; J = 0.59; LR+ = 8.89; LR- = 0.36; OR = 24.67). **Conclusions:** The PM and PL reach directions of the SEBT and the SLHT may be useful as pre-season screening measures to help clinicians identify adolescents who will go on to experience a lateral ankle sprain. Those identified individuals may benefit from ankle sprain prevention programs.

## Quadriceps Function and Hamstring Co-Activation Following Anterior Cruciate Ligament Reconstruction


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**Context:** Individuals with anterior cruciate ligament reconstruction (ACLR) demonstrate quadriceps dysfunction that contributes to physical disability and knee osteoarthritis risk. Quadriceps function in the ACLR limb is commonly evaluated relative to contralateral uninjured limb in both research and clinical settings. However, individuals with ACLR often possess bilateral quadriceps dysfunction, potentially biasing these evaluations and warranting comparison to healthy control participants. Furthermore, individuals with ACLR develop compensatory hamstring activation patterns that may influence quadriceps function assessments. **Objective:** To compare quadriceps function between individuals with ACLR and healthy control participants. **Design:** Cross-Sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty individuals with unilateral ACLR (age = 21.1 ± 1.7 years, mass = 68.3 ± 14.9 kg, time since reconstruction = 50.7 ± 21.3 months; females = 14; Tegner Activity level = 7.1 ± 0.3; 16 patellar tendon autograft, 3 hamstring autograft, 1 allograft) were matched to twenty healthy control participants (age = 21.2 ± 1.2 years, mass = 67.9 ± 11.3 kg; females = 14; Tegner Activity level = 7.1 ± 0.4) on age, sex, body mass index (BMI), and Tegner activity scale. **Interventions:** A maximal voluntary isometric knee extension using an isokinetic dynamometer was used to assess quadriceps function. **Main Outcome Measures:** Quadriceps function (peak torque (PT), rate of torque development (RTD), EMG amplitude, central activation ratio (CAR)) and hamstring EMG were assessed during maximal voluntary isometric knee extension and compared between groups via paired samples t-tests. Hamstring co-activation was quantified as the ratio of hamstring EMG amplitude during the maximal isometric knee extension to the hamstring EMG amplitude produced during maximal voluntary isometric knee flexion. The relationship between hamstring co-activation and indices of quadriceps function were assessed using pearson correlations. **Results:** ACLR participants displayed lesser PT (1.86 ± 0.74 Nm/kg vs. 2.56 ± 0.37 Nm/kg, P = 0.001), RTD (39.4 ± 18.7 vs. 52.9 ± 16.4 Nm/sec/kg, P = 0.03), and CAR (83.3 ± 11.1% vs. 93.7 ± 3.2% P = 0.002), and greater hamstring co-activation (27.2 ± 12.8 vs. 14.3 ± 3.7%, P < 0.001) compared to healthy participants. No difference was observed in quadriceps EMG amplitude between groups (0.25 ± 0.12 vs. 0.37 ± 0.26, P = 0.09). Weak to moderate negative correlations were found between hamstring co-activation and quadriceps PT (r = -0.39, P = 0.007), RTD (r = -0.30, P = 0.03) and EMG amplitude (r = -0.30, P = 0.03). **Conclusions:** Individuals with ACLR possess deficits in quadriceps function (PT, RTD, and CAR) more than 4 years following reconstruction compared to healthy participants. While quadriceps EMG amplitude is the main contributor to knee extensor torque, PT is the net result of all agonist and antagonist activity. Therefore, lesser knee extensor torque in individuals with ACLR can also be attributed to greater hamstring co-activation. Quadriceps strength predicts physical disability and contributes to knee osteoarthritis development. Therefore, regaining quadriceps function following ACLR should be a focus in rehabilitation.


## Neurocognitive Function and Non-Contact Anterior Cruciate Ligament Injury Risk


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**Context:** Diminished neuromuscular control can increase the risk of non-contact anterior cruciate ligament (NACL) injuries. Previous research has shown individuals who sustained an NACL injury displayed lower baseline neurocognitive function than individuals who did not suffer an NACL injury. Thus, neuromuscular control may be influenced by neurocognitive function. However, these findings have yet to be replicated. **Objective:** To determine if baseline computerized neurocognitive domain standard scores differ between athletes who later suffer an NACL and those who do not. **Design:** Case-control. **Setting:** Patient clinic. **Patients or Other Participants:** 14 athletes met the inclusion criteria (NACL: males = 3, females = 11, age at neurocognitive testing = 18.0 ± 1.0 yrs). A minimum of 2 healthy controls were matched to each NACL participant based on sex, sport, position, and age at baseline neurocognitive testing; if a third control participant was identified he/she was also included. 32 matched controls (males = 7, females = 25, age at neurocognitive testing = 18.3 ± 1.0 yrs) were included. **Interventions:** A retrospective medical chart review was conducted at an NCAA Division I university to identify varsity athletes who sustained an NACL injury, completed baseline neurocognitive testing prior to the NACL injury, and had no prior history of catastrophic non-contact lower extremity injury or surgery. **Main Outcome Measures:** Baseline CNS Vital Signs computerized neurocognitive domain standard scores were abstracted from medical charts. Independent samples t-tests explored

group differences for each of the following neurocognitive domain standard scores: psychomotor speed, reaction time, complex attention, cognitive flexibility, processing speed, executive functioning, verbal and visual memory, and reasoning ($\alpha \leq 0.05$). Cohen's effect sizes (d) were also calculated. **Results:** No significant differences were observed: psychomotor speed (NACL: 107.1 ± 11.4, control: 108.3 ± 12.0; t44 = -0.33, p = 0.75; d = 0.11), reaction time (NACL: 97.9 ± 19.7, control: 100.7 ± 12.5; t44 = -0.59, p = 0.56; d = 0.17), complex attention (NACL: 97.0 ± 22.2, control: 99.3 ± 13.1; t44 = -0.44, p = 0.66; d = 0.13), cognitive flexibility (NACL: 96.5 ± 9.43, control: 96.2 ± 13.5; t44 = 0.85, p = 0.93; d = 0.23), processing speed (NACL: 103.9 ± 15.1, control: 101.4 ± 14.3; t44 = 0.53, p = 0.60; d = 0.17), executive functioning (NACL: 97.2 ± 8.53, control: 97.0 ± 13.1; t44 = 0.07, p = 0.95; d = 0.02), verbal memory (NACL: 95.7 ± 23.4, control: 99.5 ± 21.5; t44 = -0.53, p = 0.60; d = 0.23), visual memory (NACL: 98.6 ± 14.7, control: 99.8 ± 16.0; t44 = -0.24, p = 0.81; d = 0.08), and reasoning (NACL: 94.7 ± 11.1, control: 93.0 ± 14.0; t44 = 0.41, p = 0.69; d = 0.14). **Conclusions:** Baseline computerized neurocognitive domain standard scores do not differ between NACL and control individuals. This contrasts previous research reporting a NACL group had "diminished" but not necessarily "impaired" neurocognitive function compared to a control group. Collectively, the current and previous studies suggest baseline neurocognitive scores may not clinically identify individuals with increased NACL risk. Future research should prospectively determine what neurocognitive domains and neuromuscular control variables may discriminate between individuals with and without increased NACL injury risk.

## Effects of Unilateral Quadriceps Strengthening on Quadriceps Symmetry Following ACL Reconstruction

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**Context:** Functional recovery following ACL reconstruction (ACLR) is essential to enable a return to pre-injury levels of physical activity. The restoration of normal lower extremity function along with functional limb symmetry after ACLR may play a vital role in improving outcomes. **Objective:** To measure the impact of a 2 week unilateral quadriceps strengthening program on symmetry of quadriceps central activation ratio (CAR) and normalized knee extension maximal voluntary isometric contraction (MVIC) torque in participants with ACLR. **Design:** Cohort study. **Setting:** University Laboratory. **Patients or Other Participants:** Ten participants with primary, unilateral ACLR (sex = 9F/1M, age = 21.0 ± 2.8 years, BMI = 23.7 ± 2.7 kg/m2, Months since surgery = 27.9 ± 16.6 mo.) volunteered. **Interventions:** Participants completed a 2-week quadriceps strengthening intervention which included 14 exercise sessions focused on the involved limb. Sessions began with a knee joint cryotherapy treatment followed by progressive strengthening and balance exercise. **Main Outcome Measures:** Participant reported knee function was assessed using the Knee Osteoarthritis Outcomes Scale (KOOS). Normalized knee extension MVIC torque (Nm/kg) and quadriceps CAR (%) were assessed bilaterally before and after the intervention. Limb symmetry index (LSI) was calculated at pre-intervention and post-intervention testing. The LSI was calculated by dividing the involved limb measurement by the un-involved limb measurement for each outcome measure. LSIs greater than 1.00 indicated that the involved limb had a greater value for a given measure compared to the healthy limb. Pre-intervention and post-intervention LSIs were compared using paired samples t-tests. To investigate the source of change in LSI, involved limb and uninvolved limb pre-intervention to post-intervention changes were independently investigated using a paired samples t-tests. Stepwise linear regression was used to predict changes in limb symmetry index using pre-intervention measures of participant reported function, quadriceps function and participant demographics. **Results:** Normalized knee extension MVIC torque (pre-intervention = 0.89 ± 0.23, post-intervention = 0.92 ± 0.31; p = 0.74) or quadriceps CAR (pre-intervention = 0.99 ± 0.08, post-intervention = 1.00 ± 0.04; p = 0.61) LSI did not significantly change over the course of the intervention. The involved (pre-intervention = 1.85 ± 0.67Nm/kg, post-intervention = 2.09 ± 0.81Nm/kg; p = 0.04) and un-involved (pre-intervention = 2.13 ± 0.80Nm/kg, post-intervention = 2.38 ± 0.94Nm/kg; p = 0.03) limbs experienced significant improvement in normalized knee extension MVIC torque while the involved (pre-intervention = 86.51 ± 5.03%, post-intervention = 92.94 ± 5.99%; p = 0.02) limb experienced significant improvement in quadriceps CAR following the intervention period. Change in normalized knee extension torque symmetry was not successfully predicted by pre-intervention measures; however, participants with greater improvement in quadriceps CAR symmetry had lower pre-intervention involved limb CAR and were older at the time of testing (adjusted R2 = 0.882, p < 0.001). **Conclusions:** A 2 week unilateral quadriceps strengthening program was able to improve both uninvolved and involved limb quadriceps function while maintaining quadriceps symmetry in participants with ACLR. Unilateral strengthening interventions may not negatively impact symmetry among those with near symmetrical quadriceps function at baseline.

## Quadriceps Function in ACL Reconstructed Patients With and Without a History of Knee Osteoarthritis

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**Context:** Regardless of treatment, young, active individuals are faced with an increased likelihood of developing post-traumatic osteoarthritis (OA) following anterior cruciate ligament reconstruction (ACL-R). Persistent quadriceps weakness has been hypothesized to contribute to the pathogenesis of knee joint disease given its role in force attenuation of articular structures. Examination of muscle function in patients with successful and poor outcomes is needed to elucidate the impact of the quadriceps musculature in this regard. **Objective:** To measure quadriceps strength and activation in patients with knee OA and a history of ACL reconstruction (OA), patients with ACL-R (ACL-R), and healthy individuals (Healthy). **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Five patients with radiographic tibiofemoral OA (Kellgren-Lawrence $\geq 1$) and a history of ACL-R (1 male/4 females; age = 46.3 ± 8.9 years; time from surgery = 13.6 ± 9.7 years), 24 ACL-R patients (8 males/16 females; age = 25.4 ± 5.5 years; time from surgery = 6.5 ± 3.6 months), and 19 healthy individuals (6 males/13 females; age = 22.6 ± 5.3 years) volunteered. **Interventions:** Isokinetic knee extensor torque and knee extensor maximal voluntary isometric contraction (MVIC) torque were measured using a stationary dynamometer. Quadriceps activation was assessed via burst superimposition at 90° knee flexion. **Main Outcome Measures:** Primary outcome measures included (1) normalized isokinetic peak torque (Nm/kg), average power (W/kg), and total work (J/kg) at 90°/second, (2) normalized knee extension MVIC torque (Nm/kg), and (3) quadriceps central activation ratio (CAR). The WOMAC scale was used to assess self-reported pain, stiffness, and physical function for each group. Separate 1x3 ANCOVAs using age and activity level measured by the Tegner scale as covariates were used to identify group differences. Cohen's d effect sizes were used to quantify the magnitude of differences. **Results:** Patients with knee OA demonstrated lower peak isokinetic torque and average power compared to ACL-R patients and healthy controls (all $P \leq .05$). Both OA and ACL-R groups demonstrated lower total work compared to healthy controls (all $P \leq .05$). MVIC torque did not differ between OA and ACL-R patients, however, each were lower compared to healthy controls (all $P \leq .05$). Quadriceps CAR did not differ between groups. Medium to large effect sizes ($d = 0.6–2.3$) with confidence intervals not crossing zero were observed for all outcome measures except CAR, indicating reduced strength in OA and ACL-R patients compared to healthy controls. WOMAC scores were significantly higher among OA patients compared to ACL-R and healthy individuals, indicating poorer self-reported knee function (all $P \leq .001$). **Conclusions:** Quadriceps strength differences are present in patients with and without knee OA after ACL-R. Varying patterns of group differences highlight the importance of mode of contraction when assessing muscle function. Isokinetic peak torque, average power, and WOMAC score appear to uniquely identify patients with poor outcomes after ACL-R.

## Continued Improvements in Quadriceps Strength and Knee Biomechanical Symmetry Over 18 Months: Time to Reconsider the 6-Month Return-to-Activity Guidelines?

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**Context:** Anterior cruciate ligament (ACL) injury and reconstruction result in strength and biomechanical deficits that are often not overcome at the time patients are cleared to return-to-activity (RTA). The lingering muscle weakness and aberrant biomechanics may predispose patients to re-injury. A better understanding of the specific biomechanical and strength deficits that persist, and when the deficits may resolve, are critical to allow for a safer RTA. **Objective:** To compare strength and biomechanical function in ACL reconstructed patients at the time of RTA and approximately 18 months following ACL reconstruction. We hypothesize that significant improvements will be seen from RTA to ~18 months. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty patients (12 female, 8 male; age = 21.4 ± 5.6 yrs, height = 171.3 ± 10.2 cm, mass = 73.2 ± 19.4 kg) who were cleared to RTA after ACL reconstruction were recruited and tested at RTA (212.25 ± 28.11 days post-operatively) and then at ~18 months post-surgery (556.44 ± 230.89 days post-operatively). **Interventions:** Time of testing (RTA and ~18 months following ACL reconstruction) served as the independent variable. **Main Outcome Measures:** Isometric and isokinetic (60°/sec) quadriceps strength were gathered for both limbs and transformed into the quadriceps index for analysis. The average sagittal plane knee flexion angles and moments during the first 50% of stance, and their respective slopes, were recorded during a single-leg forward hop for both limbs

and transformed into symmetry indices (injured/uninjured x 100). Patient-perceived function was measured using the International Knee Documentation Committee (IKDC) subjective knee form. One-way repeated measures analysis of variance was utilized to analyze all dependent variables. Significance was established as $P < 0.05$. **Results:** Significant improvements from RTA to ~18 months were found for isokinetic quadriceps index (RTA = 77.65 ± 20.79, 18mo = 93.41 ± 21.08, P = .004), isometric quadriceps index (RTA = 69.52 ± 12.92, 18 mo = 88.74 ± 17.29, P < .001), knee flexion angle (RTA = 80.77 ± 12.21, 18 mo = 94.53 ± 21.94, P = .006), slope of knee flexion angle (RTA = 81.43 ± 12.04, 18 mo = 88.29 ± 7.85, P = .011), knee flexion moment (RTA = 71.3 ± 15.84, 18 mo = 81.38 ± 16.27, P = .027), slope of knee flexion moment(RTA = 76.89 ± 12.24, 18 mo = 89.49 ± 13.75, P < .001), and IKDC (RTA = 84.43 ± 6.28, 18 = 91.49 ± 7.58, P = .003). **Conclusions:** ACL reconstructed patients show asymmetry in strength and biomechanics at RTA. These asymmetries, along with patient-perceived function, significantly improve over time. Despite improvements in strength and biomechanics from RTA, asymmetries >10% were still present at ~18 months which exceeds the clinically recommended criteria for RTA.

## A Within-Subjects Analysis of Proprioceptive Changes in Individuals With Post-Rehabilitated Unilateral Anterior Cruciate Ligament Reconstruction

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**Context:** Anterior cruciate ligament (ACL) ruptures are one of the most common injuries at the knee. Residual proprioceptive changes such as joint position sense, force sense, and dynamic stability have been identified after an ACL reconstruction (ACLR). **Objective:** To examine, using a within-group analysis, the proprioceptive changes between knees in individuals with a unilateral ACLR. **Design:** Cross-sectional study. **Setting:** Motion Analysis Laboratory. **Patients or Other Participants:** 10 active individuals (7 females, 3 males; age = 19.0 ± 1.1 yrs; height = 172.2 ± 6.0cm; mass = 70.5 ± 12.2kg) that have completed formal rehabilitation of a unilateral ACLR participated in this study. **Interventions:** Joint position sense (JPS) was measured by a six camera 3D motion capture system with reflective markers placed on the greater trochanter, lateral knee joint line, and lateral malleolus. Using a post-operative locking knee brace, participants were locked at a specific knee joint angle where they were asked to memorize that angle from a flexion and extension motion. After three practice trials, the brace was unlocked and participants were asked to replicate the joint angle from a flexion and extension motion. Force sense (FS) was measured using an isokinetic dynamometer. In a locked knee joint position, maximal voluntary isometric contraction (MVIC) for flexion and extension was measured. Using visual feedback, participants were instructed to match 50% of their MVIC. After three practice trials, without visual feedback, participants were asked to replicate 50% of their MVIC. Dynamic stability was measured when participants completed two jump-landing tasks from the forward and lateral directions. Landing single-legged onto the force plate, time-to-stability (TTS) was calculated from the vertical ground reaction force. **Main Outcome Measures:** A within-subjects paired t-test was utilized to examine the differences in JPS, FS, and TTS between the healthy and the ACLR knee. **Results:** No significant differences in JPS were found between the healthy (Extension: 4.21 ± 2.85°; Flexion: 6.06 ± 4.93°) and ACLR knee (Extension: 5.24 ± 3.27°; Flexion: 8.46 ± 5.15°) in the extension (P = 0.514) or the flexion (P = 0.066) motion. No significant differences in FS, measured in percent difference from the MVIC, were found between the healthy (Extension: 13.23 ± 6.96Nm; Flexion: 8.70 ± 4.41Nm) and ACLR knee (Extension: 8.64 ± 7.70Nm; Flexion: 9.25 ± 10.18Nm) with the quadriceps (P = 0.140) or hamstrings (P = 0.834). No significant differences in TTS were found between the healthy (Forward: 0.93 ± 0.29s; Lateral: 1.20 ± 0.41s) and ACLR knee (Forward: 1.00 ± 0.71s; Lateral: 1.11 ± 0.39s) for the forward (P = 0.742) or lateral (P = 0.581) jumps. **Conclusions:** This investigation, using a within-group analysis, did not identify any proprioceptive differences between a healthy and ACLR knee. Clinicians have made it a priority to reduce the strength disparity between the hamstrings and quadriceps during ACLR rehabilitation, aiming to improve the neuromuscular control around the joint. From the results of this study, we can conclude that current rehabilitative protocols are effective at restoring neuromuscular control to the injured knee.

## Knee Valgus is Related to Quadriceps Strength During a Single Leg Squat for Female Patients With Prior ACL Injury

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**Context:** Quadriceps weakness is well recognized in patients with a history of anterior cruciate ligament injury and reconstructive surgery (ACLR) and associated with a number of poor outcomes. Those with ACLR have demonstrated altered kinematics as a result of quadriceps weakness. Therefore, kinematic analyses during functional movement tests may be useful for identifying ACLR patients with quadriceps weakness when use of a dynamometer is not available. The ability to detect quadriceps weakness using a simple clinical assessment may prove useful to clinicians. **Objective:** The purpose of this study was to determine the relationship between isometric quadriceps strength and single leg squat kinematics of female patients with ACLR. **Design:** Cross-Sectional **Setting:** Research laboratory **Patients or Other Participants:** Forty-two female patients with self-reported ACLR participated in this study (Age = 18.86 ± 1.42 years, Height = 167.82 ± 6.98 cm, Mass = 67.56 ± 11.13 kg). **Interventions:** Three-dimensional lower extremity and trunk kinematics were collected during a single leg squat for both the injured and uninjured leg. Isometric knee extension force was collected using a handheld dynamometer. **Main Outcome Measures:** Sagittal and frontal plane joint angles of the knee, hip, and trunk were recorded at peak knee flexion during a single leg squat for both the injured and uninjured leg. Peak isometric knee extension force was collected for the injured and uninjured leg and normalized to the participants' body mass. Pearson product-moment correlation coefficients (r) were calculated between each kinematic variable and isometric force for the injured and uninjured leg; a priori alpha level of 0.05. **Results:** We observed a significant relationship between knee valgus angle and peak isometric knee extension force ( r42 = -0.31, p = 0.047, Knee Valgus: 5.21 ± 11.08°, Peak Isometric Knee Extension Force: 0.37 ± 0.11 N/kg) for the injured leg. No other significant relationships were observed for either the injured or uninjured leg (p > 0.05). **Conclusions:** We observed a significant negative relationship between knee valgus angle and peak isometric knee extension force for the injured leg, indicating that having greater quadriceps strength was related to greater knee valgus angle during a single leg squat. Quadriceps strength was not related to any other kinematic variable, indicating that having greater or lesser quadriceps strength may not determine how well a patient is able to perform a functional movement test. Our observations indicate that having greater quadriceps strength alone may not translate to improved functional movement for patients with ACLR. This supports the inclusion of functional movement tests in addition to measures of quadriceps strength to identify ACLR patients at risk for re-injury and poor outcomes.

## Lower Extremity Jump-Landing Kinematics and Kinetics After ACL Reconstruction: A Systematic Review

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**Context:** Altered lower extremity jump-landing biomechanics have been linked to increased risk of ACL re-injury as well as contralateral injury following ACL reconstruction (ACLR). Despite the increased risk for secondary ACL injury, no clear guidelines exist for evaluation of abnormal landing strategies following ACLR. **Objective:** Systematically evaluate current evidence concerning hip and knee kinematic and kinetic strategies adopted by individuals with ACLR during dynamic landing tasks. **Data Sources:** An online search using Web of Science and PubMed databases was performed to obtain pertinent peer reviewed articles. The search strategy consisted of the terms "anterior cruciate ligament" (OR "ACL"), AND "reconstruction", AND "landing biomechanics" with limits of those published after 1990 and written in English. **Study Selection:** Studies selected for inclusion provided mean data and estimates of variability for hip or knee kinematics or kinetics during a dynamic landing task. This included values at initial contact, peak values, and total range of motion measurements during the landing task as compared to a healthy contralateral limb or healthy controls. **Data Extraction:** Descriptive data, 3D hip and knee kinematic and kinetic data, and vertical ground reaction force (vGRF) data were extracted and reviewed by both authors in order to ensure fidelity. Methodological quality was assessed by both authors using the modified version of the Downs and Black checklist (0-16). **Data Synthesis:** Data were categorized based on the comparison group (contralateral limb vs. healthy control limb). Means and pooled standard deviations from each variable of interest were used to

calculate Cohen's d effect sizes with associated 95% confidence intervals. A negative effect size indicated the ACLR limb had lesser values compared to the comparison limb. Effect sizes were considered clinically meaningful if the associated confidence interval did not cross zero. Twenty-one articles (Down and Black = 10.7 ± 1.4) were included. In 6 of 8 studies, hip flexion angle was greater (Range d = 0.14,0.99) as compared to healthy control limbs. No conclusive differences existed for any other hip (Range d = -0.74,1.15). or any knee kinematic variables during landing (Range d = -1.94,2.05) as compared to healthy or contralateral limbs. Consistent, clinically meaningful reductions, ranging from small to large effects, were reported for internal knee extension moment as compared to the contralateral (Range d = -0.14, - 1.46) and healthy control limb (Range d = -0.52,-1.57). The majority of studies reported small to large magnitude reductions in peak vGRF as compared to contralateral (Range d = 0.00,-1.75) and healthy control limbs (Range d = -0.39, -1.75). **Conclusions:** Individuals with history of ACLR consistently land with reduced knee extension moments and vGRF compared to their contralateral and healthy control limbs regardless of landing task. Despite the lack of high quality, prospective evidence, these findings suggest that altered sagittal plane kinetics and overall landing forces may have significant implications for secondary ACL injury risk.

### Relationship Between Fear of Re-injury and Jump Landing Biomechanics in ACL Reconstructed Patients

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**Context:** Following anterior cruciate ligament reconstruction (ACLR), many patients do not return to sport (RTS), despite completion of rehabilitation and passing functional of exams. Fear of re-injury is one commonly cited reason for lack of RTS. ACLR patients demonstrate altered movement patterns during walking and functional movements, such as jump landings, for years following successful completion of rehabilitation. The relationship between fear of re-injury and altered movement patterns has not been previously been investigated. **Objective:** To examine the relationship between fear of re-injury and kinematic and kinetic variables during a jump landing in ACLR patients. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Forty-nine females with history of unilateral ACLR that were cleared to return-to-sport (height 167.0 ± 8.5cm, mass = 65.8 ± 18.7kg, age = 18.5 ± 1.0 yrs, 24.8 ± 10.5months from surgery) volunteered to participate in this study. **Interventions:** Subjects completed five successful trials of a jump-landing task. Participants jumped from a 30cm box to two force plates, located half of their height from the box. Subjects were instructed to land and then immediately jump for maximal height. An electromagnetic tracking system interfaced with non-conductive force plates was used to capture joint motion and forces during landing. Isometric strength of the gluteus maximus, gluteus medius, quadriceps and hamstring was measured using a hand-held dynamometer. Fear of re-injury was assessed using the Tampa Scale of Kinesiophobia-11 (TSK-11) and the International Knee Document Committee 2000 (IKDC) was administered. Higher TSK-11 scores indicate greater fear of re-injury. **Main Outcome Measures:** The dependent variables were maximum VGRF, peak kinematic and kinetics from both limbs (knee, hip, and trunk), and isometric strength indices (index=injured limb/healthy limb100). Partial Pearson's r correlation coefficients were calculated between TSK-11 and each variable while controlling for time from surgery with significance set a-priori at $p < 0.05$. **Results:** On the reconstructed limb, TSK-11 (20.1 ± 4.5) was correlated with peak hip adduction angle (-4.0 ± 7.0°, r = .46 p = .001), peak knee extension moment (-1.3 ± 0.3Nm/kg r = -.32, p = .03), peak hip internal rotation moment (0.21 ± 0.3Nm/kg, r = .32, p = .03), and gluteus medius index (100.7 ± 9.8%, r = -.34, p = .018). There was also a fair, non-significant relationship between TSK-11 and trunk forward flexion (35.5 ± 19.1°, r = .25, p = .09). TSK-11 and IKDC scores were highly correlated (83.5 ± 9.9%, r = -.61, $p < 0.001$). **Conclusions:** Increased frontal plane mechanics and knee extension moments are associated with higher levels of fear of re-injury. Specifically, increased fear of re-injury is associated with increased hip adduction, increased knee extension and internal rotation moments on the reconstructed limb, and increased trunk flexion. Higher TSK-11 is also associated with lower symmetry in gluteus medius strength between the injured and healthy limbs. Finally, higher fear of re-injury is associated with lower self-reported knee function. These associations could be related to lack of neuromuscular control, stability, or lack of confidence in the injured limb. Additional research is needed to determine the cause of this relationship.

### Inducible Reciprocating Tachycardia in Collegiate Football Player

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**Background:** A 20 year-old male collegiate football player suffered chest pain and palpitations due to inducible reciprocating supraventricular tachycardia. Mechanism of injury: while playing football, athlete states he felt his heart "racing" and complained of chest pain. The symptoms were reported after performing sprinting and blocking during one offensive series in a game. The on-field initial assessment revealed a strong and rapid pulse of 120 bpm, clear, bilateral lung sounds, and normal heart sounds. The initial treatment included removing the athlete from physical activity and trending the athlete's vital signs and chest pain levels. The athlete reported that his heart palpitation and chest pain returned to normal after he breathed deeply into his fist for a few minutes (Valsalva Maneuver). The athlete was referred to a cardiac specialist. **Differential Diagnosis:** Ischemic Heart Disease, Pulmonary Emboli, Hemopneumothorax, Angina Pectoris, Myocardial Infarction, Atrial Fibrillation, Hypertrophic Cardiomyopathy, Hypovolemic shock; Electrophysiology study confirmed inducible reciprocating tachycardia in heart's left lateral wall bypass tract. **Treatment:** An electrophysiologist was seen about 5 days after the incident. A 24h Holter Monitor recorded the athlete's heart rhythm and was worn almost 4 weeks. Several episodes of supraventricular tachycardia were captured, as well as the athlete's record of recurring heart palpitations and chest pain. 3 months after symptom onset, a successful radiofrequency cardiac ablation was performed to correct the electrical malfunction of the heart. A follow-up visit was conducted to ensure the electrical malfunction within the heart was corrected. Upon assessment, the physician found no contraindications from the treatment and cleared the athlete to play for his upcoming season. **Uniqueness:** Supraventricular tachycardia is a common congenital heart arrhythmia that affects 1 out of every 2500 people within the United States, but the arrhythmia typically corrects itself by adolescence. Typically, it is considered a non-lethal and manageable dysfunction in athletes due to vagal maneuver breathing techniques, medications, and procedures that can be taught, administered, or performed to return a patient's heart rate to within normal ranges. The athlete's choice of treatment was a cardiac catheter ablation, which has 90-95% effectiveness in correcting a heart's electrical dysfunction. This is a unique case due to the insidious onset of symptoms without any prior history of cardiac pathology, at rest or during exertion. Approximately 1 year post-surgery, the athlete reported a similar episode during exertion in football practice. Consequently, the recurring of the event discontinued his participation in collegiate football. **Conclusions:** Supraventricular tachycardia is a broad term that refers to any abnormal electrical signal that is present within the cardiac conduction system located superior to the ventricles. The sinoatrial (SA) node is responsible for stimulating the heart's electrical signal and transmitting the impulse across the atrium. After contraction of the atrium, blood is pumped into the ventricles and the electrical message is relayed to the atrioventricular (AV) node. The AV node is responsible for ventricular contraction. Supraventricular tachycardia occurs at or near the atrioventricular node and is usually the result of 2 pathological causes: (1) a divide in the AV node, or (2) the presence of multiple pathways from the SA node.4 Due to this abnormal pathway, the electrical signal becomes trapped and the impulse keeps traveling in a "looped" pattern, causing the heart to increase the rate of contraction. A possible explanation for the reoccurrence of the condition is the presence of multiple pathways in the athlete's heart. Additionally, the patient's athletic nature could have increased the probability of the arrhythmia returning due to the physical demands placed on the heart during exertion.

### Atrioventricular Reciprocating Tachycardia in a High School Football Athlete

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**Background:** A 16 year old Caucasian interscholastic football athlete reported to the athletic trainer complaining of symptoms consistent with palpitations. The patient stated that he had been experiencing symptomatic episodes for a couple months but failed to report them to the medical staff. There was no history of sudden cardiac death or cardiovascular disease in his family, however his personal history consisted of asthma, frequent headaches and multiple concussions that occurred during sport participation. The patient stated that the palpitations would last as long as 20 minutes but would resolve without intervention. The patient was not experiencing palpitations at the time he reported the complaint, but stated he decided to do so due to concern for his health and fear of a serious condition. He was completely asymptomatic at this time with nothing remarkable to report upon assessment. However, given the description of his complaint, the patient was referred to his pediatrician who then referred him to a cardiologist. The cardiologist fitted the patient with a cardiac Holter monitor and instructed him to record any palpitation episodes over the next 48 hours. During this time, the monitor registered a heart rate as low as 49 beats per minute and a maximum heart rate of 302 beats per minute. At the time of the maximum heart rate, the patient reported that he was experienced palpitation like symptoms and dyspnea while resting on a sofa. **Differential Diagnosis:** Atrial fibrillation, supraventricular tachycardia (SVT), atrioventricular nodal reentrant tachycardia (AVNRT), atrioventricular reciprocating tachycardia (AVRT), Wolff-Parkinson-White syndrome (WPWS). **Treatment:** The patient was originally diagnosed with SVT and prescribed the

beta-blocker Atenonol (Tenormin). The source of the tachycardia could not be determined from the electrocardiogram so a radiofrequency ablation procedure was performed to both diagnose and correct the condition. During the procedure, the patient was diagnosed with WPWS and AVRT. The procedure was successful for correcting the abnormal pathway between the left ventricle and left atrium. After ablation, the patient was kept overnight for observation and was released the next day. He was prescribed Aspirin at discharge and instructed to ingest 81-mg daily for one month. Three days following surgery, the patient was cleared for conditioning activities which he resumed without complication. Approximately eight months following surgery the patient experienced a palpitation like episode although not as severe as the previous episodes. The cardiologist diagnosed him with premature ventricular contractions (PVCs). He remained cleared for full participation and continues to be monitored closely by the athletic training staff. **Uniqueness:** WPWS is present in less than 1% of the general population and generally causes heart rates approaching 240 beats per minute. A heart rate over 300 beats per minute as recorded in our patient is extremely rare and can lead to sudden cardiac death. Our patient was at rest during this episode and also experienced dyspnea. **Conclusions:** Our patient failed to report his symptoms for two months. It is extremely important that athletic trainers educate the athletes as to the importance of being forthcoming regarding any changes in their health status. Many clinicians feel that electrocardiography should be included in a preparticipation cardiac screen for young athletes. We are unsure if this would have identified our patient's condition. Medications such as beta-blockers, calcium channel blockers, and antiarrhythmic drugs are the most common first-line treatment option for AVRT. However, a high-risk accessory pathway conduction, like the one our patient suffered from, usually requires catheter ablation. The long-term success rate for catheter ablation of accessory pathways is well above 90%.

## Case Report: Axillary Artery Thrombosis With Emboli as a Cause of Hand Pain in a Collegiate Pitcher

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**Background:** A twenty-one year old male Division II left handed pitcher began experiencing finger and hand pain in his throwing arm after a bare-handed catch during a baseball game. He continued to pitch over the course of the next week with decreased velocity, sporadic finger paresthesias and complaints of coolness. One week later paresthesias occurred in all digits while warming up, and he was subsequently removed from the game due to discoloration and worsening numbness. **Differential Diagnosis:** Scapular dyskinesia, glenohumeral internal rotation deficit (GIRD), internal impingement, quadrilateral space syndrome, thoracic outlet syndrome, suprascapular nerve entrapment, sensory nerve compression, and local nerve/vascular trauma. **Treatment:** After removal from the game, the athlete was taken for evaluation at the Emergency Room (ER) of their travel game location before returning home that night. He was placed in a splint with a diagnosis of suspected musculoskeletal injury. He remained symptomatic and the team athletic trainer (ATC) coordinated team physician evaluation. His exam and history were concerning for evolving vascular insufficiency and the athlete was therefore sent to our Emergency Room. He was further evaluated by the orthopedic upper extremity and vascular surgery teams where diagnostic tests were performed including radiography, Doppler exam, and Computed Tomography (CT) angiogram. CT angiogram showed a non-occlusive thrombus of the proximal left brachial artery and distal ulnar artery occlusion. He was taken to the operating room that night for operative arteriogram with initiation of local thrombolytic therapy and stayed in the Surgical Intensive Care Unit (SICU). He underwent two additional operative arteriograms before cessation of thrombolytic therapy after 32 hours. He was then transitioned to therapeutic oral anticoagulation. Three weeks later he was electively readmitted for open thrombectomy with arterial repair and pectoralis minor lengthening procedure. At the time of surgery, a thrombosed aneurysmal subscapular artery was ligated and the distal axillary artery was repaired. He subsequently transitioned to oral aspirin therapy. He has been rehabilitated conservatively with return to play estimated at 1 year. **Uniqueness:** Symptoms of vascular claudication present in the population similar to symptoms of internal rotation deficit or scapular dyskinesia. The initial complaint is often vague shoulder pain and decreased velocity. Literature on the diagnosis is sparse, with numerous reports of athletes undergoing a shoulder surgical procedure for incidental labral pathology before the vascular injury was recognized. The pathogenesis is poorly understood, but likely secondary to repetitive compression of the axillary artery and its branches. Hyperabduction and external rotation with anterior glide force can lead to diminished vascular diameters in healthy individuals. Repetitive compression in the late cocking phase can potentially lead to intravascular ulceration, platelet thrombus, and aneurysm in overhead pitchers. **Conclusions:** This case report highlights the importance of consideration of vascular injuries in overhead athletes. Careful examination of the hand and fingertips for ischemic changes, assessment for bruit or diminished pulses, and consideration of subjective complaints of cold intolerance of the hand can lead to prompt diagnosis.

## Mitral, Tricuspid and Aortic Regurgitation and Partial Shone Complex Syndrome in a Female Collegiate Swimmer: A Clinical Case Report

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**Background:** A 19-year-old female NCAA Division I swimmer complained of dizziness, syncope, heart palpations and fatigue during exercise that had become progressively worse as she continued into her second collegiate season. Her times in the 50 free, 100 free, 200 free, 500 free and the 1650 freestyle races were highly competitive. The athlete was in excellent physical condition and had no known personal or family history of heart disease or illness. After six months of diagnostic testing, a sclerotic aortic valve with moderate mitral, aortic and tricuspid valve regurgitation diagnosis was confirmed. **Differential Diagnosis:** The differential diagnosis included low blood iron levels, heart murmur, over training fatigue, and female athlete triad with a focus on malnutrition and reduced body weight. **Treatment:** The patient underwent a physical evaluation by a physician resulting in a clear chest evaluation. A cardiovascular exam was performed in the sitting, supine and standing position. The patient had a regular heart rate and rhythm. There were no audible systolic or diastolic murmurs, rubs, gallops or thrills with normal first and second heart beat sounds. There was an early mid-systolic click heard most clearly between the left lower sternal border and apex. The precordium was not hyper-dynamic and the pulse was easily palpable bilaterally at both the radial and femoral sites, with no delayed notes. A treadmill stress test was completed with a Bruce protocol; the patient was able to perform 13 minutes and showed no malignant arrhythmias. However, the patient developed shortness of breath and was unable to continue the procedure. There was significant concern that the patient's blood pressure displayed a widened pulse pressure, of 106 mmHg, at peak exercise. A stress echocardiogram was performed on the patient to determine the severity of the valve defects. During the examination the patient felt shortness of breath and fatigue when near maximum heart rate was reached. Following the stress test, the cardiologist was able to produce a final diagnosis of a sclerotic aortic valve with mitral, tricuspid and aortic regurgitation; parachute mitral valve, and partial Shone Complex Syndrome. The patient was allowed to return to swimming but was advised against open water swimming or swimming alone. The physician recommended that the patient not maintain maximum heart rate during exercise for an extended period of time. Maximal to near maximal isotonic exercises, such as heavy weight lifting needed to be avoided. Additionally, routine healthcare maintenance and lifetime cardiology supervision was recommended. **Uniqueness:** This case is a unique presentation of congenital heart disease in an adolescent athlete. It is extremely unusual for a patient to remain vastly asymptomatic throughout childhood and become symptomatic in adulthood. The athlete's heart has become an area of research that has progressively grown over the last decade, with new studies showing adaptive changes of the heart in high-level trained athletes. **Conclusions:** While patients do not always fit the description for a high-risk population, the disease may still present itself, and if undiagnosed could be life threatening. Less threatening complications are able to occur from vigorous exercise and extensive training, allowing the diagnosis of a cardiovascular problem to be overlooked. Therefore, early diagnosis and intervention is imperative to the overall health and prognosis of the athlete.

## Lower Leg Pain in an Intercollegiate Softball Player

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**Background:** An 18 year-old female intercollegiate softball player presented to the AT with severe posterior lower leg pain and swelling. The patient's previous medical history was significant for a lower leg fracture 10 days prior and underwent an ORIF three days after the injury occurred. Initially, the patient reported hearing a "pop" followed by severe pain secondary to performing a sliding drill during practice. Initial examination revealed a left distal lower leg deformity with immediate severe swelling with intact neurovascular function. Additionally the patient's medical history is significant for taking hormone replacement therapy medication for polycystic ovarian disease. **Differential Diagnosis:** Hematoma, abscess, cellulitis, osteomyelitis, sarcoma, metastatic carcinoma, lymphoma, aneurism, thrombophlebitis, thrombosis, embolism, thromboembolism. **Treatment:** The patient was immediately referred to the emergency department. Upon arrival at the hospital, the patient was evaluated by the attending physician. A diagnostic ultrasound was ordered and a deep vein thrombus (DVT) was identified in the left posterior tibial vein. Compressibility and respiratory variation in the left common femoral, superficial femoral, and popliteal veins were also noted. The patient was stabilized, prescribed ibuprofen, instructed to follow up with her health care provider, and discharged. Status-post one day, the patient was seen by the team physician and was subsequently referred to a vascular specialist. Status-post three days, the patient was definitively diagnosed with a tibial vein thrombus by the vascular specialist and prescribed 20 mg of rivaroxaban, an anticoagulant which would allow the patient to continue with her hormone replacement therapy for polycystic ovarian disease. Status-post one week, the patient complained of a severe chest

pain and was immediately referred back to the emergency department. The patient was diagnosed with a pulmonary venous thromboembolism (VTE), prescribed heparin and warfarin, and was admitted. After eight days in the hospital, the patient was stabilized and laboratory tests confirmed a 2.4 international normalized ratio. The patient was released, and instructed to follow up with her health care provider. The patient followed up with the team physician the next day who cleared her to begin rehabilitation, and after consulting with the vascular specialist, prescribed additional anticoagulants for two months. Status-post eight weeks, the cast was removed and the patient did not report calf or chest discomfort. Radiographs did not reveal any complications and the patient was cleared to gradually return to softball activities with the use of an ankle orthosis. The patient was referred to a hematologist for consultation and prescribed the continued use of the anticoagulants for an additional 6 months and cleared her for athletic activities. Status-post eight months, the patient was instructed to discontinue the use of anticoagulants, was discharged from rehabilitation, and was cleared for unrestricted activity. The patient's return to softball did not elicit any further complications. **Uniqueness:** The annual incidence of VTE in the general population is estimated at 0.001% and is highest among older women. Between 10-30% of symptomatic VTE events present as lower extremity proximal DVTs, with thrombi distal to the popliteal vein rarely ever embolizing. Additionally, the patient was currently under care for a DVT and the patient still developed a VTE. **Conclusions:** A DVT is a blood clot in one or more of the deep veins. A VTE is a clot that breaks loose and travels throughout the body and is a complication of a DVT. Specifically, the DVT breaks off, or embolizes, and flows proximally becoming a life-threatening condition. To assist the patient in managing the DVT and subsequent VTE, pharmacologic intervention was carefully selected by vascular and hematological specialists as to allow the patient to continue with the hormone preplacement therapy to manage her polycystic ovarian disease.

## Superior Mesenteric Artery Syndrome in Active Male

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**Background:** A 22 year old male collegiate lacrosse athlete had insidious complaints of severe nausea, vomiting, diarrhea, and stomach pain. The patient has no previous history of gastrointestinal (GI), cardiovascular, or general health issues. The athlete was referred to three different GI specialists, who conducted four endoscopies, one colonoscopy, two CT scans, three MRIs, and two fluoroscopies with no abnormalities. The patient was admitted to the hospital approximately 30 times before being medically disqualified from lacrosse. **Differential Diagnosis:** Gastroesophageal Reflux Disease; Peptic Ulcer Disease; Stomach Cancer; Irritable Bowel Syndrome (IBS); Crohn's Disease. **Treatment:** The MRI revealed an acute aortomesenteric angle of 12 degrees. The patient's physicians used endoflip, which allowed the physicians to see the gastroesophageal junction diameter. Endoflip confirmed the diagnosis of gastroparesis secondary to Superior Mesenteric Artery (SMA) syndrome. SMA syndrome caused the superior mesenteric artery to become occluded along with the duodenum. The occlusion of the duodenum on the artery restricted blood flow to the stomach and intestines disabling chyme to pass, consequently the intestines are unable absorb the necessary nutrients. The occlusions were linked to food passing through the gastrointestinal tract and impinging the artery. The gastroparesis aided in the arterial occlusion causing the patient to vomit and experience severe stomach pain due to lack of blood flow to the GI tract. Due to the extreme narrowing of the aortomesentaric angle, a surgical procedure was proposed which included a laparoscopic esophagogastroduodenoscopy, duodenojejunostomy, cholecystectomy, and appendectomy. During the esophagogastroduodenoscopy and duodenjejunostomy, a small portion of the small intestine was removed and transplanted for an esophageal bypass at the arterial occlusion site. The proximal insertion of the bypass was placed mid esophagus and the distal portion was placed into the stomach. Bypass of the involved portion of the esophagus allowed for chyme to successfully pass through the esophagus and into the stomach without arterial occlusion. **Uniqueness:** SMA syndrome is a rare condition that commonly occurs in females. Being a male healthy athlete, this case is unique. There are few studies on the prevalence of SMA syndrome, and the rate in athletics is unknown. Typically, dietary disorders or severe trauma lead to SMA Syndrome, though the patient has unknown mechanism. Due to the complicated procedure, few surgeons can perform the surgery, and the success rate is low. **Conclusions:** SMA syndrome is a rare, potentially life-threatening disorder characterized by complaints of severe nausea, vomiting, diarrhea, and stomach pain. Due to the severity of the symptoms and decreased aortomesenteric angle the patient underwent a series of surgeries. Post-operatively, the patient was advised to follow an increased intake of protein and complex carbohydrates that must be taken midday, an increase of these nutrients during early and late hours cause an increase of GI pain and food reversal. Eight months after surgery, the patient has regained 15 of the 45 pounds lost and has had limited bouts of vomiting, diarrhea, and stomach pain. These numbers have decreased from vomiting 8-10 times a day to 1-2 times a week.

### Comparison of Single-Leg Balance in Athletes With and Without a History of Chronic Lower Extremity Injury

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**Context:** Static and dynamic balance deficits are often noted in individuals with a history of lower extremity injuries. Poor balance also has been predictive of future injury and performance deficiencies. In athletes with chronic lower extremity injury, balance impairments may indicate an underlying pathological process that contributes to the repetitive injury. **Objective:** The purpose of this study was to determine if single-leg balance differs between participants with and without a history of chronic lower extremity conditions. **Design:** Case-control. **Setting:** Research Laboratory. **Patients or Other Participants:** Division I student-athletes with (19.63 ± 1.07 years, 175.33 ± 11.18 cm, 74.56 ± 16.49 kg; 22 females, 10 males; N = 32) and without (18.94 ± 1.10 years, 174.73 ± 9.74 cm, 72.34 ± 10.78 kg; 42 females, 20 males; N = 62) a history of chronic lower extremity conditions. Chronic lower extremity conditions included: medial tibial stress syndrome, chronic ankle instability, anterior compartment syndrome, Achilles tendinitis, patella bursitis, iliotibial band bursitis, posterior tibial tendinitis, and plantar fasciitis. **Interventions:** Subjects performed a single-leg balance test while standing atop a force plate, and they were instructed to remain as motionless as possible for 20 seconds with their eyes closed. Each leg (injured and non-injured) was assessed for a single trial. Subjects' injured leg was defined as the leg with chronic injury, while the control group was assigned an "injured leg". The non-injured leg was contralateral to the injured leg in both groups. A repeated measures ANOVA with 1 between factor (group: chronic condition, no chronic condition) and 1 within factor (leg: injured, non-injured) was used to analyze the data ($\alpha = 0.05$). Tukey's HSD was used for post hoc analysis. **Main Outcome Measures:** Resultant vector of the center-of-pressure velocity (cm/s). Lower values were indicative of better balance. **Results:** No significant difference was found for the main effect for group (chronic condition = 1.51 ± 0.55 cm/s, no chronic condition = 1.62 ± 0.52 cm/s; $F(1,92) = 0.88$, $P = 0.35$) or for the main effect for leg (injured leg = 1.58 ± 0.68 cm/s, non-injured leg = 1.57 ± 0.59 cm/s; $F(1,92) = 0.46$, $P = 0.50$). A significant group by leg interaction was found ($F(1,92) = 6.93$, $P = 0.01$). Tukey's HSD post-hoc testing revealed that the chronic condition group had lower velocity on their injured leg (1.39 ± 0.56 cm/s) compared to their contralateral leg (1.63 ± 0.62 cm/s) and the assigned injured leg (1.68 ± 0.71 cm/s) of the control group. The velocity of the assigned non-injured leg of the no chronic condition group (1.54 ± 0.57 cm/s) was not significantly different from the other reported means. **Conclusions:** The injured leg of the chronic condition group had superior balance. Reasons for our results are not clear, but the enhanced balance may be due to participation in rehabilitation programs or the use of a compensatory strategy to maintain stability during the single-leg stance test. Future research can monitor chronic injury incidence in our subjects to determine if enhanced balance is associated with a decrease rate of injury.

### Kinematic Predictors of Star Excursion Balance Test Performance in Individuals With Chronic Ankle Instability

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**Context:** The Star Excursion Balance Test (SEBT) has identified dynamic postural control deficits in individuals with chronic ankle instability (CAI). While kinematic predictors of SEBT performance have been evaluated in healthy individuals, this has not been thoroughly examined in individuals with CAI. Examining kinematic predictors of SEBT performance in people with CAI may provide insight into functional movement pattern alterations and intervention strategies. **Objective:** Identify kinematic predictors of SEBT performance in people with CAI. **Design:** Cross-sectional. **Setting:** Laboratory. **Patients or Other Participants:** Fifteen individuals with CAI (5 males, 10 females, 22 ± 2 years, 1.68 ± 0.09 m, 69.45 ± 13.27 kg) participated. Participants were included if they reported >1 ankle sprain, >2 episodes of "giving way" in the past three months, and answered "yes" to >4 Ankle Instability Instrument questions. **Interventions:** During a single session, participants completed the anterior reach direction of the SEBT. Each participant performed 4 practice trials followed by 3 experimental trials. In the event of an error, the trial was discarded and repeated. Maximum reach distances were measured in cm and normalized to leg length (MAX%). Three-dimensional trunk, hip, knee, and ankle motion of the stance limb were recorded during each anterior reach trial using a motion capture system. Sagittal, frontal, and transverse plane displacement (°) observed from trial initiation to the point of maximum reach was calculated

during each trial for each joint or segment and averaged for analysis. **Main Outcome Measures:** Predictor variables included sagittal, frontal, and transverse plane displacement of the trunk, hip, knee, and ankle. A backward multiple linear regression model was developed with MAX% as the criterion variable. Pearson product-moment correlations were performed to examine the relationships between predictor variables and MAX%. The predictor variable from each joint or segment most correlated with MAX% and not demonstrating strong correlations ($r < 0.70$) with other predictor variables were entered into the regression model. The significance level was set at $p < 0.05$ for the regression analysis. **Results:** Frontal plane displacement of the trunk (0.47 ± 5.30°), hip (8.02 ± 3.87°) and ankle (-5.58 ± 1.84°) along with sagittal plane knee displacement (-50.45 ± 11.96°) were entered into the analysis. The final model ($p = 0.004$) included all three frontal plane variables and explained 81% of the variance in MAX% (76.92 ± 4.28%). Including sagittal plane knee displacement in the model explained <1% of additional variance in MAX%. **Conclusions:** Individuals with CAI who demonstrated greater trunk displacement towards the stance limb, hip adduction, and ankle eversion achieved greater MAX%. While previous research determined sagittal plane motion strongly predicted MAX% in healthy individuals, this study suggests people with CAI may rely on alternative strategies from the frontal plane to achieve greater MAX%. The role of central alterations in movement and ankle range of motion restrictions should be further examined to explain these findings.

## A Comparison of Postural Control Between High and Low-Arch Foot in Chronic Ankle Instability Following Diminished Plantar Cutaneous Sensation

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**Context:** Patients with CAI experience postural perturbations due to the deficit of proprioception and neuromuscular control. A CAI patient may depend more on other sensory inputs such as the intrinsic foot muscle to maintain postural control. **Objective:** To investigate the relationship between different foot types and postural control with reduced plantar cutaneous sensation in CAI. **Design:** Case control study. **Setting:** Research laboratory. **Patients or Other Participants:** A total of 19 subjects with CAI [10 High (age: 26.20 ± 3.43 years; height: 171.81 ± 7.71 cm; weight: 68.05 ± 11.60 kg) and nine Low (age: 24.22 ± 2.39 years; height: 168.09 ± 7.17 cm; weight: 68.92 ± 14.48 kg)] were recruited for this study. **Interventions:** Independent variables of this study were the group (High or Low-Arch) and the time (pre or post ice immersion). Subjects placed the plantar surface of their foot in ice water for 10minutes. Before and after ice-immersion, subjects performed three trials of a 10 second single-leg stance balance test with their eyes closed while standing on an Accusway forceplate. **Main Outcome Measures:** Six center of pressure related traditional variables including center of pressure medial-lateral (M-L) range (RangeX); anterior-posterior (A-P) range (RangeY); M-L velocity (VelX); A-P velocity (VelY); M-L standard deviation (SDx); and A-P standard deviation (SDy) were measured. In addition, six time to boundary variables including M-L time to boundary (TTBx); A-P time to boundary (TTBy); M-L mean time to boundary (mean TTBx); A-P mean time to boundary (mean TTBy); M-L standard deviation time to boundary (SD TTBx); and A-P standard deviation time to boundary (SD TTBy) were measured to quantify their postural control. A 2 by 2 mixed model two-way repeated measures of ANOVA was used to analyze the differences between the group and time. **Results:** No significant interactions were found between the group and time. A main effect for time was found to be significant in SDx ($F1,17 = 22.38$; $P = .00$), SDy ($F1,17 = 20.31$; $P = .00$), RangeX ($F1,17 = 22.09$; $P = .00$), RangeY ($F1,17 = 18.10$; $P = .00$) and VelY ($F1,17 = 6.08$; $P = .02$). Post hoc analysis showed that diminished plantar cutaneous sensation resulted in increased SDx (pre: 0.7 6 ± .11; post: 0.89 ± .15), SDy (pre: 0.88 ± .11; post: 1.06 ± .19), RangeX (pre: 3.15 ± .41; post: 3.60 ± .56), RangeY (pre: 4.21 ± .60; post: 4.90 ± .82), and VelY (pre: 3.34 ± .84; post: 3.66 ± .92). However, all time to boundary variables did not have any significant differences. **Conclusions:** Importantly, low arched foot which seemed to utilize plantar cutaneous sensory input information more to maintain balance did not demonstrate postural control deficit even though plantar cutaneous sensation was eliminated. CAI in the low arched group may facilitate intrinsic muscle recruitment to maintain balance after ice immersion.

## Lateral Ankle Joint Complex Stiffness to Inversion in Those With Chronic Ankle Instability

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**Context:** In-vivo lateral ankle joint complex stiffness in those with chronic ankle instability (CAI) is poorly understood. Increased laxity is linked to decreased stiffness, but has not been demonstrated consistently in those with CAI. **Objective:** To determine if there are differences in beginning- and end-range linear stiffness values during an inversion load among several ankle injury groups. We hypothesized those with mechanical laxity would demonstrate decreased linear stiffness. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. P**atients or Other Participants:** From 93 volunteer recreational athletes, 87 meeting inclusion criteria were divided into control (n = 31), coper (n = 23), mechanical ankle instability (MAI; n = 17), and functional ankle instability (FAI; n = 16) groups (42 males, 45 females, age 20.7 ± 2.0 yrs, height 169.9 ± 9.5cm, mass 70.2 ± 13.1kg). Participants completed ≥90 minutes of physical activity/week. Controls (no history of ankle injury) and copers (1 sprain ≥12 months ago from which they recovered) scored ≥27 on the Cumberland Ankle Instability Tool (CAIT). MAI and FAI groups reported a history of moderate-severe ankle sprain ≥1 year ago, ≥2 episodes of ankle instability in the last 12 months, and scored ≤26 on the CAIT, indicating poor function. In those with ankle injury history, the MAI group was defined as the upper quartile of inversion talar tilt values to instrumented arthrometer (≥32.6°), while the FAI group was the lower 3 quartiles. **Interventions:** Participants self-reported ankle injury history and completed the CAIT, then underwent 3 trials of instrumented arthrometry testing for inversion talar tilt to the lateral ankle joint complex. A single rater (ICC2,1 >0.80) positioned the ankle in neutral and flexed the knee to 15º, then 150N load was applied to the ankle. **Main Outcome Measures:** Inversion angle (°) at 150N and linear stiffness (N/mm) values at beginning- (40-60N) and end-range (125-150N) were extracted from load-displacement curves and averaged over the last 2 trials. One-way ANOVAs with Tukey post-hoc comparisons ($\alpha = 0.05$) were applied. **Results:** Groups were not significantly different in age, mass, or height ($p > 0.05$). The MAI group beginning-range stiffness value (3.1 ± 0.6 N/mm) was significantly lower than controls (3.7 ± 0.7 N/mm) and copers (3.7 ± 1.0 N/mm; $p < 0.05$), while end-range stiffness (5.9 ± 0.9 N/mm) was significantly lower than controls (6.9 ± 1.0 N/mm) and FAI (7.0 ± 1.8 N/mm; $p < 0.05$). No other group differences were found. **Conclusions:** The MAI group demonstrated significantly decreased linear stiffness at beginning- and end-range inversion loading compared to control, coper or FAI groups. There were no differences among control, coper and FAI groups. In an MAI sub-group with demonstrable lateral complex laxity, decreased stiffness could contribute to poor joint complex response to loading. Alterations in lateral joint complex stiffness may contribute to repeated ankle injury. Future research should determine if decreases in stiffness develop after the index ankle sprain and if appropriate acute care could mitigate alterations in stiffness.

## Changes in Diagnostic Accuracy of Functional Performance Tests When Analyzing Raw Scores and Normalized Scores in People With Chronic Ankle Instability

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**Context:** Despite the common use of the SEBT, Side Hop Test (SHT), and Figure 8 Hop Test (FEHT) clinically and in research, the reported diagnostic accuracy of these tests has been poor when used to identify chronic ankle instability (CAI). It is possible that normalizing patients' performance on the involved limb to that on the uninvolved limb may improve diagnostic accuracy by controlling for variability between patients. **Objective:** To examine the effects of normalizing SEBT, SHT, and FEHT scores on the diagnostic accuracy of these tests. **Design:** Cross-sectional design. **Setting:** Controlled research laboratory. **Patients or Other Participants:** 209 recreationally active individuals (mean age = 23.03 ± 3.72 yr), 134 females (mean weight = 65.74 ± 14.54 kg, mean height = 165.26 ± 7.28 cm), 74 males (mean weight = 82.75 ± 17.73 kg, mean height = 178.80 ± 9.58 cm), participated. Participants' ankles were classified as chronically unstable (>3 sprains or > 1 sprain with reports of symptoms) or healthy (< 3 sprains and denies symptoms). **Interventions:** Participants performed the SEBT, SHT, and FEHT bilaterally as described in previous literature. SEBT reach distances were normalized to height and leg length for analysis. For the hop tests, time for completion was analyzed. **Main Outcome Measures:** For each test, the Area Under the Curve (AUC) for receiver operating characteristic curves was used to estimate accuracy and Youden's index was used to identify the cutoff score that maximized sensitivity (Sn) and specificity (Sp). Sn, Sp, and the numbers needed to diagnose (NND) were calculated for each cutoff score. Separate analyses were performed on the involved limb scores

("raw scores") and the scores of the involved limb normalized to those for the uninvolved limb ("normalized scores"). **Results:** For all directions of the SEBT, except the medial direction, the diagnostic accuracy was greater when using the normalized score (AUC = 0.58 - 0.75, NND = 2.17-4.42) compared to the raw score (AUC = 0.51 - 0.67, NND = 2.80 - 8.90). When using the normalized scores, the lateral direction (Cut-off = 0.99, AUC = 0.75, p= 0.00, Sn = 0.70 , Sp = 0.76, NND = 2.17) demonstrated the greatest diagnostic accuracy. For the two hop tests, the raw scores had greater diagnostic accuracy but the AUC for both hop tests was non-significant (side hop p = 0.08; figure of eight p = 0.11). **Conclusions:** Normalizing SEBT reach distances to the uninvolved side may improve diagnostic accuracy but it still has poor to fair diagnostic accuracy. It also appears the SHT and FEHT may not be useful diagnostic tests. Future research is necessary to identify more appropriate tests to screen for CAI or to explore how these tests may be interpreted more effectively.

### Assessment of Athletic Trainers Communication Skills in the Orthopaedic Trauma Hospital Setting


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**Context:** Anxiety in orthopaedic trauma patients is high. Medical staff communicate with patients at irregular hours. **Objective:** To assess the effect of athletic trainers' (ATs) ability to communicate with patients in the acute orthopaedic trauma setting and impact patient anxiety. **Design:** Longitudinal-cohort pilot study. **Setting:** Subjects were recruited from the University of Florida Level-I Trauma Hospital. Data were collected in the acute hospital setting and at patients' 2, 6, and 12 weeks clinical follow-up appointments. **Patients or Other Participants:** Individuals admitted to the Orthopaedic Trauma service requiring one or more surgical interventions for their orthopaedic injury and not currently receiving treatment for psychological disorders. A total of 55 patients were recruited, 46 with complete data at baseline, (average age 37.8 ± 14.1 years, 13.4 ± 3.6 years of education). Injuries of the lower extremity were most predominant (15% pelvis, 18% femur, and 33% tibia). Follow-up response rate was high; 2 weeks follow-up 71.5%, 6 weeks 72.0%, and 12 week 43.5%. **Interventions:** Two ATs worked with the Chief of Orthopaedic Trauma to facilitate communication to the patients regarding surgical interventions and addressing patient-driven questions. **Main Outcome Measures:** Dependent variables were Communication Assessment Tool (CAT) and measures of anxiety and depression (State Trait Anxiety Index; STAI and Beck Depression Inventory-II; BDI-II). The CAT was used to assess the ATs ability to communicate information and interact with orthopaedic trauma patients at the conclusion of the study. This measure is scored on a 0-5 scale; 5 being the highest (range 0-75). The STAI and BDI-II were collected at all time points. The independent variable was data collection time points (baseline, 2, 6, and 12 weeks). SPSS version 23 was used to analyze the data. General linear model with repeated measures was used to assess STAI and BDI-II scores. **Results:** All data are reported as means and standard deviations. Baseline patient population STAI was high (STAI; 39.6 ± 12.8) Wilks' Lambda = 0.033. As time progressed significant decreases (relative to baseline) in anxiety levels were noted at 6 weeks (29.7 ± 9.0; $p = 0.018$) and 12 weeks (29.2 ± 8.4; $p = 0.037$). No significant changes for BDI-II were noted; Wilks' Lambda=0.380. When asked, patients reported the ATs ability to communicate effectively was extremely high (73.9 ± 3.7). **Conclusions:** Previous studies have shown that patients have less anxiety when they feel informed and included in their healthcare. Our data suggests that ATs in the orthopaedic trauma hospital setting are effective at communicating patient injury information and decreasing patient anxiety. This was a feasibility study of ATs in the orthopaedic trauma setting. Our next step is to expand the intervention to include a control group (no AT interaction with patients), study measures and subject numbers to fully evaluate the impact of athletic trainers in this setting.

### Developing a Health Communication Intervention for Caregivers of Youth Athletes


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**Context:** Sports related brain injuries (SRBI) are considered a national health problem for youth athletes, and all 50 states have legislation geared toward education and management. Despite state laws and educational materials, experts claim caregivers of youth athletes (CYA) are not fully educated about SRBIs. CYAs exhibit a culture of resistance and skepticism towards the recognition, treatment, and management of SRBIs. As primary decision makers, it is imperative to develop a tested health communication intervention for CYAs. **Objective:** The purpose was to use a public health model to develop a theory-based SRBI communication intervention for CYAs. The Health Belief Model (HBM) and Message Source Credibility (MSC) theory guided the research. Research questions: 1) What are CYAs' perception of susceptibility/severity of SRBIs, barriers and cues to action for education, and actions post-injury (HBM model), 2) What message sources are credible? **Design:** HBM and MSC theory guided questionnaire development for small group and one-on-one interviews. A phenomenological approach was used to understand experiences CYA's had with SRBIs. **Setting:** CYAs were interviewed in Texas and California. Large cities were selected due to the abundance of youth sport participation. **Patients or Other Participants:** Thirty CYAs (3 males, 27 females) were selected using criterion sampling to find CYAs of children of all ages that played different sports. **Data Collection and Analysis:** Using the transcribed recordings, researchers used Atlas.ti software to systematically analyze the data. Two

researchers trained two coders, who coded every interview and discussed codes with the researchers. Consensus coding resolved differences. Two additional coders reviewed the codes and discussed disagreements resulting in six coders examining the transcriptions and a master set of coded interviews. **Results:** CYAs had a high-perceived severity regardless of child's sport but mixed views of susceptibility of SRBIs. Despite receiving SRBI information material from schools or youth leagues and reading or hearing Internet or media reports, CYAs consistently stated their own lack of education. There were very few recalled cues to action pre-injury confirming CYA's lack of SRBI education. The amount of information CYAs received and the source were barriers to being educated. Educational messages were considered credible when the source had specific SRBI knowledge, including their child's medical history. The most trusted sources were physicians and athletic trainers (ATs). Coaches were not trusted as they were seen as having ulterior motives. **Conclusions:** There is a gap in communication with CYAs because laws exist and educational materials are accessible but CYAs still lack an understanding of SBRIs. A health communication intervention that comes from a trusted source, like ATs, and focuses on HBM constructs, e.g., increasing perceived susceptibility, removing barriers of education, including cues to action pre-injury, and identifying steps on post-injury treatment may fill this gap.

## Athletic Trainers' Attitudes Toward Lesbian, Gay, Bisexual, and Transgender Patients

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**Context:** Healthcare professionals work with diverse patients including sexual and gender minority individuals. It is important to understand healthcare professionals' attitudes toward these populations and whether these attitudes impact their professional practice. **Objective:** This study aimed to assess attitudes toward lesbian, gay, bisexual, and transgender (LGBT) patients among certified athletic trainers in the United States. **Design:** Cross-sectional study. **Setting:** Electronic survey. **Patients or Other Participants:** A total of 26,921 certified athletic trainers who were members of the National Athletic Trainers' Association were emailed to participate in this study. We received 4,846 responses (18% response rate; age = 35 ± 10.2 years, gender = 60% women and 39% men). **Interventions:** All participants completed an online survey which included two instruments: Attitudes Toward Lesbian, Gay, and Bisexual Patients (ATLGBP) and the Attitudes Toward Transgender Patients (ATTP). Previous research has established the reliability and validity of the ATLGBP ($\alpha$ = .830) and ATTP ($\alpha$ = .834). Data were also captured form each participant regarding gender (man or woman), race/ethnicity (White/Caucasian, Hispanic/Latino, Black/African American, Asian/Asian American, Multiracial/Multiethnic, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, or other), clinical work setting (college/university, clinic, secondary school, or other), and geographic location (Northeast, Southeast, Midwest, Southwest, West, or International). **Main Outcome Measures:** Dependent variables were the responses to the ATLGBP and ATTP. Scores range from 15 to 75 for the ATLGBP and 10 to 50 for the ATTP. Lower scores reflect more positive attitudes. Both instruments utilize a Likert scale and some items are reverse scored. We utilized two MANCOVAs, one to analyze the effect of gender and race on the ATLGBP and ATTP and one to analyze the effect of athletic trainers' clinical work setting and geographic location on the ATLGBP and ATTP. **Results:** In both the ATLGBP and ATTP scores, we identified a significant difference between genders ($F_{2, 4693} = 11.35$, $p < .001$; Wilk's $\Lambda = .995$) and race/ethnicities ($F_{14, 9386} = 1.71$, $p = .047$; Wilk's $\Lambda = .995$). Women (ATLGBP = 28.52 ± 6.60; ATTP = 21.73 ± 5.96) have significantly more positive attitudes toward LGBT patients than men (ATLGBP = 32.08 ± 7.48; ATTP = 25.37 ± 6.49). Multiracial/multiethnic participants (ATTP = 20.73 ± 5.54) had significantly more positive attitudes toward transgender patients than other races/ethnicities ($p = .022$). Athletic trainer location elicited significantly different responses, ($F_{10, 9284} = 6.84$, $p < .001$; Wilk's $\Lambda = .985$). Participants in the Northeast (ATLGBP = 28.69 ± 6.75; ATTP = 22.03 ± 6.12) show more positive attitudes toward LGBT patients compared to participants in the Southeast (ATLGBP = 30.39 ± 7.14; ATTP = 23.82 ± 6.48), Southwest (ATLGBP = 31.36 ± 7.55; ATTP = 24.70 ± 6.75), and Midwest (ATLGBP = 30.23 ± 7.03; ATTP = 23.21 ± 6.27). There was no statistical significant difference between the different clinical work settings and scores on the ATLGBP and ATTP. **Conclusions:** Many athletic trainers report positive attitudes towards LGBT patients, especially women, multiracial/multiethnic individuals, and those in the Northeast. Athletic trainers' clinical work setting does not appear to have an effect on their attitudes. The results show a continuing need to provide interventions aimed at ensuring safe environments for all patients regardless of sexual orientation and gender identity.

## Athlete's Perception of Athletic Trainer Empathy: How Important Is It?

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**Context:** Patient care has experienced a paradigm shift from the disease-centric to a more patient-centered focus, making the patient the center of the health care plan. This change emphasizes that patients and caregivers communicate effectively so patients can actively participate in their healthcare decision processes. Practitioner empathy is an important factor in this communication. Empathy has been correlated with improved patient compliance and positive treatment outcomes. Furthermore, in the field of counseling a predictive relationship exists between clients' ratings of their clinician's empathy and treatment outcomes, which is more important than how clinicians rate themselves. Despite the positive benefits, there is a dearth of studies examining empathy using qualitative methodology and factors of empathy in athletic training. **Objective:** The purpose of this research was to gain an understanding of athletes' perceptions of empathy in the patient-clinician relationship. **Design:** Qualitative interviews were completed using grounded theory techniques. **Setting:** A quiet office. Patients or Other Participants: A typical, purposeful sample of 15 college-aged Division I student-athletes (8 females; 7 males; 19.3 ± 1.2 yrs) from a variety of sports (football, wrestling, volleyball, baseball, etc.) participated in an interview. **Data Collection and Analysis:** Interview questions were targeted to better understand the definition and factors of empathy related to athletic training. We used a detailed literature search in other healthcare settings to develop the semi-structured interview protocol. The protocol was used to establish a concept of empathy to help facilitate discussion of ideas. Data was transcribed verbatim and coded. Coded data was analyzed for themes and patterns using grounded theory techniques. Trustworthiness of the data was ensured using an external auditor, member checks, and methods triangulation. **Results:** The interviews revealed three themes that facilitated empathy: advocacy, communication, and approachability. Advocacy was described as the athletic trainer representing the patient. Communication was the ability of the athletic trainer to effectively listen and disclose information while approachability was described as the comfort and personal connection the patient felt while working with the athletic trainer. In addition, patient's felt that access and technical competence needed to be established before empathy could be developed. **Conclusions:** Developing a good patient-clinician relationship is critical in facilitating best treatment outcomes. ATs portray empathy through these skills: advocacy, communication, and approachability which improves the patient-clinician relationship making them critical in care delivered by ATs. Therefore, educational programs need to intentionally include course work and activities to develop such skills.

## Requirements for Sports Medicine Professionals in Central and South America

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**Context:** The globalization of athletic training and therapy has emerged in recent years. In general, athletic health care is somewhat standardized in North America, specifically the United States, Canada, and in parts of Europe, while other nations/regions are slow to formalize such a position/profession in their countries. While sports medicine is not a new concept around the world, information about sports medicine professionals (SMP) is not easily identifiable. **Objective:** To identify formalized disciplines and expectations among sports medicine professionals in Central and South America. **Design:** Qualitative analysis. **Setting:** Document review. **Patients or Other Participants:** The study targeted countries with English, Spanish, or Portuguese as the primary language. Countries included in the study from Central and South America were Cuba, Costa Rica, Puerto Rico, Guatemala, Mexico, Brazil, Chile, and Argentina. **Data Collection and Analysis:** Data were included based on availability of documents. Search terms included sports medicine professionals, physiotherapist, sports medicine universities in South America, and kinesiologist in South America in a web search query to identify relevant documents for review. The principle documents reviewed included professional organization websites, educational curricula, and university web pages. **Results:** Through our search we were unable to find a specific sports medicine professional in Central and South America who provided athletic health care in the same way athletic trainers/therapists do. We were able to identify that sports medicine was more often a specialty area for other healthcare providers (i.e., physicians, physical

therapists, kinesiologists). Because of this, the educational requirements and scope of practice for SMPs is substantially different than in North America. In Cuba, physicians must hold a master's degree in sports medicine whereas in Mexico and Guatemala a physician must complete 3-6 years of postgraduate studies (much like a residency) in sports medicine to be considered a SMP. In Brazil SMPs study to become physical therapists with a specialty in sports medicine. Regulation, like certification and licensure, also differs in Central and South America. In Costa Rica and Puerto Rico SMPs receive specialties and degrees through board certification. In Brazil and Chile, certification is completed through membership in SMP organizations, some of which only requires payment, while others require professionals to meet specific criteria. Only Brazil specifies that SMPs can work in prevention and emergency care, while Argentina and Chile focus on evaluation, diagnosis, and treatment of musculoskeletal injuries. Professional organizations were the main source of standardization for SMPs' educational requirements, certification, and scope of practice. **Conclusions:** It is evident that there is no discipline like Athletic Training/Therapy in Central and South America. SMPs are trained in other disciplines such as physician or physical therapist and then complete specialty certificates or join sports medicine organizations. Central and South America may be an area of potential growth for athletic training/therapy.

## Perceived Susceptibility of Torso Injuries Among High and Middle School Football Players

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**Context:** Prior to this project, the Taylor Haugen Foundation distributed over 1000 torso protectors to football and baseball players. The researchers investigated the effectiveness of providing torso protectors to football players. Contact injuries account for 58% of injuries during athletic events and 41.6% of injuries during athletic practices (Hootman, Dick, and Agel, 2007). Trunk/Back injuries account for 13.2% of injuries during games and 10% of injuries during practices compared to head and neck injuries which account for 9.8% of game injuries and 12.8% of practice injuries (Hootman, Dick, and Agel, 2007). **Objective:** The research questions for this project were: 1) When provided a torso protector, will it be worn in practice and games? 2) What are the reasons football players choose to not wear torso protective equipment? **Design:** This project used a cross-sectional survey design. **Setting:** High schools and middle schools located in a two county area of northwest Florida. **Patients or Other Participants:** 302 football players participated in the pre-questionnaire and 113 participated in the post-questionnaire each group were a voluntary cluster sample. The average age was 14.87 years old and had 6-7 years of sport participation. 77% of the participants were white and 20% were African American. **Interventions:** The questionnaire was administered in person by one researcher. The survey was created through a literature review which identified similar projects. The questions and language of the instrument was altered based on the outcomes of two focus groups conducted at different times with two different groups. The demographics of the focus groups were consistent with the participants of the study. Validity was determined using two disciplinary related professionals, who analyzed the format and content of the questionnaire. It was determined that the content addressed the objectives and was formatted appropriately. Pearson's correlation of .225-.741 demonstrates reliability of the non-demographic questions. **Main Outcome Measures:** Student action is the dependent variable being addressed in this study. The student athlete was given the torso protector (IV) and the questionnaire was designed to determine if the IV influences the decision (DV) of the athlete. **Results:** The top three reasons athletes gave as motivators to wear protective equipment was "If it prevented injury," "feeling safe," and "History of previous injury." 52% reported always wearing the protective equipment during practice and 83% reported always wearing it during games. Athletes who choose not to wear the protective equipment cited it being too hot (24%), too uncomfortable (11%), and too restrictive (8%) as the most common reasons. **Conclusions:** This study shows that, if provided proper protective equipment, a majority of football players will wear the equipment consistently. The athletes who did not wear the equipment could be swayed through proper educational intervention that demonstrates the benefits and safety outcomes.

## Examination of Depression, Low Self-Esteem, and Eating Disorder Risk Among Collegiate Female and Male Swimmers and Divers

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**Context:** Participation in aesthetic and endurance sports may place additional pressures on athletes to be thin. These pressures may increase the likelihood of athletes resorting to drastic weight control measures, such as eating disorder (ED) behaviors, and increase risk for mental health issues (e.g., depression and low self-esteem [LSE]). **Objective:** To estimate EDs, depression, and LSE prevalence among male and female collegiate swimmers and divers. A secondary purpose examined differences between gender, sport type and academic status among EDs, depression, and LSE risk. **Design:** Cross-sectional study. **Setting:** NCAA Division I institutions. **Patients or Other Participants:** Collegiate swimmers and divers (n = 310; males: n = 99, age: 19.6 ± 1.3 years, height: 183.7 ± 7.6cm, weight: 79.1 ± 8.1kg; females: n = 211, age: 19.6 ± 1.4 years, height: 170.2 ± 6.8cm, weight: 65.9 ± 8.1kg) across 12 NCAA Division I institutions participated in an online survey. Sport and academic status distribution included: Men's Diving (MD, n = 12) and Swimming (MS: n = 87); Women's Diving (WD: n = 27) and Swimming (WS: n = 184); freshman (n = 92), sophomores (n = 97), juniors (n = 63), and seniors (n = 58). The response rate was 39.7% (n = 310/780). **Interventions:** Participants completed an online survey which consisted of: self-reporting height and weight, and completed the Eating Attitudes Test, Center for Epidemiological Depression Scale, and the Rosenburg Self-Esteem Scale. Independent variables included sport position and academic status. **Main Outcome Measures:** Crosstabulations examined the proportion of participants classified as at risk for EDs, depression, and LSE. Chi-square analyses examined differences in sport position and academic status. Odds ratios determined risk between co-morbid factors (ED, depression, LSE). **Results:** Overall prevalence was estimated: 41.3% (n = 128) for ED risk; 21.5% (n = 58) for depression, and 8.5% (n = 25) for LSE. Females reported a significantly higher ED risk ($\chi 2$ = 7.24, P = .007: 31.6% vs. 9.7%) and depression ($\chi 2$ = 6.73, P = .009: 18.1% vs. 3.3%) compared to males. WS reported a significant higher EDs risk ($\chi 2$ = 8.3, P = .04: 27.7%) and depression ($\chi 2$ = 9.1, P = .03: 15.2%) compared to WD, MD, MS. No significant differences were found between gender and LSE, sport type and LSE, and academic status for depression, LSE, and ED risk. All athletes reported 6.3% (n = 18) binging, 6.1% (n = 19) self-induced vomiting, 5.8% (n = 18) diet pills, laxatives, or diuretics use, and 10.3% (n = 32) engaged in excessive exercise to control weight. Odd ratios revealed if an athlete reported LSE they were 33.9X more likely to have depression symptoms and 3.4X likely to be at risk for an ED. If at risk for an ED, the athlete was 3.0X likely to be at risk for depression. **Conclusions:** Male and female swimming and diving athletes are an at risk population for depression, LSE and EDs. Athletes who displayed a high risk for LSE, also displayed a high co-morbidity risk with depression. Therefore, it is imperative health care providers recognize mental health risk in athletes and provide appropriate care when necessary.

## Baseline Concussion Performance Does Not Differ Between ACL Injured and Non-ACL Injured Athletes


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**Context:** Prior to participating in sport, student-athletes are often required to complete baseline concussion assessments, including symptom, balance, and neurocognitive assessments. Previous literature suggests that poorer baseline neurocognitive performance may be an indicator of anterior cruciate ligament (ACL) injury risk. It seems possible that athletes with poorer performance on measures, such as balance, reaction time, and impulsivity, may be at increased risk of knee injury. Although intended to be used as a comparison point if an athlete sustains a concussion, baseline concussion assessment values may also be useful for identifying whether an athlete is at risk for sustaining a musculoskeletal injury. **Objective:** To determine whether athletes that sustained an ACL injury present with poorer performance on baseline concussion assessments compared to matched controls. **Design:** Prospective cohort. **Setting:** Clinical Research Laboratory. **Patients or other Participants:** Twenty-two division I collegiate athletes that sustained an ACL injury (height = 72.1 ± 4.4 cm, mass = 92.9 ± 22.0 kg, age = 19.2 ± 0.9 years) and 22 control participants matched on sport, position, and age at baseline (height = 72.0 ± 3.8 cm, mass = 96.5 ± 26.4 kg, age = 19.2 ± 0.9 years). **Interventions:** Prior to participation in sport, student-athletes completed a baseline concussion protocol including a graded symptom checklist, balance assessment (Sensory Organization Test), and neurocognitive assessment (Immediate Post-Concussion Assessment and Cognitive Testing). A retrospective chart review was performed to identify athletes that sustained an ACL injury after completing their baseline assessment. **Main Outcome Measures:** We compared the total symptom score, sensory organization test composite score (unitless), and the following neurocognitive domain composite scores (unitless): verbal memory, visual memory, visual motor speed, reaction time, and impulse control between the ACL injured group and control group using seven separate one-way ANOVAs ($\alpha = 0.05$). **Results:** Groups did not significantly differ in height, mass, age, total symptom score, or balance performance. The injured group (0.56 ± 0.10) presented with significantly quicker reaction time at baseline compared to the control group (0.62 ± 0.10, $F_{1,42} = 4.97$, $p = 0.031$). Groups did not significantly differ on any other neurocognitive domains. **Conclusions:** Individuals that sustained an ACL injury did not present with poorer baseline concussion assessment performance compared to matched controls. Contrary to our hypothesis, atudent-athletes that sustained an ACL injury performed slightly better on reaction time measures at baseline. However, reaction time differences between groups were small. It is possible that athletes with better reaction time gain more playing time and are, therefore, more exposed to ACL injury. Our results do not support previous literature that suggests that neurocognitive performance differs between ACL and non-ACL injured athletes. More research is needed to investigate whether baseline concussion assessments may differentiate between contact versus non-contact ACL injury risk.

## Effect of Concussion History on Neurocognitive and Neuromuscular Function of College Football Players


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**Context:** Sport-related concussion impairs cognitive function, postural balance, and reaction time, and, if not corrected post-injury, can lead to increased risk of subsequent musculoskeletal injury. An athlete's ability to perceive and respond to stimuli in the peripheral visual field may also play a role in increasing injury risk. **Objective:** To identify any associations between concussion history, neurocognitive function, neuromuscular control, and incidence of core or lower extremity (Core/LE) injury among college football players. **Design:** Case-control. **Setting:** Sports Medicine Clinic. **Patients or Other Participants:** 17 NCAA Division-I football players with history of concussion and 17 age-matched controls with no history of concussion (Concussion group: age: 20.2 ± 1.3 years; Control group: age: 19.4 ± 1.1 years). Concussion history was assessed during pre-participation screening prior to the preseason training period. **Interventions:** Prior to the initiation of preseason training, all participants underwent baseline neurocognitive assessments using the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT). Additionally, participants completed Dynavision® testing including specific assessment of peripheral and central visual detection. A 60-second unilateral squat hold (USH) was also completed for each limb. **Main Outcome Measures:** Composite scores for verbal memory, visual memory, visual-motor processing speed, reaction time, and impulse control were obtained from ImPACT test results.

Central and peripheral detection time (milliseconds) was quantified during Dynavision® testing and defined as the time elapsed from target illumination to the release of a depressed button. During the USH, the time to loss of balance (seconds) and sway variability was measured using a tablet application and internal accelerometer. Sway variability represents the standard deviation of acceleration experienced during each USH. Greater variability implies reduced postural control. All Core/LE injuries were documented throughout the season. Receiver operating characteristic (ROC) analyses and logistical regression were used to identify models that provided maximum discrimination between those with history of concussion and those without. **Results:** A 4-factor ($X^2 = 11.04$, $P = 0.026$) prediction model was identified using cut-offs of <23s for USH time-to-failure (ORadj = 5.68), >298ms for peripheral visual detection time (ORadj = 3.23), <73.5 for visual memory composite (ORadj = 3.11), and >675ms for reaction time (ORadj = 2.27). Participants who had >2 and those with >3 of these four factors were 7.8 (90% CI = 2.16-28.19) times and 14.22 (90% CI = 2.18-92.69) times more likely to have prior history of concussion, respectively. Concussion history was also associated with an increased risk of Core/LE sprain or strain (OR = 8.56, 90% CI = 2.24-32.63). **Conclusions:** These results suggest that concussion history is a risk factor for Core/LE injury. It is unclear whether deficits in cognitive function, reaction time, and postural control predispose athletes to concussion or if these deficits are solely a product of concussive injury. Athletic trainers should use this information to formulate both prophylactic and post-injury training protocols to reduce concussion risk and to potentially reduce musculoskeletal injury risk post-concussion.

## Lower Extremity Strength Changes Across the Competitive Season in Football Players With and Without Concussion

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**Context:** Neuroanatomical, neurophysiological, and neurometabolic alterations have been found in the primary motor cortex in athletes following concussion. Limited evidence also suggests decreased strength post-concussion. Strength changes have been shown across a competitive season in athletes without a concussion. It is unknown if strength changes in athletes with a concussion differ from strength changes in uninjured controls. **Objective:** To compare changes in lower extremity strength across the competitive season in football players with a recent concussion to uninjured controls. **Design:** Case-control with repeated measures study. **Setting:** UF Health Orthopaedics and Sports Medicine Institute **Patients or Other Participants:** Male Division I football players who sustained a concussion within 180 days to the end of the season (CONC, n = 16, age = 19.7 ± 1 years) and uninjured controls matched by age, weight, position, and season (UNINJ, n = 16, age = 19 ± 1.2 years). **Interventions:** Knee flexor and extensor torques were measured at pre- and post-season sessions with an isokinetic dynamometer set at 60 deg/sec. **Main Outcome Measures:** Peak torques of the knee flexors and extensors were normalized to bodyweight (BW) and averaged between right and left sides. Additionally, side-to-side asymmetries in knee flexor and extensor torques were calculated as: absolute value [(peak torque right side – peak torque left side)/BW x 100%)]. A mixed design repeated measures ANOVA determined group and time changes in lower extremity strength. **Results:** In CONC subjects the average time from concussion to the post-season session was 98.7 ± 45.4 days, and time loss from concussion was 8.8 ± 8.8 days. There was a significant group x time interaction for knee extensor asymmetry ($F_{1,30} = 9.7$; $p < 0.01$) and knee flexor torque ($F_{1,30} = 5.44$; $p = 0.02$). In CONC subjects, knee extensor side-to-side asymmetry increased 9.0 ± 13.1% and knee flexor peak torque decreased 3.0 ± 8.9 BW between test sessions. The main effect for time was significant for knee extensor torque, as values decreased from pre- to post-season sessions in both CONC and UNINJ subjects (Pre: 98.3 ± 18.7 BW vs Post: 81.5 ± 15.5 BW; $F_{1,30} = 7.6$; $p < 0.01$). The group x time interaction was not significant for knee extensor torque or knee flexor asymmetry ($p > 0.06$). **Conclusions:** CONC subjects demonstrated greater knee extensor asymmetry and reduced knee flexor torque compared to UNINJ subjects. Altered quadriceps and hamstring strength following concussion may affect movement patterns and potentially increase the risk of lower extremity injury. Neuromuscular training may need to be included in clinical practice to decrease the risk of lower extremity injury following concussion.

## Is Current Legislation Up-to-Date on Concussion Management?

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**Context:** Results vary in attempts to educate stakeholders in concussion management. Parents are able to identify signs (21.25%) and symptoms (20.41%) of concussion correctly. Coaches (77%) felt more prepared to identify S&S after "Heads Up: Concussion in Youth Sport", but 35% were still not removing from play. After the Zachary Lystedt Law passed in 2009, parents, coaches, volunteers reported being aware of the seriousness of concussion (93%). The current National Athletic Trainers' Association (NATA) Position Statement: Management of Sport Concussion and The Consensus Statement on Concussion in Sport: The 4th International Conference on Concussion in Sport identify standards of care for concussion management, yet to date there is no literature examining if current legislation is upholding these standards. **Objective:** We aimed to evaluate current United States concussion legislation while determining both similarities and inconsistencies between states, while also comparing legislation to the Consensus Statement on Concussion in Sport and the NATA National Position Statement. **Design:** A web-based descriptive approach was used to evaluate differences among current legislature. **Setting:** Web searches. **Patients or Other Participants:** Each of the 50 states and Washington DC were searched for concussion legislation. **Interventions:** Concussion legislation was retrieved from web sites for each of the 50 states and Washington DC. Arkansas was excluded for purposes of this study because a pilot project for concussion management was the only identifiable legislative bill. **Main Outcome Measures:** Data were analyzed by frequency counts to determine percentages of concussion training, concussion education, immediate removal after suspected concussion, concussion clearance, return to play guidelines, and the age ranges to which the legislation applies to in each state. **Results:** Concussion education, training in concussion, authority to clear from concussive injury, and a progressive return to play varies within state legislature. One hundred percent of states mandate immediate removal for an athlete with a suspected concussion. A "licensed health care provider" is authorized to clear an athlete after a suspected concussion, yet the term varies between states (e.g., physician 54%, physician assistant 28%, nurse practitioner 26%), whereas 26% of legislation does not identify a definition. Sixty-eight percent of legislation requires the licensed health care provider to be trained in evaluation and management of concussion, yet only 10% of those legislations define the training. **Conclusions:** Uniformity in concussion management legislation is lacking. States vary in education, training, authorization for return to play, and having a developed return to play protocol. These discrepancies describe a lack of standard of care, and thus warrant the need to update the legislation to adhere to the current standards of practice.

## Investigation of the Concussion Goggle™ Education Program With High School Athletic Teams: A Pilot Study

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**Context:** Many researchers have investigated different types of concussion education programs with various populations across the country with mixed results. What defines an effective concussion education program has yet to be determined. To date, no research has been published using the Concussion Goggles™ or the educational program associated with the Concussion Goggles™. **Objective:** The purpose of this study was to compare high school soccer and basketball athletes' knowledge about concussions before and after attending a concussion education program using the Concussion Goggles™. The researchers hypothesized that there would be a statistically significant improvement in the participants' scores after attending the educational session. **Design:** Pre- posttest. **Setting:** Public high school. **Patients or Other Participants:** 41 secondary school students (14 girls soccer players, 14 boys basketball players, and 13 girls basketball players) with a mean age of 15.37 ± 1.22. **Interventions:** The concussion educational session included PowerPoint slides with 3 activities using the Concussion Goggles™ and short video segments within the presentation. The interactive activities were intended to allow participants to feel what it might be like to have a concussion with altered vision and coordination through the Concussion Goggles™ and to increase dialog about concussions. The PowerPoint addressed how a concussion can occur, signs and symptoms, prevention, and what to do if a concussion occurs. At the end of the presentation and activities there was time for participants to ask questions. **Main Outcome Measures:** Participants completed a test developed by the manufacturers of

the Concussion Goggles™ and the educational program. The test asked 13 true or false questions about general concussion knowledge. Statistical significance between the overall pre- and posttest scores was determined using paired sample t-Test. The Wilcoxon Signed Ranks Test was used to determine if a significant difference existed in the pre- and posttest scores of the individual test questions due to the educational program. **Results:** A statistically significant difference between the overall pretest (9.37 ± 1.20) and posttest (9.63 ± 1.04) scores was not found ($t = -1.451$, $p = 0.155$). Statistically significant difference in pre- and posttest scores for question 1 ($Z = -2.00$, $p = 0.046$) question 7 ($Z = -2.11$, $p = 0.035$) and question 11 ($Z = -2.673$, $p = 0.008$) were found. All other questions did not show a statistically significant difference between the pre- and posttest scores. **Conclusions:** The Concussion Goggle™ education program did not affect participant knowledge of concussions in the posttest. In its current form, the Concussion Goggle™ program may not be an effective concussion education program. Investigation of incident of concussions and concussion reporting data after athletes attend a concussion education program along with their knowledge about the importance of reporting them needs to be assessed.

## Comparing the Material Properties of Various Athletic Helmet Protective Outer Shells

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**Context:** Athletic helmets have evolved over time, which has resulted in modifications in an attempt to increase the safety of athletes through improved designs. However, it remains unknown how the material properties of helmet shells from different sports compare. **Objective:** Compare the material properties of the protective outer shells of various athletic helmets in their final, fully manufactured form using nanoindentation methods. **Design:** Descriptive laboratory study **Setting:** Mechanical engineering laboratory **Patients or Other Participants:** Bauer RE-AKT hockey helmet, Cascade R lacrosse helmet, and Riddell Speed Flex football helmet. We acquired all helmets in new condition directly from the respective manufacturers. **Interventions:** We cut sections from each of the 3 different helmets at 4 different locations (front, side, top, rear) for 18 total samples. We potted the samples from each of the 3 helmet models from one location in an epoxy mold (puck) for a total of 4 pucks. Each puck was then put through multiple sandings and polishings to remove blemishes on the surface of the samples. The different helmet brands and locations served as the independent variables. **Main Outcome Measures:** We measured stiffness2/load (ratio of elastic modulus to flow stress), phase angle (relative level of damping in material), hardness (effort required to indent), and modulus (intrinsic stiffness) using nanoindentation. The iNano nanoindentation system (Nanomechanics, Oak Ridge, TN) was used to apply forces measuring only a few millinewtons. We ran a repeated measures ANOVA to compare each of the dependent variables for each of the 3 helmets across the 4 different locations. We used a one-way ANOVA to follow-up significant interactions. **Results:** The interaction between helmet type and location was significant for the modulus ($F_{6,63} = 6.412$, $P < .001$, $\Omega = .02$), hardness ($F_{6,63} = 6.412$, $P < .017$, $\Omega = .01$), phase angle ($F_{6,63} = 6.412$, $P < .001$, $\Omega = .003$), and stiffness2/load ($F_{6,63} = 6.412$, $P < .001$, $\Omega = .07$). One-way ANOVAs revealed significant differences between helmet brands at each location for all 4 of the dependent variables ($P < .001$). When comparing the 3 helmets, the Riddell Speedflex yielded the highest modulus and hardness measurements and the lowest phase angle and stiffness2/load measurements for all 4 locations. The Bauer RE-AKT yielded the highest phase angle measurements and the lowest hardness and modulus measurements at all locations. The Cascade R yielded the highest results for SSOP for the 4 locations measured. **Conclusions:** Significant differences in mechanical properties were found when comparing locations of the same helmet and when comparing the same location of different helmets. Further investigation of helmet designs and mechanical properties is warranted to determine how these properties relate to performance and if new modifications can be made to improve protective athletic helmet performance.

## An Assessment of Helmet Fit Among Youth Hockey Players

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**Context:** Ice hockey is a collision sport requiring full body equipment at all competitive levels. Even in youth ice hockey, where body checking is not allowed until the age of 13, considerable contact and incidental collisions occur. The proper fit of equipment, especially the helmet, is an important factor in injury prevention (Williams et al., 2014). However, at the youth level, unlike at higher competitive levels, there is a lack of trained personnel to assure a proper fit of any protective equipment. It is currently unknown what portion of youth ice hockey players are wearing a properly-fitted helmet. **Objective:** The purpose of this study was to determine the percentage of youth ice hockey players that were playing with properly fitted helmets. **Design:** A cross-sectional study using a novel helmet fit checklist to collect data. Purposeful sampling was utilized to obtain volunteer participants. **Setting:** A multi-rink ice hockey arena in western Massachusetts. **Patients or Other Participants:** Fifty youth ice hockey players from western Massachusetts volunteered to participate in the study. The mean age of the participants was 8.9 +/- 2.2 years and the range was 4-15years. **Interventions:** A helmet fit checklist (Williams 2014) was adapted and used to assess helmet fit. **Main Outcome Measures:** Descriptive statistics were calculated for each of the 13 different criteria on the helmet fit checklist. Helmets were required to fit snugly with the chin cup centered in the chin and the straps present and tight enough to ensure minimal motion on the head in order to pass the fit assessment. **Results:** Eleven out of 50 helmets were fitted properly leaving the other 39/50 to be improperly fitted in at least one aspect of the helmet fit checklist. Twenty-one out of 50 had improperly fitted chinstraps, 21/50 had a loose fitted chin cup, 13/50 did not have a 2 fingers width space between front of helmet and eyebrows. Nine out of 50 of the helmets were not stable with rotational movement, and 25/50 the helmets did not have a snug fit on the participants' head. **Conclusions:** A high percentage of youth ice hockey players were found to be playing with improperly fitted helmets. It is speculated that some parents might purchase larger equipment that the young players can "grow into", causing the large number of improperly fit helmets. Helmets are designed to prevent traumatic injuries, such as skull and facial fractures, but when helmets are not fitted properly they may not be as efficient at preventing these types of injuries. While it is unknown the extent to which helmets can prevent traumatic injuries, there is a consensus that a properly fitted helmet would be more effective at preventing injuries than an improperly fitted helmet.

## Association Between Student-Athletes' Demographics, Injury Factors and Post-Concussion Symptom Burden in the Primary Care Setting

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**Context:** Concussions are a growing concern among youth athletes and are often evaluated and treated in primary care clinics, yet few studies have examined concussions in this setting. In order to improve clinical decision making, it is imperative to better understand factors that affect initial concussion presentation and patient outcomes. **Objective:** To examine the relationship between demographic factors, injury factors, and symptom burden presentation at initial concussion office visit among pediatric and adolescent student-athletes. **Design:** Prospective cohort study. **Setting:** Primary Care Clinic. **Patients or Other Participants:** A prospective cohort of pediatric and adolescent student-athletes ages 8-18 years, presenting to the primary care setting within 3 days of a sport-related concussion, and consenting to participate in the study (n = 133; age = 14.3 ± 2.0 years). **Interventions:** Participants completed a standardized initial concussion visit, including a thorough medical and injury history, clinical exam, symptom checklist, and standardized testing. Certified athletic trainers completed data collection at the initial visit. Predictor variables in the multiple linear regression models included gender (female vs. male), age (8-14 years vs. 15-18 years), history of head injury (yes vs. no), amnesia (yes vs. no), and loss of consciousness (yes vs. no). **Main Outcome Measures:** The primary outcome was total symptom burden at initial clinical presentation. Secondary outcomes were symptom cluster burdens at initial presentation: cognitive-migraine-fatigue

(CMF–headache, dizziness, fatigue, drowsiness, sensitivity to light/noise, feeling slowed down, and difficulty remembering/concentrating), affective (AFF–sadness, nervousness, feeling more emotional), somatic (SOM–vomiting, numbness/tingling), and sleep (SLP–trouble falling asleep, sleeping less than usual). Five separate multiple linear regression models were used to predict total symptom burden and symptom cluster burdens (CMF, SOM, AFF, SLP) at initial visit. An a priori alpha level of 0.05 was used. **Results:** A total of 131/133 patients had valid outcomes for study variables. Fifty-six (42.8%) were female, 16 (12.2%) had amnesia, 10 (7.9%) had LOC, and 46 (35.1%) had a previous history of head injury/concussion. Average total symptom cluster burdens in the sample were: Total burden = 27.3 ± 21.3; CMF burden = 17.3 ± 11.5; AFF burden = 1.2 ± 2.6; SOM burden = 0.3 ± 0.9; SLP burden = 1.1 ± 2.3. In the models with all predictors, being female was associated with greater total symptom burden (Beta = 11.9 ; P = 0.001; Female = 34.1 ± 25.1 vs. Male = 22.3 ± 16.4), greater CMF symptom burden (Beta = 6.1 ; P = 0.002; Female = 20.7 ± 12.5 vs. Male = 14.6 ± 9.9), AFF symptom burden (Beta = 1.6 ; P = 0.001; Female = 2.1 ± 3.5 vs Male = 0.5 ± 1.3), and SLP symptom burden (Beta = 0.9 ; P = 0.024; Female = 1.7 ± 2.8 vs. Male = 0.7 ± 1.7). No other associations with symptom burden were observed. **Conclusions:** Gender is the factor most strongly associated with symptom burden and burden of symptoms in specified clusters. These findings further support the importance of considering gender in clinical decision making post-concussion.

## Association Between Student-Athletes' Demographics, Symptom Cluster Presentation, and Neurocognitive Performance Post-Concussion in the Primary Care Setting

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**Context:** Few studies have examined concussion in the primary care setting, yet following initial field evaluation, this is often the first physician point of contact post-concussion. Understanding factors affecting presentation and outcomes in these patients is key to improving concussion care. **Objective:** To examine the association between demographic factors, symptom cluster presentation, and neurocognitive performance at initial office visit for concussion among pediatric and adolescent student-athletes. **Design:** Prospective cohort study. **Setting:** Primary Care Clinic. **Patients or Other Participants:** Pediatric and adolescent student-athletes ages 8-18, presenting to the primary care setting within 3 days of a sport-related concussion, and consenting to participate in the study (n = 133; age = 14.3 ± 2.0 years; 75 males). Patients with invalid neurocognitive scores were excluded (n = 2; final n = 131). **Interventions:** Participants completed a standardized initial concussion visit, including a clinical exam and standardized testing that included a symptom checklist and the Immediate Post-Concussion and Cognitive Test (ImPACT). Certified athletic trainers collected data at the initial visit. Predictor variables in the univariate and multivariate analyses included age, gender, and the following symptom cluster burden scores: cognitive-migraine-fatigue (CMF–headache, dizziness, fatigue, drowsiness, sensitivity to light/noise, feeling slowed down, and difficulty remembering/concentrating), affective (AFF–sadness, nervousness, feeling more emotional), somatic (SOM–vomiting, numbness/tingling), and sleep (SLP–trouble falling asleep, sleeping less than usual). **Main Outcome Measures:** The primary outcomes included the four ImPACT composite scores of verbal memory, visual memory, reaction time, and processing speed. Univariate correlations for all predictors and outcomes were conducted. Multivariable linear regression models were utilized to predict each of the four ImPACT composite scores. An a priori alpha level of 0.05 was used. **Results:** Mean ImPACT scores were: visual memory = 71.8 ± 13.9; verbal memory = 81.8 ± 12.4; reaction time = 0.7 ± 0.2; processing speed = 33.7 ± 8.1. Mean total symptom and cluster burdens were: Total burden = 27.3 ± 21.3; CMF burden = 17.3 ± 11.5; AFF burden = 1.2 ± 2.6; SOM burden = 0.3 ± 0.9; SLP burden = 1.1 ± 2.3. Increased CMF burden was associated with slower reaction time scores (Beta = 0.005; P = 0.007), and lower visual memory scores (Beta = -0.392 ; P = 0.003), lower verbal memory scores (Beta = -0.271; P = 0.024), and lower processing speed scores (Beta = -0.210; P = 0.006). Older age was associated with higher visual memory scores (Beta = 1.384; P = 0.034), higher verbal memory scores scores (Beta = 1.869; P = 0.002), and higher processing speed scores (Beta = 1.573; P < 0.001). No other associations were observed (P > 0.05). While gender was associated at the univariate level with visual and verbal memory, it was not significant in any multivariable model. **Conclusions:** There is significant variability in symptom presentation following concussion in primary care concussion patients. The CMF symptom cluster was more strongly associated with neurocognitive outcomes than other symptoms. Age was also a factor of consideration. Student-athletes with the CMF cluster of symptoms may need closer observation and specific academic adjustments based on their reported symptoms. Clinicians should be mindful of symptom cluster presentation and age when developing management plans.

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**Learning Objective:**

At the conclusion of the program, participants will be able to describe demographic and symptom-related factors associated with neurocognitive outcomes acutely following concussion in young student-athletes.

**References:**

1. Broglio SP, Cantu RC, Gioia GA, et al. National athletic trainers' association position statement: management of sport concussion. J Athl Train. 2014;49(2):245-265.

2. Kontos AP, Covassin T, Elbin RJ, et al. Depression and neurocognitive performance after concussion among male and female high school and collegiate athletes. Arch Phys Med Rehabil. 2012;93:1751-1756.

## Measurement of Sleep Quantity and Quality During Acute Concussion Via Actigraphy

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**Context:** Sleep disruption following concussion is common and long-lasting, yet the acute effects on sleep (<1 month post-injury) are unclear. **Objective:** To quantify sleep quantity and quality differences between concussed and healthy control individuals within the first week and at one month from injury. **Design:** Case-control repeated- measures. **Setting:** Continuous monitoring during daily activities. **Patients or Other Participants:** University Sports Medicine referred four concussed participants (age: 22.4 ± 1.4; days from injury: 1.8 ± 1.5). Ten control participants (age: 24.1 ± 1.9) were also tested. **Interventions:** Participants completed i) two 5-day sleep monitoring sessions: Session one (S1) upon referral and session two (S2) 30 days from the injury date; and ii) sleep journals, noting in-bed and wake times for all sleep periods. Daily sleep and wake periods were quantified relative to journal records using an actigraph on the dominant wrist. **Main Outcome Measures:** Total minutes of sleep including daytime naps (TST), total minutes of nighttime sleep (nTST), minutes awake after sleep onset (WASO), and sleep efficiency (percentage of total time asleep/total time in bed; EFF) were extracted from the actigraphic data. Given the small sample and high day-to-day variability, data are reported as the mean and range of individual standard deviations. **Results:** For total sleep time (TST minutes), concussed participants were more variable (standard deviation; range) than control participants during S1 (concussed = 99.2; 34.8-168.5 vs. control = 51.0; 22.1-87.8) and S2 (concussed = 90.8; 23.5-130.4 vs control = 58.8; 28.9-90.5). Nighttime total sleep time (nTST minutes) were also more variable for concussed participants relative to control participants during S1 (concussed = 107.6; 21.6-196.4 vs. control = 45.3; 22.1-87.8) and S2 (concussed = 93.3; 27.3-135.8 vs. control = 56.4; 26.9-89.7). Thus, sleep quantity may be more variable immediately following concussion. In contrast, however, post-concussive variability in sleep quality was comparable to control participants during S1 for both WASO minutes (concussed = 14.4; 7.8-23.4 vs. control = 16.1; 6.5-32.4) and EFF percentage (concussed = 3.3; 1.4-4.4 vs. control = 2.9; 0.7-5.9). Sleep quality during S2 also showed comparable variability between the groups for WASO (concussed = 21.7; 11.9-31.0 vs. control = 23.4; 2.1-42.9) and EFF (concussed = 5.2; 1.0-9.8 vs. control = 4.8; 0.8-11.0). **Conclusions:** Concussed individuals may exhibit high degrees of day-to-day variability in sleep quantity, even one month post injury. When concussed individuals do sleep, however, the day-to-day variability in sleep quality (WASO and EFF) appears relatively unaffected. Collectively, these data provide preliminary evidence of altered day-to-day sleeping habits for concussed individuals at the time of injury and that persist at one month from injury. Caveat: Recruitment for concussed individuals is in progress, as evidenced by the small current sample, and is part of an ongoing study (NATA Grant# 14DGP013).

## The Effect of Tackling Training on Head Accelerations

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**Context:** Reducing head contact and the number of resultant linear accelerations during tackling have been recommended to improved safety. USAFootball has recommended leagues adapt practice patterns as well as encouraging a head up, vertical tackling style. Recent studies have shown USAFootball leagues, in which these recommendations are utilized, experience a decrease in number of linear head accelerations during practice when compared to non-USAFootball leagues. While there may be changes in number of head accelerations experienced during practice, the contribution of the tackling style alone is not currently known. **Objective:** Determine the effect of training in a head up, vertical tackling style on the number of head accelerations experienced in a controlled laboratory setting. **Design:** Cohort study. **Setting:** Motion Analysis Laboratory. **Patients or Other Participants:** Thirteen youth football athletes (11.5±.5 years, 154.2±5.5cm, 49.7±8.9kg). **Interventions:** All athletes completed five baseline tackles then received verbal and video feedback on the correct performance of six criteria for a successful head up, vertical style tackle through three training sessions over a four- day period. Participants then completed five tackles during a 48 hour retention test. **Main Outcome Measures:** Linear acceleration experienced by the participants was recorded during baseline and retention tackling drills. Impacts that measured over 10gs were recorded and counted. A paired t-test was utilized to compare number of accelerations over 10gs per participant at baseline and retention time points. **Results:** Twenty-four tackles in the baseline time frame and six tackles in the retention period measured over 10gs. Participants averaged 1.8±1.5 tackles with a measure over 10gs during baseline and 0.5±0.7 tackles during retention. Paired t-test results indicate a significant difference ($p=0.027$) between baseline and retention time points. **Conclusions:** Training to perform a head up, vertical tackling style utilizing verbal and video feedback was effective in reducing the number of head accelerations greater than 10gs experienced in a small group of youth participants. These results indicate this tackling style may be effective in reducing the total number of head impacts received during football tackling. Additional research should be performed to further analyze both the effects of feedback and tackling style on head accelerations in youth athletes both in a laboratory setting and over the course of a playing season.

### Validity of Core Temperature Measurements at Three Depths in the Rectum During Rest, Exercise, Cold-water Immersion, and Recovery

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**Context:** To diagnose exertional heat stroke (EHS), clinician's assess central nervous system function and measure rectal temperature (Trec). However, no evidence-based recommendation exists regarding how far clinicians should insert a thermometer rectally to obtain the most valid measure of body core temperature (Tcore). Understanding which rectal depth provides the most valid measurement of Tcore under extreme exercise-induced hyperthermia is vital for the diagnosis and management of EHS. **Objective:** Determine which rectal depth, 4 cm (T4cm), 10 cm (T10cm), or 15 cm (T15cm) from the anal sphincter, provides the most valid measure of Tcore during rest, exercise to extreme hyperthermia, cold-water immersion, and post-immersion recovery. Esophageal temperature (Teso) was the criterion standard because of its proximity to the major arteries delivering blood to the hypothalamus and its rapid response to acute temperature changes. **Design:** Experimental, repeated-measure design. **Setting:** Laboratory. **Patients or Other Participants:** Seventeen physically-active individuals (14 males, 3 females: age = 23 ± 2 y, mass = 79.7 ± 12.4 kg, height = 177.8 ± 9.8 cm, body fat = 9.4 ± 4.1%, body surface area = 1.97 ± 0.19 m2). **Interventions:** Subjects were tested on 1 day. They self-inserted into their rectums a single, custom-made thermistor capable of measuring Trec at 4 cm, 10 cm, and 15 cm from the anal sphincter. A different thermistor was inserted 42 cm into the esophagus. Subjects entered an environmental chamber (40.3 ± 0.5°C, 27 ± 5% humidity). We compared Teso to Trec at each depth during four sequential periods: (1) a 10-minute, pre-exercise rest period, (2) exercise until subjects' Teso reached 39.5°C, (3) cold-water immersion (10°C) until all Trec and Teso were <38°C, and (4) a 30-minute post-immersion recovery period. Teso and Trec were compared every minute during rest and recovery. Since subjects' exercise and cooling times varied, we compared temperatures at 10% intervals during these periods. **Main Outcome Measures:** We used Teso and Trec to calculate bias (i.e., the difference between Trec at each depth and Teso). Descriptive statistics (means±SD) were calculated; repeated measures ANOVA with Tukey-Kramer post-hoc tests identified differences in bias between rectal depths over time (alpha = .05). **Results:** No interaction occurred between time and rectal depth for bias ($F_{2,32} = 1.0$; $P = .37$). However, bias differed between rectal depths ($F_{2,24} = 6.8$; $P = .008$). Bias at T15cm (.66 ± .69°C) was less than T4cm (.85 ± .78°C; $P < .05$). Bias at T10cm (.75 ± .76°C) was not different from T15cm or T4cm ($P > .05$). Bias also changed over time ($F_{2,34} = 79.5$; $P < .001$). Bias during rest (.42 ± .27°C), exercise (.23 ± .53°C), and post-immersion recovery (.65 ± .35°C) were less than cooling (1.72 ± .65°C; $P < .05$). Bias during exercise was also less than recovery ($P < .05$). **Conclusions:** T15cm was the most valid rectal depth while T4cm was the least valid depth. Bias varied depending on the physiological stressor applied to the body. Athletic Trainers should insert flexible thermistors 15 cm into the rectum to diagnose, treat, and monitor EHS patients.

### Muscle Cramps Increase Motor Neuron Pool Excitability

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**Context:** Exercise-associated muscle cramps (EAMC) are painful, involuntary contractions of skeletal muscles during or after exercise. For many athletes, EAMC are a recurrent problem. However, it is unclear why some athletes experience multiple EAMC in the same muscle during exercise or why cramp symptoms persist post-exercise. Evidence from experimental and field studies suggest EAMC are caused by neurological changes rather than dehydration or electrolyte losses. Thus, muscle cramp recurrence during or after exercise may also be due to changes in nervous system excitability. **Objective:** We tested two hypotheses: (1) volitionally-induced muscle cramps would increase Hoffmann reflex (H-reflex) amplitude and (2) if H-reflex amplitude increased, it would remain elevated for at least 10 minutes post-cramp. **Design:** Single group, repeated measures design. **Setting:** Laboratory. **Patients or Other Participants:** Thirteen subjects capable of voluntarily inducing cramp in their dominant limb's medial gastrocnemius completed testing (6 males: age = 23 ± 5 y, ht = 183.3 ± 12.7 cm, mass = 91.9 ± 23.2 kg; 7 females: age = 21 ± 2, ht = 162.1 ± 7.1 cm, mass = 66.5 ± 9.2 kg). **Interventions:** Subjects lay supine with their dominant leg resting in a foam support that kept their hip and knee slightly flexed for the duration of testing. We transcutaneously stimulated the dominant limb's tibial nerve using a constant current stimulator (square waves, pulse duration = 1 ms, pulse frequency = 1 Hz, 1 min rest between stimulations) in 2 mA increments until we observed the medial gastrocnemius' maximum M-wave (Mmax) amplitude. Then, we found the electrical stimulation intensity necessary to

evoke an H-reflex amplitude that was 25% of Mmax amplitude. We measured H-reflex amplitude at this intensity in triplicate (baseline measurement), averaged the responses, and had subjects rest for 15 minutes. Subjects had 5 opportunities (1 min between attempts) to voluntarily induce a cramp in their dominant leg's gastrocnemius by maximally plantarflexing their ankle. H-reflex amplitude was reassessed in triplicate and averaged at 1, 5, 10, 30, and 60 minutes post-cramp. **Main Outcome Measures:** H-reflex amplitude (V). Descriptive statistics (means ± SD) were calculated; repeated measures ANOVA with Tukey-Kramer post-hoc tests identified differences in H-reflex amplitudes between times ($\alpha = .05$). **Results:** H-reflex amplitude changed over time ($F_{2,26} = 3.3$, $P = .04$). H-reflex amplitude at 1 min (1.22 ± .39 V), 5 min (1.16 ± .48 V), 10 min (1.37 ± .59 V), and 30 min (1.48 ± .65 V) post-cramp were not significantly different than baseline (1.06 ± .39 V, $P > .05$). However, H-reflex amplitude at 60-min post-cramp (1.52 ± .96 V) was 44% higher than baseline ($P < .05$). **Conclusions:** Motor neuron pool excitability increased following a volitionally-induced muscle cramp in rested, unexercised subjects. Thus, muscle cramping, irrespective of fluid or electrolyte losses, may alter central nervous excitability and increase the likelihood of future cramping. Clinicians and athletes may wish to use strategies that decrease neural excitability (e.g., stretching) for at least 60 minutes post-cramp to prevent cramp recurrence.

## Does the Shortened Environmental Symptoms Questionnaire Accurately Represent Physiological Adaptations Following a 10 Day Heat Acclimation Protocol?

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**Context:** Heat acclimation (HA) mitigates exertional heat illness risk. HA occurs over a 10-14 day period and confirmation of physiological adaptations is seldom plausible in a clinical setting. The modified environmental symptoms questionnaire (ESQ) measures symptom severity during exercise in a hot environment and could help verify HA status resulting in an inexpensive, accessible, and easy to use tool for clinicians. **Objective:** To determine if the ESQ detects HA induction. **Design:** Randomized controlled, pair-matched design. **Setting:** Controlled environmental chamber. **Patients or Other Participants:** Fifteen healthy males (mean ± sd; age, 23 ± 3 y; height, 179 ± 6 cm; weight, 73.47 ± 7.71 kg; percent body fat, 7.6 ± 4.8%; VO2max, 55.1 ± 5.7 ml·kg-1·min-1). **Interventions:** Participants completed a HA protocol over 10-11 days involving 90-240 min exercise at 45-80% VO2max (40°C, 40% relative humidity). During HA trials rectal temperature (Trec) was ≥ 38.5˚C for ≥ 56 min. Before and after HA, a heat stress test (HST), determined HA status. The HST consisted of two 60 min bouts of treadmill exercise (45% VO2max, 2% grade) with a 10 min break between bouts and under similar environmental conditions as the HA protocol. **Main Outcome Measures:** ESQ scores, heart rate (HR) and Trec) were measured before exercise (Pre) and immediately post exercise (IPE) for both HST. The ESQ change score was calculated as IPE ESQ-Pre ESQ. Mixed model ANOVA evaluated ESQ differences. A Pearson's product-moment correlation followed by a linear regression assessed the ESQ and physiological data correlations. Alpha level was set at 0.05 for all tests. Data are reported as mean ± SD, unless stated otherwise. **Results:** HA was confirmed by lower IPE HR (mean difference (pre HA-post HA) = 16 ± 1 bpm) and Trec (0.58°C ± 0.02) (both $p \leq 0.05$). ESQ symptom severity IPE were increased before HA (22 ± 8) and after HA (11 ± 7), compared to symptoms severity PRE before HA (5 ± 3) and after HA (5 ± 3) (all, $p \leq 0.05$). Importantly, symptom severity at IPE was significantly lower after HA compared to before HA ($p \leq 0.05$). ESQ change score was correlated with change in Trec after HA ($r = 0.573$ [$r^2 = 0.328$], $p = 0.026$) and was moderately, but not significantly, correlated with change in HR ($r = 0.471$ [$r^2 = 0.228$], $p = 0.089$). Linear regression established change in HR and Trec accounted for 34.7% of the explained variability in ESQ change score after HA ($r^2 = 0.347$, $p = 0.096$). **Conclusions:** Heat acclimated individuals perceived and incurred less physiological heat stress compared to their pre-acclimated state. The ESQ assessed overall HA induction, through the reduction of symptom severity, and verified some (Trec), but not all (HR) HA induction responses. Therefore, the ESQ may not be useful in detecting specific HA adaptations, but is useful in assessing overall HA induction due to the reduction of symptom severity. Athletic trainers can use the ESQ to assess subjective responses to HA when objective physiological measures cannot be obtained.

## Exertional Rhabdomyolysis in a High School Football Player

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**Background:** The patient was a seventeen year old African-American, high school football player. The patient was five foot seven inches and weighed 190 pounds. He reported at the start of the season deconditioned and had not experienced much physical activity since the previous football season. The patient had completed his second day of football practice when he began to feel ill. He informed the athletic trainer that he had a migraine and was experiencing cramps in his lower extremity, specifically to his groin and quadriceps. The athletic trainer then questioned the patient about his water consumption in which he responded that he had only drank two bottles of water throughout the day. The athlete also had a significantly low caloric intake compared to the output required for competition. The patient was given twenty ounces of Gatorade with added electrolytes. The patient was placed in an ice bath and following the ice bath the patient experienced a full body cramp. The athletic trainer contacted the patient's parents and suggested that he be taken to the local emergency room. **Differential Diagnosis:** Dehydration, Heat cramps, Exertional heat exhaustion, Exertional rhabdomyolysis. **Treatment:** Upon arrival at the emergency room the patient was examined and a complete blood count (CBC) was conducted. With testing the patient had deoxygenated – dark red blood and was hypertensive. The CBC displayed inequalities of the electrolyte levels. The patient was diagnosed by the emergency room staff with exertional rhabdomyolysis, heat exhaustion and dehydration. Due to the patient's condition he was admitted to the hospital for three days until his electrolyte levels returned to normal. The patient was treated intravenously with sodium chloride. In addition, the patient's nutrition was monitored during his three day hospital stay. The patient was released from the hospital and was ordered not to return to activity for thirteen days. On the fourteenth day post-incident the patient was cleared to begin a return to exercise protocol. He was monitored by the athletic trainer during this process and was ordered to cease activity if signs and symptoms returned. The patient's weight, hydration, and nutrition were monitored before and after practice. **Uniqueness:** Usually exertional rhabdomyolysis appears with hypotension. However in this case he presented with hypertension when his blood pressure was taken at the emergency **Conclusions:** Exertional Rhabdomyolysis is not fully understood and patients should be treated on a case by case basis. Medical professionals must not become too comfortable in their daily clinical diagnoses and remember to seek other options when caring for patients. Most important, to prevent dehydration, exertional heat exhaustion and other associated conditions, patients need to be educated on proper hydration, food intake and nutrient timing.

## The Effects of Intravenous Cold Saline on Hyperthermic Cross-Country Runners

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**Context:** Exertional heat stroke (EHS) is a deadly condition that can affect a physically active population working in the heat. At particular risk are long distance runners due to the intensity and duration of the sport combined with the potential for hot and humid environmental conditions. EHS must be treated immediately with rapid cooling or central nervous system dysfunction, multi-organ failure, or death will occur. Although there are many methods for rapid cooling, few studies have examined the use of intravenous cold saline (CS) on hyperthermic physically active participants. **Objective:** To evaluate the cooling effects of intravenous cold normal (0.9%) saline on hyperthermic cross-country runners. **Design:** Randomized crossover study design. **Setting:** Controlled research laboratory. **Patients or Other Participants:** Six male participants (height: 177.08 ± 4.85 cm, mass: 70.15 ± 3.71 kg, %body fat: 11.30 ± 4.85) that were current collegiate cross-country runners or representative of a collegiate cross-country population. **Interventions:** Participants underwent body composition analysis using a BodPod. They were placed in an environmentally controlled chamber and brought to a Tc of 39.5°C with dynamic exercise. When hyperthermic core temperatures were reached they were treated with either 2L of CS (4°C) or room temperature (22°C) intravenous saline (RS) over a 30-minute period. Tc was measured with a rectal temperature probe every minute during the treatment period. Participants were randomly allocated to CS or RS treatment for the first trial, and finished the remaining treatment on the final trial. **Main Outcome Measures:** Total

change in Tc (ending Tc-starting Tc), rate of cooling per minute (total change in Tc/30 minutes). Dependent t-tests with a Bonferroni correction were used to assess total change in Tc and cooling rates between trials. A priori statistical significance was defined as $P \leq 0.017$. **Results:** Significant differences ($P = 0.005$) were found in the total change in Tc between the CS (-2.18 ± 0.19˚C) and RS (-1.92 ± 0.16˚C) trials. A significant difference ($P = 0.004$) was also determined for rate of cooling per minute between CS (-0.073 ± 0.006˚C·min) and RS (-0.064 ± 0.005˚C·min). **Conclusions:** The total change in Tc was significantly greater in the CS intervention and we were able to produce an average cooling rate just shy of the acceptable cooling rate (< -0.078˚C·min) supported in the literature. This study was able to demonstrate that the CS intervention was more effective than ice packs placed over major arteries (0.028˚C·min), ice packs covering the whole body (0.034˚C·min), and water dousing with convective fanning (0.035˚C·min), which are rapid cooling methods commonly used in clinical practice. Further research is needed to increase the current sample size to obtain a more representative average cooling rate and to include a more varied body composition for analysis.

### Efficacy of a Novel Cooling Vest Following Exercise-Induced Hyperthermia

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**Context:** Exertional heat stroke (EHS) survival relies on rapid body cooling, with the gold standard being cold-water immersion (CWI). However, rapid access to appropriate cooling is limited in many situations and subsequently it requires patient transport to provide cooling that meets the standard of care. Cooling vests have been proposed as a portable cooling therapy to optimize cooling during transport; however, limited evidence exists examining the cooling efficiency of a cooling vest after exercise-induced hyperthermia. **Objective:** To investigate the efficacy of a cooling vest, CAERvest® (BodyChillz Ltd, West Sussex, UK) for cooling hyperthermic individuals. **Design:** Randomized cross-over design. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen recreationally active participants (mean ± SD; male, n = 8; age, 25 ± 4 y; height, 181.1 ± 7.4 cm; body mass, 86.7 ± 10.5 kg; body fat, 16.5 ± 5.2%; female, n = 6; 22 ± 2 y; 163.5 ± 6.7 cm; 61.3 ± 6.7 kg; 22.8 ± 4.4%). **Interventions:** Participants completed cycles of 5-minutes of walking (3.5-4.5 mph, 5% incline) and 15-minutes running (5.5-7.5 mph, 1% incline) on a motorized treadmill until they reached a rectal temperature (TRE) of 39.9°C or volitional fatigue in an environmental chamber (ambient temperature, 39.8 ± 1.9°C; relative humidity, 37.4 ± 6.9%; wet bulb globe temperature, 31.9 ± 2.2°C). Upon termination of exercise, subjects lay supine on a cot, and were cooled using the CAERvest® (VEST) or passive rest (PASS). Cooling was stopped at a TRE of 38.25°C for both conditions. **Main Outcome Measures:** Cooling rates for TRE and esophageal temperature (TES) were compared using independent samples t-tests. Two-way ANOVAs were conducted to evaluate the relationship between body mass, body fat, gender and cooling rates. A significance level of $p < 0.05$ was set a priori. **Results:** There were no differences in exercise duration (PASS = 48.37 ± 7.1 min, VEST = 51.63 ± 6.76 min, $p = 0.225$), end of exercise TRE (PASS = 39.63 ± 0.40°C, VEST = 39.55 ± 0.36°C, $p = 0.625$) or end of exercise TES (PASS = 39.17 ± 0.63°C, VEST = 38.94 ± 0.61°C, $p = 0.625$). VEST trials had greater TRE cooling rates than PASS (0.06 ± 0.02°C·min-1 vs. 0.04 ± 0.01°C·min-1, $p = 0.002$). In addition, cooling time was greater for PASS than VEST (42.77 ± 21.96 min vs. 28.43 ± 13.32 min, $p = 0.047$). There were no differences in TES cooling rate between trials (PASS = 0.05 ± 0.03 °C·min-1, VEST = 0.06 ± 0.02°C·min-1, $p = 0.471$). There was a main effect of gender on TES cooling rates, with females have higher rates of cooling (male = 0.04 ± 0.02°C·min-1, female = 0.06 ± 0.03°C·min-1, $p = 0.027$). **Conclusions:** VEST was more effective at cooling than PASS, however, TRE VEST cooling rates did not approach levels with CWI (≥0.15°C·min-1). Although cooling vests should not replace CWI for EHS care, they may be appropriate when logistics preclude the use of more advanced cooling modalities during transport to CWI.

## Tarp-Assisted Cooling is an Effective Method of Whole Body Cooling in Hyperthermic Individuals

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**Context:** The gold standard for the treatment of exertional heat stroke (EHS) is immediate whole-body cooling using cold water immersion (CWI), which is reported to have a cooling rate ≥0.22°C·min-1. However, resources and logistics may limit the application of CWI in some remote settings. The U.S. military has utilized the tarp-assisted cooling (TACo) method as an alternative to cool an EHS patient in the absence of CWI. **Objective:** To investigate the cooling rate of the TACo method. **Design:** Randomized crossover design. **Setting:** Research laboratory (ambient temperature, 39.8 ± 1.9°C; relative humidity, 37.4 ± 6.9%; wet bulb globe temperature, 31.9 ± 2.2°C). **Patients or Other Participants:** Recreationally active males (mean ± SD; n = 8; age, 25 ± 4 y; body mass, 86.7 ± 10.5kg; height, 181.1 ± 7.4cm; body fat, 16.5 ± 5.2%) and females (n = 6; 22 ± 2 y; 61.3 ± 6.7kg; 163.5 ± 6.7cm; 22.8 ± 4.4%). **Interventions:** Participants exercised on a motorized treadmill by alternating between a 5-minute walk (3.5- 4.5 mph, 5% incline) and 15-minute jog (5.5- 7.5 mph, 1% incline) until they reached a state of hyperthermia. Participants removed their shirts and were cooled using the TACo method or passive rest (PASS). The TACo method consisted of participants laying in a tarp supported by researchers with 20 gallons of water and 10 gallons of ice, allowing for partial-body cooling (water temperature 9.20 ± 2.81°C) The PASS condition involved participants sitting quietly while remaining in the climatic chamber. Cooling was ceased at a rectal temperature (TRE) of 38.25°C. An independent T-test compared the cooling rates between TACo and PASS. Separate independent T tests compared cooling rates by sex. Pearson correlations examined the relationship between body mass and cooling rates. Significance level was set a priori as $p < 0.05$. **Main Outcome Measures:** Cooling rate using TACo and PASS. **Results:** There were no differences in exercise duration ($p = 0.97$) and end exercise TRE ($p = 0.44$) for TACo (exercise duration [minutes: seconds], 48:28 ± 08:16; end exercise TRE, 39.73 ± 0.27°C) and PASS (48:22 ± 07:06; 39.63 ± 0.40°C). Cooling rates for TACo and PASS were 0.17 ± 0.07°C·min-1and 0.04 ± 0.01°C·min-1, respectively ($p < 0.01$). Females (0.04 ± 0.01°C·min-1) had greater cooling rate than males (0.03 ± 0.01°C·min-1) in PASS ($p = 0.026$) with negligible clinical impact (mean difference = 0.01°C·min-1). No sex differences were observed in TACo cooling rate ($p = 0.62$). Body mass was moderately negatively correlated with the cooling rate in PASS ($r = -0.580$, $p = 0.03$) but not in TACo ($r = -0.206$, $p = 0.479$). **Conclusions:** TACo resulted in a cooling rate that is approximately 75% as effective as CWI. In the absence of a stationary cooling station dedicated for EHS treatment, TACo can serve as an alternative, field expedient method to provide on-site cooling with a satisfactory cooling rate. Future research should explore modifications in TACo to allow for cooling during transport of an EHS victim to definitive CWI care.

## Exercise Recovery and Forced Vital Capacity in Relationship to Body Position

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**Context:** It is a common belief that an upright posture with arms supported above the head will increase ventilation and decrease recovery time. The aim of this study is to test these claims. **Objective:** The following questions were addressed: (a) Do differing body positions post-exercise influence exercise recovery time, (b) Do differing body positions influence forced expiratory volume, (c) Is there a relationship that can be drawn from forced expiratory volume and exercise recovery time? **Design:** Repeated measures **Setting:** Public recreational facility. **Patients or Other Participants:** Selection procedures included a convenience sample of 24 non-smoking volunteers (12 male and 12 female; Age: 22.7 ± 2.1years, Height: 174 ± 7.4cm, Weight: 74.1 ± 15kg). Inclusion criteria mandated being able to run on a treadmill for four minutes at eight miles per hour. **Interventions:** Initially seated, participants had a baseline pulse taken for thirty seconds via radial artery. Next, the best of three trials of forced expiratory volume was taken in the body position of standing upright with arms supported on the head, and standing bent at the waist with arms on knees supporting upper body weight. The order of position (upright or bent) was randomly assigned. Participants ran on a treadmill at eight miles per hour for four minutes. Immediately post-exercise the participant stepped off the back of the treadmill and assumed one of the body positions determined by random order. While maintaining this position, pulse was taken for the first thirty seconds of every minute via carotid artery. Participants remained in this position until their pulse returned to baseline or ceased to decrease for two consecutive minutes. Participants had twenty minutes to recover in the facility

before running the second trial on the treadmill, recovering in the position for exercise not previously used in the first trial. **Main Outcome Measures:** Forced expiratory volume and post-exercise heart rate at minute one, two, and three were calculated from the body positions of standing upright and bent at the waist. A MANOVA was used to determine changes among forced expiratory volume and post-exercise heart rate in both body positions. **Results:** There were no significant differences between body positions when looking at forced expiratory volume ($F(1,46) = .806$; $p = .374$), nor in exercise recovery at minute one ($F(1,46) = .253$;$p = .617$), in exercise recovery at minute two ($F(1,46) = 1.619$; $p = .210$), nor in exercise recovery at minute three ($F(1,46) = 1.185$; $p = .282$). **Conclusions:** Body position does not affect exercise recovery time or lung forced expiratory volume. This discredits the common misconception that manipulating body position influences recovery time. Athletes should be able to place themselves in the most comfortable position for recovery.

### The Impact of Inclined Backward Versus Forward Treadmill Walking on Ankle Musculature and Postural Sway Measures During Bilateral Stance Immediately Following the Task

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**Context:** In recent years, backward walking has been used to improve neuromuscular strength in rehabilitation settings following lower extremity injury and/or surgery. Several investigations have shown changes in ankle musculature and postural motion during quiet stance immediately following various walking tasks; however, the impact of inclined backward walking on postural control is not known. **Objective:** Examine the impact that backward (BW) and forward (FW) walking on a treadmill had on ankle musculature and center of pressure (COP) motion during bilateral quiet stance recorded immediately following the task. **Design:** Repeated-measures experimental design. **Setting:** Controlled human performance research laboratory. **Patients or Other Participants:** A convenience sample of 7 male and 10 female (19.4 ± 1.1 yrs.; 172.1 ± 8.5 cm; 70.3 ± 12.4 kg; BMI = 23.6 ± 3.1 kgm-2) healthy college-aged adults were recruited. **Interventions:** Subjects performed a 15-minute BW trial (67 m/min-1, 10% grade), and a FW trial at matched intensity (~27 ml/kg/min) in 2 sessions separated by at least 7-14 days. Prior to and immediately following each walking trial subjects were instructed to stand comfortably for 30s under eyes opened (EO) and eyes closed (EC) vision conditions. A Mixed General Linear Model (GLM) with repeated measures was used to determine significant differences between the walking conditions. Alpha level was set a priori at $P<.05$. **Main Outcome Measures:** Surface EMG (Biometrics, Ltd., UK) of tibialis anterior (TA) and medial gastrocnemius (GM), and COP motion was recorded during bilateral stance on a force plate (Model 5050, Bertec Corp., Columbus, OH). COP and EMG data were sampled at 1,000 Hz. and analyzed using a customized Matlab software design (MatlabR2014b, Mathworks, Inc., Natick, MA). COP data were low-pass filtered using a 2nd order Butterworth filter (cutoff~30 Hz) and extrapolated variables include path length (mm), mean mediolateral (ML) and anteroposterior (AP) sway (mm). EMG data were rectified and filtered using a 4th order Butterworth filter (cutoff~400 Hz) and mean amplitude (mV) values were reported. **Results:** The results indicated that BW elicited a significantly greater path length (1456.3 ± 800.3, $p = 0.004$) and mean AP (17.5 ± 10.5, $p = 0.003$) sway compared to FW (1071.3 ± 588.1, 17.7 ± 11.3), respectively, regardless of vision condition. Standing with EC elicited greater postural sway than with EO in all COP variables ($p < 0.001$). Additionally, standing following BW required significantly greater activation of the TA (127.0 ± 130.5, $p = 0.001$) and GM (67.4 ± 24.7, $p = 0.002$) compared to FW (54.0 ± 61.2; 48.8 ± 38.2), respectively. **Conclusions:** BW compared to FW elicited increases in the total amount of COP motion (path length, mean A-P/M-L) and required greater lower leg muscle activation to maintain position. These results indicate that walking backward places greater demands upon the ankle musculature responsible for postural control compared to walking forward at a matched intensity. These factors should be taken into consideration when developing a rehabilitation protocol following lower extremity injury/surgery.

### Influence of Dorsiflexion Range of Motion on Star Excursion Balance Test Reach Distances

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**Context:** The Star Excursion Balance Test (SEBT) is a clinical balance test that has been shown to be a valid outcome tool for identifying dynamic balance deficits associated with lower extremity injury. SEBT performance is a combination of strength, neuromuscular control, and joint ROM; however it is unclear how these individually contribute to performance. Of all the factors investigated in SEBT performance, ankle dorsiflexion ROM (DROM) appears to be critical in at least one of the reach directions. DROM deficits are a risk factor for LE injuries, and clinicians have begun to use the SEBT to assess such risk factors. **Objective:** The purpose of this study was to validate the evidence associated with the relationship between ankle DROM and reach direction within the SEBT. **Design:** Cross-sectional study. **Setting:** Research Laboratory **Patients or Other Participants:** Twenty-eight healthy adults (15 males, 13 females, age: 19.8 ± 1.0 years, height: 171.4 ± 12.3 cm, weight: 78.7 ± 22.6 kg) participated in this study. All subjects were free of any musculoskeletal and neurological injuries, and reported no disability that would impair their balance. Prior to participating in the study, all subjects provided written informed consent. Similar subject size and demographics were seen in other studies. **Intervention:** All subjects performed 3 trials of the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions of the SEBT on both the dominant (preferred kicking limb) and nondominant limbs. As well, all subjects performed 3 trials of the weight-bearing lunge test (WBLT) to measure the maximum weight-bearing DROM on each

limb. The mean of the 3 trials for each variable was used for analysis. **Main Outcome Measure:** Pearson's product moment correlation coefficients were calculated between the WBLT and the three directions of the SEBT. Alpha was set a priori at $p < 0.05$. Because there were no differences between the dominant and non-dominant limbs on any of the dependent variables, the right and left reach distances were pooled for analysis. **Results:** There was a moderate correlation between the WBLT (9.6 ± 3.4cm and the ANT reach (69.4 ± 6.8cm, $r = 0.55$, $r^2 = 0.30$, $p < 0.01$). However, weak correlations were found between WBLT and the PM (82.0 ± 8.8cm, $r = 0.29$, $r^2 = 0.08$, $p = 0.14$) and the PL (74.8 ± 10.4cm, $r = 0.29$, $r^2 = 0.08$, $p = 0.14$) reaches. **Conclusions:** Weight-bearing dorsiflexion explained approximately 30% of the variance in ANT reach direction whereas it only explained 8% of the variance in the posterior directions. Our findings directly support the previously published evidence and help to further the validity of the relationship between weight-bearing dorsiflexion and performance on the anterior reach of the SEBT. Since decreased DROM has been shown to be a contributing factor to other LE injuries, our study provides additional evidence to support using the SEBT as a clinical tool to assess lower extremity injuries.

## Postural Control Strategies Are Dependent on Reach Direction in the Star Excursion Balance Test

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**Context:** The Star Excursion Balance Test (SEBT) is a common clinical measure of dynamic balance. It is unclear how each reach direction challenges the sensorimotor system in maintaining single limb balance. Calculating center of pressure (COP) area and velocity during the 3 reach directions of the SEBT may provide insight into how single limb balance is maintained in the context of reach direction. **Objective:** The purpose of this study was to examine differences in COP area and velocity among three SEBT reach directions. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-eight college-aged students participated (15 males and 13 females, age: 19.8 ± 1.0 years, height: 171.4 ± 12.3 cm, mass: 78.7 ± 22.6 kg). All participants were healthy with no recent history of lower extremity injury or conditions that affected balance. **Interventions:** All participants performed the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions of the SEBT on their non-dominant limb (preferred stance limb during kicking motion) while standing on a force plate with a sampling rate of 200Hz. Subjects were instructed to balance on their non-dominant limb, maximally reach the opposite limb in one of the three directions (ANT, PM, PL), and then return to balance while COP data was recorded. Participants completed 4 practice trials in each direction prior to performing the 3 reach trials. **Main Outcome Measures:** Dependent variables included the average COP velocity (cm/s) and the area of a 95% confidence ellipse of the COP ($cm^2$) in each of the 3 reach directions. The mean of the 3 trials of each direction was used for creating the COP velocity and area dependent variables. Separate 1x3 ANOVAs were used to determine the influence of reach direction on COP velocity and area. Paired t-tests were used for post hoc analyses. Alpha was set a priori at $p > 0.05$ for all analyses. **Results:** Significant reach direction effects for both COP velocity ($p = 0.02$) and area ($p < 0.01$) were found. The ANT direction (8.4 ± 1.6cm/s) resulted in lower COP velocity compared to the PM (9.1 ± 1.5cm/s, $p < 0.01$) and the PL (9.1 ± 2.0cm/s, $p = 0.04$) directions. There was no difference between the posterior directions ($p = 0.99$). The ANT direction also demonstrated higher COP area (28.1 ± 9.7cm2) compared to the PM (22.5 ± 7.0cm2, $p < 0.01$) and PL (22.4 ± 7.4cm2, $p < 0.01$) directions. There was no difference between the posterior directions, $p = 0.95$). **Conclusions:** The ANT direction requires a different balance strategy (larger COP area with lower COP velocity) compared to the posterior directions of the SEBT, however the posterior directions do not differ from one another. Understanding how healthy individuals control their dynamic balance during the SEBT enhances framework for building a relationship between clinical and laboratory measures of balance and their implications as rehabilitation outcome measures.

### Female Adolescent Athletes' Attitudes and Perspectives on Injury Prevention Programs

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**Context:** Injury prevention programs (IPP) are proven to reduce risk of lower extremity injury, improve movement technique and improve measures of performance. A greater understanding of what influences athletes to participate in a lower extremity IPP could lead to improved and focused IPP education efforts. **Objective:** Examine factors that influence a high school female athlete's stated willingness to perform a lower extremity IPP. A secondary aim was to examine if participants' stated willingness affects her compliance with an IPP. **Design:** Repeated measures **Setting:** High school **Patients or Other Participants:** Seventy-six female athletes (Age 15 ± 1 years; field hockey n = 21, soccer n = 31,volleyball n = 24) volunteered to participate in the study. **Interventions:** Participants completed the Injury Prevention Program Attitude Survey (IPPAS), a paper and pencil survey utilizing Likert-style and open-ended questions, before and after a season-long IPP warm-up intervention. The IPPAS was used to assess the players' willingness to perform an IPP if data demonstrated that they would experience improved performance and fewer injuries, identify factors that influenced their willingness to perform an IPP, identify who they would feel comfortable leading their team in an IPP, and assess perceptions on the effects of an IPP on performance. An open-ended question was used to ascertain what exercises or activities the participants believed should be included in an IPP. **Main Outcome Measures:** Open-ended questions were analyzed using open coding borrowing from the grounded theory method. Questions assessed on a Likert Scale (1-Strongly Disagree through 5-Strongly Agree) were dichotomized into Yes or No, "5-Strongly Agree" was considered a Yes and responses of 1 through 4 were considered No. Separate chi-square tests were utilized to identify differences between players' stated willingness and IPP beliefs. **Results:** Participants' stated willingness and beliefs prior to the intervention did not appear to affect their compliance. Participants responded that they were willing to perform an IPP if data demonstrated that they would have fewer injury risk factors ($P < .001$) and be less likely to suffer an ACL injury ($P < .001$). Improved sport performance did not play a role in participants' willingness. Before and after the warm-up intervention, participants stated that stretching, strengthening, and cardiovascular activity should be included in an IPP. Before the intervention, participants were not comfortable having any of the listed IPP facilitators lead an IPP. At POST, participants indicated that they were comfortable with their athletic trainer leading an IPP ($P = .01$). **Conclusions:** Female adolescent athletes are willing to perform IPPs if data indicated that they would have fewer injury risk factors and suffer fewer ACL and leg injuries. They are also comfortable with their athletic trainer leading their team in an IPP. Further work should investigate if telling female athletes that ACL IPPs will decrease injury by 80% increases compliance.

### The Effect of a Six Week Functional Training Program on Performance Outcomes in Softball

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**Context:** Despite inclusion of functional training in current rehabilitation and strength and conditioning programs in softball, few studies have examined the implementation of kinetic chain progressions, and the benefits therein. **Objective:** To determine the effectiveness of a 6-week functional training program on performance outcomes in softball. **Design:** Repeated measures design. **Setting:** Athletic Training Facility. **Patients or Other Participants:** Subjects consisted of 19 healthy female softball athletes from a Division III collegiate setting. There were 10 subjects in the experimental group (20.20 ± 1.55 yrs, 71.41 ± 18.76 kg, 166.37 ± 5.65 cm) and 9 subjects in the control group (19.78 ± 1.09 yrs, 68.28 ± 13.93 kg, 165.52 ± 6.16 cm). Subjects were placed into groups using stratified randomization based on position of infield, outfield, catchers, and pitchers. **Interventions:** Those in the experimental group completed a 6-week functional training progression (2 times a week/30-minutes each session) aimed at improving throwing accuracy, throwing velocity, and proprioception. The kinetic chain progression of exercises were advanced from week to week and incorporated open kinetic chain exercises, closed kinetic chain exercises, plyometric exercises, and functional exercises. **Main Outcome Measures:** Pre and post-test measurements for throwing accuracy using the functional throwing performance index (FTPI), upper extremity proprioception using the closed kinetic chain upper extremity stability test (CKCUEST) and

joint position sense (JPS), and upper extremity power using the throwing velocity test (Velocity) were conducted prior to and following a 6-week functional training progression. Separate 2 (group)x 2 (time) repeated measures ANOVAs were used to evaluate the dependent variables of average index scores from FTPI, average throwing velocity, and average number of touches from the CKCUEST. A 2x2x2 Repeated Measures ANOVA was used to evaluate average absolute total error measured by the JPS for right and left arm. Cohen's d effect sizes (ES) with 95% confidence intervals and minimal detectable change (MDC) scores were also calculated. **Results:** Throwing accuracy testing showed a significant group effect ($F = 5.386$, $P = 0.033$) favoring the experimental group ($P = 0.033$). There was a large ES between groups (ES = -1.02; -0.06 to -1.98) in favor of the experimental group, however MDC (0.460) was not exceeded. The CKCUEST showed a significant difference from pre to post test ($F = 14.111$, $P = 0.002$) with a large ES (0.75, -0.16 to 1.66) for the experimental group that encompassed 0. However, both the control (0.026) and experimental group (0.030) exceeded the MDC (0.021). No other results were significant for JPS or Velocity testing, even though the experimental group exceeded the MDC (2.133) for throwing velocity. **Conclusions:** A multi-segment training program may be used to improve throwing accuracy. Further, the results support use in the clinical setting based on MDC scores for CKCUEST and throwing velocity. However, prior to implementation, further research is warranted to ascertain the efficacy of functional training among a larger population.

## Youth Athletes Improve and Retain Long Jump Performance Following Injury Prevention Program

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**Context:** Incorporating lower-extremity exercise-based injury prevention programs (IPPs) in youth sport may enhance long-term IPP fidelity. Success with IPPs is dependent on correct movement technique but too many corrective cues may be overwhelming for younger athletes. Demonstrating a link between IPPs and performance measures could enhance coaches' IPP adherence. It is unknown if a simplified IPP can elicit performance improvements in a youth population or if improvements are retained beyond the length of a season. **Objective:** To compare the effects of a simplified and a traditional IPP on long jump (LJ) performance, a validated measure of power in youth athletes, and also if changes in performance were retained 2- and 4-months after the season. **Design:** Cluster-randomized controlled trial. **Setting:** Soccer fields. **Patients or Other Participants:** Twenty-eight youth soccer teams (n = 420 athletes; n = 200 males, n = 220 females, age = 11 ± 3 years) were stratified by sex and cluster-randomized into a warm-up group: Basic = 10 teams (n = 141), Traditional = 9 teams (n = 97), Control = 9 teams (n = 114). **Interventions:** Participants volunteered to participate and completed two trials of a standing LJ before (PRE), immediately (POST), 2-months (POST-2M), and 4-months (POST-4M) after an 8-week intervention period. The Basic and Traditional groups were assigned a research assistant (RA) who implemented the IPP as a team warm-up prior to practice 2-3 times per week. Both groups performed a 10-12 minute IPP with identical flexibility, agility, core strength, balance, and plyometric exercises. Basic IPP RAs only provided movement correction cues related to flexion and force absorption in the sagittal plane. Traditional IPP RAs gave movement corrections in all three planes of motion. Control teams performed their normal warm-up routine as determined by the team's coach. **Main Outcome Measures:** A linear mixed effects model clustered by team was used to compare LJ performance between groups (Basic, Traditional, Control) across time (PRE, POST, POST-2M, POST-4M). Separation of 95% confidence intervals was used to evaluate pairwise comparisons for post-hoc testing ($\alpha < 0.05$). **Results:** Traditional IPP teams (mean ± SD, [95% CI]) PRE: 136.45 ± 22.25 cm, [132.03,140.87], POST: 147.22 ± 24.89 cm, [132.03,140.87]) trended towards greater improvements in LJ at POST compared to Control teams (PRE: 137.16 ± 22.78 cm, [132.97,141.35], POST: 134.44 ± 21.26 cm, [130.07,138.81] ($P = 0.056$). At POST-2M, Traditional (POST-2M: 135.26 ± 27.99cm, [127.67,142.85]) significantly improved LJ compared to Control (POST-2M: 123.14 ± 27.25cm, [116.56,129.72]) ($P = 0.02$). Group differences were not retained at POST-4M. No other significant differences were found between warm-up groups. **Conclusions:** The Traditional program utilized a larger variety of feedback cues compared to the Basic program, which may have influenced athletes' abilities to improve LJ. These improvements were retained for 2-months but not 4-months after completing the program. These results support that IPPs improve measures of power. Loss of improvements at the 4-month mark suggests a need to continue utilizing IPPs during the off-season to retain any performance gains.

## Effects of a Lower Extremity Injury Prevention Program on a Sport-Specific Performance Task

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**Context:** Injury prevention programs (IPPs) can reduce the risk of lower extremity injuries, but are currently used by less than 20% of high school sport teams. This underutilization is likely due to a lack of buy-in from coaches and participants. Demonstrating these programs do not impair sport performance may assist in their promotion. There is limited knowledge about the effects of these programs on sport-specific performance measures. The time required to perform a program is also a commonly reported barrier for adoption. There is no evidence comparing an established 20-minute duration program (F11+) to a shorter duration program (SD). **Objective:** The purpose of this study was to evaluate the effects of a long and short duration IPP on a sport-specific performance task in high school female athletes. A secondary purpose was to assess the relationship between sport-specific performance and landing biomechanics. **Design:** Randomized controlled trial. **Setting:** Local high school athletic facilities. **Patients or Other Participants:** Seventy-four female athletes volunteered to participate in this study (n = 30 soccer, 24 volleyball, 20 field hockey; age = 15 ± 1 years, height = 166.9 ± 6.4 cm, weight = 60.3 ± 10.4 kg). **Interventions:** Participants were randomized into warm-up groups (SD, F11+, or Active Control (CON)) and performed their assigned program as a dynamic warm-up prior to sport activities during their season (approximately 8 weeks). Participants completed testing sessions before (PRE) and after (POST) the season. During testing, participants performed a sport-specific performance task (Shuttle Dribble Task (SDT)). During the SDT, participants performed a sport-specific skill during a shuttle sprint drill. Participants also performed three trials of a standardized jump-landing task to assess changes in landing biomechanics. The jump-landing task was recorded and scored using the Landing Error Scoring System (LESS) at a later date by a single rater blinded to group assignment. **Main Outcome Measures:** The SDT was measured as SDTBEST (the fastest trial), SDTAVG (average of all trials), and SDTCHANGE (change score calculated SDTAVGPOST - SDTAVGPRE). A univariate analysis of variance was used to evaluate differences in SDT while controlling for LESSAVG, sport, sport level, and total exposures to the warm-up. The association between SDTBESTPRE and LESSAVG was assessed using a Pearson product-moment correlation. **Results:** No significant differences were observed between groups (SDTBEST, SDTAVG) ($P > 0.05$). A positive correlation ($R2 = 0.11$, $P = 0.004$) was observed between LESSAVG and SDTBESTPRE. **Conclusions:** There were no detrimental effects on sport-specific performance observed by implementing IPPs over the duration of the season. LESS scores explain a small amount of variance in sport-specific performance, where higher LESS scores were correlated with slower SDT times. These data suggest that efforts to improve lower extremity biomechanics and reduce injury have little effect on sport specific skill performance.

## Analysis of Hip Muscle Fatigue Throughout a One-Mile Run in Recreational Runners

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**Context:** Many variables contribute to the efficiency of running cadence and kinematics. A complete understanding of hip strength throughout a period of running has not been evaluated through the use of surface electromyography (EMG). **Objective:** To evaluate muscle activation in recreational runners throughout a one-mile run. **Design:** Randomized, counterbalanced, within subject design. **Setting:** Human Performance Laboratory at a Research 1 institution. **Patients or Other Participants:** Thirty recreational runners (15 males, 15 females; age: 30.9 ± 8.9 years; height: 173 ± 7.5 cm; mass: 70.3 ± 12.1 kg) participated in the research protocol. Recreational runners were defined as running a minimum of ten miles per week for at least three months and not currently competing on a team at any level. Runners were excluded for any nerve conduction health history, current lower extremity running related injury, or running related injury within past three months. **Interventions:** Male and female participants ran a total of one-mile on a treadmill at zero percent incline. They were asked to run at a pace comparable to their daily training pace. Raw data was obtained using surface electromyography (EMG) through Biopac Systems, Inc. (Version 4.1; Goleta, CA). Data was collected for .05 miles at each of the following increments: 0.20-0.25 miles (first), 0.45-0.50 miles (second), 0.70-0.75 miles (third), and 0.95-1.0 miles (fourth). **Main Outcome Measures:** Muscles tested included Rectus Femoris, Tensor Fascia Latae, Gluteus Medius, and Gluteus Maximus. Following initial ANOVA results, follow-up Tukey's HSD tests were conducted using SPSS software to compare

average muscle contractions. **Results:** Rectus Femoris gender differences were strongly significant ($p = .001$) with females activating anterior hip muscles much more than males. Within subject measurements resulted in marginal statistical significance between the first and fourth observations of the Tensor Fascia Latae ($p = .060$) with activation decreasing throughout the mile. Difference in amount of Tensor Fascia Latae activation was strongly significant between genders ($p = .014$) with females activating the muscle at a higher capacity. Tukey's HSD revealed statistically significant differences within subjects between the first and fourth observations of the Gluteus Medius ($p = .056$). Gender difference in the Gluteus Maximus was statistically significant ($p < .001$) with females activating the Gluteus Maximus more than males. Gluteus Maximus observations were statistically significantly different in two cases: between the first and third observations ($p = .015$) and the first and fourth observations ($p = .007$). **Conclusions:** These findings indicate that in as little as a one-mile run, recreational runners' hip muscles fatigue. In addition, it is interesting to find that females used more of the Rectus Femoris and Gluteus Maximus muscles during running gait. Because no to little research reports on the activation of hip musculature throughout a specified distance, these results can assist athletic trainers with injury evaluations as well as developing rehabilitation protocols with evidence-based outcomes.

### Effect of Salted Ice Bags on Surface and Intramuscular Tissue Cooling

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**Context:** Research indicates ice bags are more effective at lowering cutaneous and intramuscular temperature than other cryotherapies. Current best-practice indicates wetted-cubed-ice results in greatest cooling; no previous research has examined the effect of adding salt to ice. **Objective:** Evaluate effect of adding ½-tablespoon salt to bags of crushed and cubed-ice on cutaneous and intramuscular cooling rates; compare to wetted-cubed ice. Hypotheses: salted-cubed-ice will produce greatest decreases in cutaneous and intramuscular temperatures. **Design:** Repeated-measures counterbalanced design (crossover study) **Setting:** University research laboratory. **Patients or Other Participants:** Volunteer sample of 24 healthy participants (13 men, 11 women, age = 22.46 ± 2.33 years, height = 173.25 ± 9.78cm, mass = 74.51 ± 17.32kg, subcutaneous thickness = 0.63 ± 0.27cm) aged 18-26 were included in this study. **Interventions:** Ice bags made of wetted-ice (2000mL ice, 300mL water), salted-cubed-ice (2000mL cubed ice, ½tablespoon salt), and salted-crushed-ice (2000mL crushed ice, ½ tablespoon salt) were applied to calf for 30-minutes. Each participant underwent all treatment conditions (counterbalanced order), with a minimum of 4-days and maximum of 10-days between sessions. Intramuscular temperature was measured via 26-gauge needle thermistor thermometer inserted into the medial aspect of the calf with the widest girth at a posterior depth of 2.0 ± 0.3cm below subcutaneous fat (placement verified via diagnostic ultrasound). Cutaneous temperature was measured via a surface thermistor. **Main Outcome Measures:** Cutaneous and intramuscular temperatures were recorded every 30-seconds during 30-minute treatment period. Mixed-model analysis of variance with repeated measures were calculated for each dependent variable (muscular cooling, cutaneous cooling). Correlations between muscle and cutaneous temperature were calculated. **Results:** Significant main effects for treatment-by-time for intramuscular cooling ($F(3, 21) = 20.53$, $p < 0.001$). Mean temperature decrease for wetted-ice was 4.7 ± 1.56°C, salted-cubed 4.5 ± 1.83°C, salted-crushed 2.9 ± 1.02°C. Pairwise comparisons demonstrated significant difference between wetted and salted-crushed ($p < .001$), and between salted-cubed and salted-crushed ($p < .001$), but non-significant between salted-cubed and wetted ($p = .957$). Intramuscular temperature continued to decrease for an additional 21 minutes following ice bag removal. Significant main effects for treatment-by-time for intramuscular temperature during continued cooling ($F(3,21) = 2.518$, $p < 0.001$). Mean continued decrease for wetted was 1.9 ± 0.43°C, salted-cubed 1.9 ± 0.54°C, salted-crushed 1.7 ± 0.42°C. Pairwise comparisons demonstrated significant difference between wetted and salted-crushed ($p = <0.001$), and between salted-cubed and salted-crushed ($p < 0.001$), but non-significant between salted-cubed and wetted ($p = 1.000$). Significant main effects for treatment-by-time for cutaneous cooling ($F(3,21) = 8.59$, $p < 0.001$). Mean temperature decrease for wetted-ice was 19.2 ± 1.71°C, salted-cubed 16.8 ± 1.59°C, salted-crushed 15.7 ± 1.87°C. Pairwise comparisons demonstrated significant difference between wetted and salted-cubed ($p < .001$), and between wetted and salted-crushed ($p < .001$), but non-significant between salted-cubed and salted-crushed ($p = .337$). There were no significant correlations between intramuscular and cutaneous temperatures in any condition at any time points (all $P > 0.05$). **Conclusions:** Wetted and salted cubed ice bags were equally effective at decreasing intramuscular temperature at 2cm sub-adipose. While wetted-ice may be an effective sideline cryotherapy modality, salted-ice-bag may be more practical in a clinical setting.

## Recommended Cooling Times Based on Subcutaneous Tissue Thickness Decrease Intramuscular Temperature Similarly in Lower Extremity Muscles

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**Context:** Ice bag application over lower extremity muscles is common practice when these muscles are injured. Previous research has identified specific cooling times for ice bag application based on subcutaneous tissue thickness, however these recommendations were made following cooling the thigh to 7°C. It is unknown if these timing recommendations hold true to other lower extremity muscles. **Objective:** To examine cooling of the thigh, hamstring, and calf based on subcutaneous thickness timing recommendations. **Design:** Controlled laboratory study. **Setting:** Athletic Training Laboratory. **Patients or Other Participants:** Fourteen healthy participants volunteered to be in the study (Age: 21.1 ± 2.2 yrs; Height: 174.2 ± 4.5 cm; Mass: 74.0 ± 7.5 Kg). **Interventions:** Diagnostic ultrasound was used to measure subcutaneous tissue thickness over the hamstring (8.4 ± 4.4 mm), calf (5.8 ± 3.2 mm), and thigh (11.0 ± 4.9 mm). Participants were randomly assigned to which leg would be tested and which muscle(s) would be iced first. If the thigh was iced first, the participant would report back a week later to ice the hamstring and calf. Using sterile techniques, an IT-21 thermocouple was inserted 1cm into the muscle of interest using a catheter method. The participant rested for 10 minutes while temperature stabilized and baseline measurements were obtained. Ice was applied for 10, 25, 40, or 60 minutes depending on subcutaneous thickness of 0-5mm, 6-10mm, 11-15mm, or 16-20mm respectively. Once the ice was removed, temperature readings were recorded immediately and 10, 20 and 30 minutes post-intervention. **Main Outcome Measures:** Intramuscular temperature of the thigh, hamstring, and calf at baseline, post-intervention, 10, 20, and 30 minutes post-intervention. Repeated measures ANOVAs were used to assess cooling based on subcutaneous tissue for each muscle, with post-hoc testing for significant findings. **Results:** There were 3 significant main effects for cooling across all subcutaneous tissue thicknesses when using the timing recommendations for the hamstring, calf, and thigh ($p \leq .001$). For the hamstring, all temperature time points (baseline (37.1 ± 0.5°), post-intervention (28.2 ± 0.8°), 10min (29.4 ± 0.6°), 20min (30.6 ± 0.5°) and 30min post-intervention (31.5 ± 0.4°)) we significantly different from one another ($p \leq .033$). For the calf, temperature time points (post-intervention (27.8 ± 2.0°), 10min (28.0 ± 1.1°), 20min (29.2 ± 0.8°) and 30min post-intervention (30.1 ± 2.1°)) were significantly different from baseline (36.2 ± 0.5°, $p \leq .001$). While 10min, 20min, and 30min post-intervention were significantly different from each other ($p \leq .014$), post-intervention temperature was not different from them ($p \leq .787$). For the thigh, temperature time points (post-intervention (29.5 ± 1.2°), 10min (30.2 ± 1.1°), 20min (31.0 ± 1.0°), and 30min post-intervention (31.7 ± 0.9°)) were significantly different from each other ($p \leq .02$), except post-intervention temperature was not different from 10min post-intervention ($p = .058$). **Conclusions:** Cooling recommendation times based on subcutaneous tissue thickness are effective at cooling various lower extremity muscles similarly. These timing recommendations should be incorporated for ice bag application of the thigh, calf, and hamstring.

## Does a Single Exposure to Cold Water Immersion Reduce the Perception of Soreness in Male Athletes? A Systematic Review

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**Context:** Cold-water immersion is a widely used modality in an attempt to decrease an athlete's perception of soreness after rigorous activity. **Objective:** To determine if a single exposure to cold-water immersion reduced the perception of soreness in male athletes (1) immediately post-activity (2) 24 hours post-activity (3) 48 hours post-activity. **Data Sources:** An exhaustive search of online databases was performed using PubMed, SPORTDiscus, and CINAHL from 1970 through October 2014 with the search terms: cold water immersion OR ice bath; cold water immersion AND recovery; cold water therapy AND recovery; post-exercise recovery; recovery; cryotherapy AND post-exercise recovery; or a combination of all of the above terms. Search limits included human subjects, male subjects, and studies published in the English language. **Study Selection:** Original research studies which met the following criteria were included in the review: (1) randomized controlled trials, (2) male participants, (3) participants completed uniform exertion protocol, (4) included a cold water immersion group with a water temperature of 10-15 degrees Celsius, (5) reported perception of soreness, (6) reported means, standard deviations, and sample sizes of groups. **Data Extraction:** All five investigators pulled the means and standard deviations of the reported perception of soreness ratings for all time points (immediately post-activity, 24 hours post-activity, 48 hours post-activity) if available. Selected studies were evaluated using the PEDro assessment scale to determine methodological quality. **Data Synthesis:** Effect sizes and 95% confidence intervals were then calculated using the obtained means

and standard deviations to determine the efficacy of a single cold-water immersion exposure as a recovery modality in regards to perception of soreness. The pooled data did not provide conclusive evidence that a single cold-water immersion exposure is effective over the entirety of the three analyzed time points. Due to the nature of the collected data, effect sizes that were negative showed a decrease in perception of soreness. Three studies had effect sizes that showed a decrease in soreness following a single cold water immersion exposure (Elias 2012 (-5.625); Elias 2013 (-2.0); Ascensao 2011 (-0.3007)). Some effect sizes for collected data also showed that any decrease in soreness was negated 48 hours post-activity (Bailey 2007 (-0.0725); Elias 2013 (4.01), Ascensao 2011 (-0.1808)). **Conclusions:** A single cold water-immersion exposure may decrease perception of soreness 24 hours post-activity, and any effects are gone or negated 48 hours post-activity. More standardization of cold-water immersion methods may help to see stronger conclusions in future research. All evaluated studies received an average PEDro score of 6 due to the inability to blind subjects and/or researchers. Further research is also necessary to determine if multiple cold-water immersion exposures may increase or lengthen the effects of cold-water immersion on decreasing perception of soreness.

### The Effects of Post-Exercise Cooling on Muscle Performance and Pain Perception

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**Context:** It is a common trend for athletes to prophylactically use cold water immersion post exercise with the collective understanding that by doing this, there will be quicker muscle recovery and a reduction of soreness. **Objective:** To determine if cold water immersion impacts an athlete's post-exercise recovery in muscle performance or pain perception. **Design:** Cross-Sectional. **Setting:** Research Laboratory. **Patients or Other Participants:** Twenty-two healthy college athletes volunteered to participate. Seven males (20.71 ± 1.40 yrs, 175.81 ± 5.20cm, 76.80 ± 10.00kg) and 15 females (20.60 ± 1.82 yrs, 168.50 ± 9.20cm, 64.20 ± 11.20kg) enrolled in the study. **Interventions:** Muscle performance measures included flexibility, power, agility, and speed for the lower extremity. The sit and reach test was used for muscle flexibility, the Vertec Jumping System was used to assess muscle power production, 5-10-5m shuttle pro-agility shuttle test was used for agility measurement, and 10m dash was used for measuring speed. The best of 3 measurements were used from each for both pre-intervention and 48 hours following (post-intervention). A Pain/Soreness Likert Scale was used prior to pre-intervention measurements, 24 hours, and 48 hours following intervention. All subjects performed an eccentric resistant, plyometric exercise protocol, consisting of body variation movements for 60 seconds each. The subjects were pseudo-randomly assigned to a cold-water immersion or control group. They were immersed up to their iliac crest at roughly 10°C for 15 minutes. **Main Outcome Measures:** The independent variables were sex (male vs. female), group (ice immersion vs. control), and time (pre-intervention vs. post-intervention). The dependent variable were muscle performance measurements and Pain/Soreness Likert Scale. **Results:** A 2 [group] x 2 [time] mixed design ANOVA with repeated factors with gender as a covariate (flexibility, power, agility, and speed) revealed a significant interaction for group x time for speed ([ice immersion (pre-intervention = 1.87 ± 0.21, post-intervention = 1.75 ± 0.24)]; [control (pre-intervention = 1.89 ± 0.17, post-intervention = 2.05 ± 0.14)]; P = .002). A 2 [sex] x 2 [group] x 3 [time] mixed design ANOVA with repeated factors (Pain/Soreness Likert Scale) revealed a significant main effect for time ($P < 0.001$) and interaction for group x time ([ice immersion (pre-intervention = 0.58 ± 0.90, 24 hours = 1.67 ± 1.65, 48 hours = 1.33 ± 1.87)]; [control (pre-intervention = 0.35 ± 0.75, 24 hours = 4.00 ± 0.89, 48 hours = 2.70 ± 1.15)]; P = 0.001). A Post-Hoc Independent Sample T-test revealed significant difference at 24 hours (P = 0.001). Additionally, there were no other significant main or interaction effects. **Conclusions:** Our results disclose ice immersion has a significant positive impact on speed up to 48 hours after treatment. The perception of pain reported was significantly decreased despite the lack of statistically significant performance measures 48 hours post treatment.

## A Comparison of Cryotherapy and Intermittent Compression Therapy and Their Effect on Muscle Recovery Following Exercise

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**Context:** Optimizing recovery is beneficial for reducing fatigue and overtraining and overall injury risk when performing successive bouts of training or competition over a season. The inability to repeat the same level of performance in the days following intense training is frequently attributed to peripheral fatigue involving metabolite accumulation and muscle damage. Thus, various techniques have been suggested to accelerate the clearance of muscular damage or metabolite accumulations and optimize recovery. Cold water immersion (CWI) and intermittent pneumatic therapy (ICT) using extremity compression sleeves are two modalities commonly used to enhance recovery. However, at this time their efficacy is not fully understood and comparisons between the two have not been investigated. **Objective:** To compare the effects of CWI and ICT on recovery following a bout of intense exercise. **Design:** A randomized and counterbalanced single blind cross-over design. **Setting:** Athletic training facility. **Patients or Other Participants:** Twelve healthy varsity athletes and recreationally active males and females (age = 20 ± 0.7 y, height = 166.2 ± 16.9 cm, mass = 70.9 ± 12.6 kg) who did not suffer from any contraindication to CWI or ICT volunteered. **Interventions:** Each participant reported for three sessions separated by a period of at least one week. At each session, the participants completed a drop jump protocol consisting of 100 drop jumps (5 sets of 20). The participants dropped off a 0.61-m platform with both legs and performed a maximal vertical jump in place immediately upon landing. A 10-s rest was provided between jumps and a 2-min rest between sets. Immediately following exercise, the participants completed one of three treatment conditions, CWI, ICT or control (CON). CWI consisted of immersion in 10°C water to the level of the iliac crests for 20-min. ICT utilized the NormaTec MVP Recovery System (Normatec, Newton Center, MA) applied using manufacturer's instructions for a 20-min treatment. The CON condition consisted of seated recovery alone for 20-min. **Main Outcome Measures:** General muscle soreness using a visual analogue scale (VAS), maximum vertical jump height (Vertmax), 54.9-m shuttle time, and Yo-Yo intermittent recovery test (Yo-Yo IR1) performance were assessed immediately prior to and 24-h following the bout of exercise. **Results:** Muscle soreness was greater 24-h after exercise ($F_{1,11} = 55.06$, $p = .001$), however no treatment effect was observed. Likewise, Vertmax ($F_{1,11} = 10.28$, $p = .008$) and 54.9-m shuttle time ($F_{1,11} = 8.65$, $p = .013$) performance declined 24-h following exercise however the treatment had no effect on these measures. In contrast, a significant decline in Yo-Yo IR1 ($F_{2,22} = 4.77$, $p = .019$) performance was observed following the CWI (pre = 1186.3 ± 484.2, post = 1054.1 ± 455.9 m) and control (pre = 1268.0 ± 489.3, post = 1048.0 ± 490.7 m) conditions, but not following ICT (pre = 1196.0 ± 426.2, post = 1120.0 ± 360.2 m). **Conclusions:** While CWI and ICT did not appear to affect short duration anaerobic performance, ICT did provide improved recovery for aerobic performance. Thus, this treatment can be considered beneficial as a recovery modality.

### The Association Between Leg Stiffness and Chronic Injury in Intercollegiate Athletes

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**Context:** A certain level of leg stiffness is needed for adequate joint stability, which is typically due to enhanced muscle spindle sensitivity. Researchers have suggested that impairments in leg stiffness may predispose athletes to chronic overuse injuries. No data currently exist, however, to support the association between decreased stiffness and chronic lower extremity injury. **Objective:** The purpose of this study was to determine if leg stiffness differs between participants with and without a history of chronic lower extremity conditions. **Design:** Case-control. **Setting:** Research Laboratory. **Patients or Other Participants:** Division I student-athletes with (19.63 ± 1.07 years, 175.33 ± 11.18 cm, 74.56 ± 16.49 kg; 22 females, 10 males; N = 32) and without (18.94 ± 1.10 years, 174.73 ± 9.74 cm, 72.34 ± 10.78 kg; 42 females, 20 males; N = 62) a history of chronic lower extremity conditions. Chronic lower leg conditions included: medial tibial stress syndrome, chronic ankle instability, anterior compartment syndrome, Achilles tendinitis, patella bursitis, iliotibial band bursitis, posterior tibial tendinitis, and plantar fasciitis. **Interventions:** Subjects stood barefoot atop a force plate, with their hands on their hips, and hopped on a single leg at a frequency of 2.2 Hz. While hopping, subjects were instructed to minimize ground contact time. Fifteen consecutive hops were recorded. Independent t-tests examined group (chronic condition, no chronic condition) leg stiffness differences for injured and uninjured legs. Subjects' injured leg was defined as the leg with chronic injury, while the control group was assigned an "injured leg". The non-injured leg was the contralateral leg to the injured leg in both groups. Alpha level was set a priori at 0.05. **Main Outcome Measures:** Leg stiffness was calculated using the equation $K = m(2\pi/T)2$, where m is the subject's body mass and T is the resonant period of oscillation. T was computed as 2-times the duration of time in which vertical ground reaction force was greater than body weight during the stance phase of hopping. Stiffness values were normalized to body mass (kN/m/kg). Percent differences were computed between legs to provide a measure of asymmetry. **Results:** No significant difference was found between groups on the non-injured leg (chronic condition = 0.37 ± 0.04 kN/m/kg, no chronic condition = 0.42 ± 0.24 kN/m/kg; t(92) = 1.17, P = 0.12). However, group differences were found for the injured leg (chronic condition = 0.38 ± 0.04 kN/m/kg, no chronic condition = 0.40 ± 0.06 kN/m/kg; t(86.7) = 1.88, P = 0.03) and differences existed for percent asymmetry (chronic condition = 6.35 ± 3.80%, no chronic condition = 4.61 ± 4.24%; t(89) = -1.94, P = 0.03). **Conclusions:** The injured leg of the chronic condition group had lower leg stiffness and greater asymmetry between legs than the no chronic condition group. The results provide evidence that decreased leg stiffness is associated with a history of chronic lower extremity injury. Identifying these deficits in screening examinations may help identify vulnerable athletes and allow clinicians to initiate intervention strategies to correct these impairments and prevent future injury.

### Altered Stiffness Regulation Strategies Following Hamstring Strain Injury

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**Context:** Hamstring strain injury (HSI) continues to rank as the highest re-occurring medical problem in active populations and while many risk factors have been explored, injury mechanism evidence to date remains inconclusive. The active mechanical strain placed on the hamstrings during injury and ensuing implications on tissue properties may cause a decoupling between the nervous system and muscle that leads to changes in muscle stiffness regulation during physical activity. Identifying underlying factors contributing to this neuromechanical dysfunction of the hamstring muscles could help to improve current prevention and rehabilitation programs. **Objective:** To examine stiffness regulation strategies in a previously injured population to identify alterations throughout a joint range. It is hypothesized that hamstring stiffness is increased following HSI, which may elevate the risk of subsequent injury. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-three physically active males (22.1 ± 2.4 years, 181.9 ± 8.2 cm, 92.1 ± 21.2 kg) volunteered for this study, including 15 subjects with a previous unilateral HSI. **Interventions:** Subjects were tested for hamstring stiffness on a custom-built assessment device. Changes in torque throughout a 30° knee extension perturbation were measured between the control (n = 18) and injured (n = 15) groups. Participants were instructed to regulate muscle contraction in response to the perturbation for two conditions: active reactive stiffness (ARS- 85% MVIC pre-contraction with maximum contraction at perturbation) and active non-reactive stiffness

(NRS- 30% pre-contraction held constant through perturbation). The bilateral average for controls and affected limb of the injured group were used for analysis. Testing order for leg and condition was randomized. **Main Outcome Measures:** Dependent variables included stiffness (N·m/deg) throughout the perturbation [short (0-4°), peak torque (3°-peak torque), end (15°-30°), and total (0-30°) ranges] and coefficient of variation (%) for stiffness. Descriptive statistics were calculated for stiffness. Separate repeated measures ANOVAs were used to compare stiffness between groups for the two conditions. **Results:** A significant main effect of group was observed for the ARS condition ($F_{1,30} = 5.90$, $P = .021$). Post hoc analyses revealed that the injured group had significantly greater stiffness at the 3°-peak torque range ($16.80 \pm 4.69$, $P = .012$) than controls ($13.30 \pm 2.60$). No significant differences existed for the NRS condition. Coefficients of variation revealed a range from 15.5%-56.1% for controls and 19.9%-76% for the injured group. **Conclusions:** Optimal stiffness regulation leading up to peak eccentric torque production is altered following HSI when reactive muscle activation is required. Higher stiffness in HSI athletes may reflect altered passive connective tissue properties related to previous injury and/or a neuromechanical dysfunction needed to safely attenuate musculotendinous loads. Greater variability in stiffness regulation among HSI patients may expose these individuals to episodes where excessive strain is encountered. Clinicians should consider implementing exercises to restore optimal stiffness regulation following HSI to decrease the risk of re-injury.

### Sex-Based Differences in Tendon Composition and Mechanical Properties

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**Context:** Epidemiological evidence shows tendon pathologies are more prevalent in males than females, but does not give insight to the physiological reasons why. The purpose of this study was to investigate sex-based differences in tendon mechanics, gene expression, proteomics, cell biology, and histology. **Objective:** Given the epidemiological evidence, we hypothesized that male tendon, when compared to female tendon, would have decreased biomechanical properties, decreased gene expression of key regulators in collagen synthesis and turnover, and decreased extracellular matrix protein content. **Design:** Animal-model study. **Setting:** Controlled research laboratory. **Patient or Other Participants:** N/A. **Interventions:** Male and female plantaris tendons were removed and tested for mechanical properties over a 300-stretch protocol. Achilles tendons were used for RNA isolation, protein analysis, and histology. Mouse-tail tendons were used for fibroblast and collagen isolation. **Main Outcome Measures:** Male Achilles and plantaris tendon cross-sectional area and cell density, gene expression, protein content, and mechanical properties were measured and compared to female Achilles tendon values. Differences between the groups were tested using t-tests. **Results:** Histologically, male tendons, when compared to female tendons, have significantly greater Achilles cross-sectional area ($0.2995 \pm 0.0378$ mm2 and $0.2498 \pm 0.0133$ mm2, $P = 0.005$) and lower Achilles cell density ($1780.9 \pm 98.9$ cells/mm2 and $2119.4 \pm 156$ cells/mm2, $P < 0.001$). Mechanically, over the 300-stretch protocol, there were no significant differences in load, stress, tangent modulus, or energy loss between male and female plantaris tendons. The male tendon proteome has significantly ($P < 0.001$) less extracellular matrix associated protein content and peptide crosslinking. Microarray analysis shows, at baseline, gene expression of key regulators of collagen maintenance and fibroblast proliferation are not significantly different. The analysis of male and female fibroblast gene expression in response to sex-specific serum or extracellular matrix is currently underway; as is the baseline whole-tendon gene expression analysis. **Conclusions:** Males have larger Achilles tendon cross-sectional area and lower cell density when compared to female tendons. Male plantaris tendons have lower extracellular matrix protein content when compared to female tendons. However, the differences in male and female tendon proteome do not correlate with significant differences in tendon function, further studies are needed. Currently underway is, whole-tendon and cell culture gene expression analyses, which will help to identify sex-specific baseline and serum- or extracellular matrix-dictated changes in gene expression.

## Neuromechanical Links Between Cortical Activity and Knee Stiffness During Joint Loading

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**Context:** Neuromechanical uncoupling between knee joint structures and the central nervous system (CNS) contributes to the high incidence of non-contact joint injury mechanisms. Recent studies have suggested that the brain plays an important role in maintaining joint stability and mechanoreceptor function within the anterior cruciate ligament (ACL) is critical for detecting knee loading and laxity. However, it remains unclear how the brain perceives sensory traffic and couples the proprioceptive information with mechanical stiffness in the knee during ligamentous loading. **Objective:** To simultaneously examine cortical activity and mechanical stiffness between limbs during knee loading. **Design:** Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-four healthy controls (12 Males: 25.9 ± 6.4 yrs, 75.5 ± 11.3kg, 175.6 ± 7.6cm, 12 Females: 28.7 ± 5.1 yrs, 57.1 ± 7.4kg, 162.6 ± 4.7cm) with no history of knee injury volunteered. **Interventions:** Mechanical stiffness was measured using a customized knee arthrometer (KT2000) that applied mechanical load at constant force (45N/sec) anteriorly (3sec) and posteriorly (2sec) while event-related desynchronization (ERD) was quantified in alpha-2 frequency band (10-12Hz) using electroencephalography (EEG) of the contralateral somatosensory cortex activity (CP3, CP4). Subjects were instructed to relax, and minimize eye/body movements while in a position of 25-35 degrees of knee flexion. **Main Outcome Measures:** One second intervals of cortical ERD (% decreased power; ERD1, ERD2, ERD3) and stiffness (N/mm; STIF1, STIF2, STIF3), during anterior loading were compared across limbs (2-levels) and time (3-levels) by using repeated-measures ANOVAs. Pearson's correlation coefficients were used to examine relationships between dependent variables. **Results:** Significant main effects for the times (ERD; $F_{2,80} = 5.044$, $p = .009$, Stiffness; $F_{1.245,57.288} = 27.002$, $p < .001$) revealed that ERD3 (32.23 ± 19.46 ERD) produced higher somatosensory cortex activity than ERD1 (24.11 ± 14.76 ERD) while STIF1 (65.23 ± 44.26 N/mm) showed greater stiffness values than STIF2 (27.65 ± 15.89 N/mm) and STIF3 (39.99 ± 16.96 N/mm). No significant interaction effect was observed for the cortical ERD ($F_{2,80} = .968$, $p = .384$) and stiffness ($F_{1.245,57.288} = 1.007$, $p = .338$). ERD1 showed large, positive relationships with ERD2 ($r = .734$, $p < .001$) and ERD3 ($r = .531$, $p < .001$), but large, negative relationships with STIF1 ($r = -.337$, $p = .024$) and STIF2 ($r = -.315$, $p = .035$). A large, positive relationship between ERD2 and ERD3 was also observed ($r = .736$, $p < .001$). STIF2 showed a large, negative relationship with ERD3 ($r = -.373$, $p = .013$), but a large, positive association with STIF3 ($r = .506$, $p < .001$). **Conclusions:** Our findings reveal greater somatosensory cortex activity during late-loading, while joint structures produce greater mechanical stiffness during early-loading. Moreover, greater stiffness values during early- and mid-loading correlate with less brain responses. This suggests that different sensory perceptions may exist in the brain to changes in mechanical stiffness as a result of joint loading. Less mechanical stiffness during joint loading may be offset by enhanced neural excitation in the brain, optimizing neuromechanical coupling needed for muscle coordination and maintenance of knee stability through dynamic restraints. Future studies should explore the brain's role in neuromuscular control to prevent joint injury.

## The Assessment of Hamstring Related Deficiencies in Collegiate Football Athletes With a Prior History of Hamstring Strains: A Case Control Study

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**Context:** Hamstring strain injury (HSI) commonly occurs in sports that require sprinting and cutting activities. Potential risk factors have been investigated in rugby, soccer, and Australian Rules football, but collegiate football athletes are an understudied population. **Objective:** To examine commonly established HSI risk factors in collegiate football athletes with a HSI history compared to healthy matched controls. **Design:** Case-control study. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Thirty competitive football athletes) were included. Participants of HSI group (n = 15; 20.93 ± 1.28 years old; 213.33 ± 23.83 pounds; 72.66 ± 3.81 inches) suffered at least one activity-limiting HSI diagnosed by a healthcare professional in the past 2 years, but not within 6 months of study. The control group (n = 15; 20.60 ± 1.18 years old; 215.60 ± 23.59 pounds; 73.26 ± 4.46 inches) matched on position, age, height and weight never experienced a diagnosis of a HSI. **Interventions:** Independent variables included group assignment (HSI versus healthy) and side (injured versus uninjured). **Main Outcome Measures:** Five dependent variables were assessed: 1.) health-related quality of life via the Disablement in the Physically Active Scale (DPA), 2.) pelvic position measured with a CHEK Inclinometer, 3.) hamstring flexibility via the active straight leg (ASLR) test, 4.) hamstring endurance during a single-leg bridge test (SLHB) to fatigue and 5.) isokinetic strength using the functional eccentric hamstring strength to concentric quadriceps strength ratio (H:Qfunc) at 60°/s,180°/s, and 300°/s. Five mixed

2 X 2 ANOVAs were used to determine statistical differences between the two groups (HSI and healthy) and within the testing legs (injured and uninjured) for 5 variables: ASLR, H:Qfunc at 60o/s, H:Qfunc at 180o/s, H:Qfunc at 300o/s and SLHB. Two independent samples t-tests were used to assess differences between groups in pelvic tilt values and DPA scores. **Results:** DPA scores were significantly higher ($t(14) = -3.66$, $p = .003$) in the HSI group ($7.67 \pm 8.11$) compared to healthy control ($0.00 \pm 0.00$). There were no significant differences between the HSI and healthy groups, nor injured and uninjured limb in regards to pelvic tilt, ALSR, SLHB, and H:Qfunc scores @60°/s, 180°/s, and 300°/s. **Conclusions:** We did not find significant strength, posture, flexibility or endurance differences in HSI and healthy groups. No side (injured versus uninjured) differences were noted either. Despite the lack of significant findings, average hamstring flexibility was below established norms while the H:Qfunc averages were above established healthy norms. Subjects of the HSI group were also experiencing low levels of disability more than 6 months post injury. The demands of other sports like soccer, rugby, and Australian Rules football differ from football; therefore previous research may have limited applicability to football.

## Immediate Effects of Proprioceptive Neuromuscular Facilitation Stretching Programs Compared to Passive Stretching Programs for Hamstring Flexibility: A Critically Appraised Topic

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**Context:** Hamstring strains are common athletic injuries that result in significant time lost from participation and impaired health-related quality of life. To reduce hamstring strain incidence, stretching has become a common prevention strategy in clinical practice. There are several stretching techniques to increase flexibility, including static stretching and proprioceptive neuromuscular facilitation (PNF). Currently, it is unclear if one technique can more effectively create immediate increases in hamstring flexibility. **Objective:** The purpose of this critically appraised topic was to determine if PNF stretching programs are more effective in immediately improving hamstring flexibility compared to static stretching programs in healthy individuals. **Data Sources:** Systematic literature searches in PubMed, Medline, CINHAL, SPORTDiscus, EBSCO Host, and Science Direct databases as well as hand searches were conducted for articles published from 2005-2015. The search was limited to studies published in English, involving human subjects between the ages of 18-60. **Study Selection:** Studies were included if they were randomized control trials comparing PNF to static stretching, included hamstring flexibility or range of motion as the main outcome, completed multiple treatment bouts, and completed immediate post intervention outcome assessments. Studies were excluded if they only included a single treatment bout, only included a PNF or static stretching program, did not include hamstring flexibility as an outcome, or if hamstring flexibility was not measured immediately following the program. **Data Extraction:** Two reviewers independently appraised each study using the Physiotherapy Evidence Database Scale (PEDro), and a consensus score was reached to determine methodological quality. Studies scoring ≥6/10 were considered high quality. The Oxford Center for Evidence–Based Medicine's Level of Evidence (2009) was used to provide a recommendation on the evidence. **Data Synthesis:** The search resulted 195 studies after duplicates were removed; five studies met the eligibility criteria. All five studies were categorized as low methodological quality. Four studies observed improvements in hamstring flexibility following both PNF and static stretching programs but neither program was deemed more effective. One study concluded static stretching was the only technique that increased hamstring flexibility. The consistent results and low methodological quality of the included studies indicates there is Grade B evidence that there is no difference in immediate hamstring flexibility improvements when comparing PNF stretching to static stretching programs in physically active adults. **Conclusions:** The current evidence does not support performing PNF stretching programs over static stretching programs. However, both techniques immediately increased hamstring flexibility in most studies. When selecting a stretching program in clinical practice, the ability of the patient to independently perform static stretching should be balanced with the clinician oversight and the potential for greater compliance associated with PNF stretching. The findings of this critically appraised topic should be revisited when high quality evidence becomes available.

Learning Objectives:

At the conclusion of this presentation, participants should be able to review and critically appraising the best available evidence associated with PNF and static stretching programs. Participants should also be able to provide recommendations for improving hamstring flexibility in clinical practice.

Citations

1. Beltrão NB, Ritti-Dias RM, Pitangui ACR, De Araújo RC. Correlation between Acute and Short-Term Changes in Flexibility Using Two Stretching Techniques. International Journal of Sports Medicine. 2014;35(14):1151-1154.
2. Davis DS, Ashby PE, McCale KL, McQuain JA, Wine JM. The Effectiveness Of 3 Stretching Techniquest On Hamstring Flexibility Using Consistent Stretching Parameters. Journal of Strength & Conditioning Research (Allen Press Publishing Services Inc.). 2005;19(1):27-32.

## Consistency of H-Reflex Measures During Explosive Muscular Contraction

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**Context:** There is increasing interest in rapid, explosive muscular force production, with particular interest in ways to improve it, due to its role in protecting against joint injury. Considering the nervous system is a major contributor to muscular force production, it is important to measure nervous system changes when evaluating training interventions. The Hoffmann-reflex (H-reflex) is a non-invasive measure of motor neuron pool excitability and is used to gain insight into the role of the nervous system during muscle contraction. While H-reflexes are typically evaluated at rest or a steady level of muscular force, they are contextually dependent and are likely more clinically relevant if measured during functional actions (e.g., explosive muscle contractions). However, the consistency of H-reflexes during explosive contractions across time is unknown - thereby limiting its use for assessing changes in motor neuron pool excitability in response to training interventions. **Objective:** To evaluate the consistency of motor neuron pool excitability using the H-reflex technique during an explosive muscular contraction of the plantarflexors. **Design:** Cohort. **Setting:** Research Laboratory. **Patients or Other Participants:** Ten healthy and recreationally active individuals (5 male and 5 female, age = 24.3 ± 4.5 yrs, height = 177.8 ± 4.8 cm, mass = 75.6 ± 5.5 kg). **Interventions:** Participants were assessed in two identical testing sessions three weeks apart and instructed to maintain their normal activity levels between sessions. H-reflexes were elicited with participants seated on a Biodex System 3 dynamometer (Biodex Medical Systems Inc., Shirley, NY) interfaced with a BIOPAC MP100 Data Collection System (BIOPAC Systems Inc., Goleta, CA). Participants were instructed to isometrically plantarflex against the dynamometer footplate "as hard and fast as possible." The initial three explosive contractions were averaged to determine peak torque, and during subsequent explosive contractions an H-reflex recruitment curve was generated. H-reflexes were elicited with a 1 ms square wave stimulus of varying intensity delivered to the tibial nerve using a Grass S88 stimulator (Grass Technologies, West Warwick, RI) at 20% of peak torque. **Main Outcome Measures:** The peak-to-peak amplitude of the maximal H-reflex (Hmax) and maximal M-wave (Mmax) were determined for each session. The ratio of the Hmax and Mmax (Hmax:Mmax) were calculated as the measure of motor neuron pool excitability. A one-way repeated-measures ANOVA and intraclass correlation coefficient were used to determine mean differences and consistency, respectively, between sessions. **Results:** There was no difference in Hmax:Mmax values between sessions (0.696 ± 0.163 vs. 0.693 ± 0.084, p = 0.941). The ICC (2,1) equaled 0.59 with a SEM of 0.10. **Conclusions:** Hmax:Mmax measured during explosive contractions three weeks apart were not significantly different and demonstrated moderate-strong consistency between sessions. The results indicate that this measure remains stable across a relatively long period of time and might be a useful tool for assessing changes in motor neuron pool excitability in response to training interventions.

## Comparison of Static Lower Extremity Alignment Between Korean and Caucasian

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**Context:** Korean males and females are often observed to have different lower extremity construct as compared to US. Even though anecdotal differences have been observed in characteristics of the lower extremity alignment (LEA) among ethnicities, there is a lack of studies regarding ethnical differences. **Objective:** To identify differences in static LEA among gender and ethnicity. **Design:** Case control study. **Setting:** Research laboratory. **Patients or Other Participants:** A total of 144 subjects (37 Korean males: age = 21.32 ± 3.04 years, height = 175.86 ± 6.55 cm, weight = 71.99 ± 8.45 kg; 34 Korean females: age= 20.97 ± 1.66 years, height = 163.90 ± 4.94 cm, weight = 56.80 ± 5.32 kg; 39 Caucasian males: age = 33.77 ± 3.61 years, height = 178.46 ± 6.92 cm, weight = 82.31 ± 10.80 kg; 34 Caucasian females: age = 31.71 ± 2.78 years, height = 164.87 ± 6.71 cm, weight = 67.13 ± 16.20 kg) participated in the study. **Interventions:** Ethnicity (Korean vs Caucasian) and gender (male vs female) were independent variables of the study. **Main Outcome Measures:** Reliability of LEA (ICC>.7) were pre-established before data collection. The list of LEA measures is as follows: pelvic tilt, femoral anteversion, quadriceps angle, tibiofemoral angle, genu recurvatum, tibial torsion, rearfoot angle, and navicular drop. A two-way ANOVA was used for identifying differences among gender and ethnicity, and post hoc analysis was conducted if significant results were found. **Results:** Since interaction of gender and ethnicity was main interest of this study, only interaction results will be reported. There was a significant moderate interaction in the genu recurvatum (= 9.54, p= .002) and small interaction in the femoral anteversion (= .046, = 6.78, p= .010). In post hoc analysis, Caucasian females had a greater genu recurvatum than all three groups (Caucasian female = 5.88 ± 4.07˚, Korean female = 2.76 ± 3.46˚, Korean male = 2.00 ± 3.25˚, Caucasian male = 1.81 ± 1.75˚). Females had greater femoral anteversion as compared to all three groups (Caucasian female = 17.95 ± 6.76˚, Korean female = 10.23 ± 6.01˚, Caucasian male = 8.90 ± 5.47˚, Korean male = 6.68 ± 6.97˚). **Conclusions:** Caucasian females had an increased knee hyperextension and hip anteversion, both of which are potential risk factors of ACL injury. Interestingly, frontal plane knee alignments did not show any differences among groups. This may cause a different ACL injury incident rate between males and females in Korean population as compared with US.

# Free Communications, Poster Presentations: Mechanics and Postural Stability in Chronic Knee Populations

Baltimore Convention Center, Swing Hall; Thursday, June 23, 10:00AM-5:00PM; Friday, June 24, 10:00AM-5:00PM; Saturday, June 25, 10:00AM-1:00PM

Authors present June 23: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

### Influence of Pain: Lower Extremity Kinematics and Muscle Activity in Individuals With Patellofemoral Pain

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**Context:** Individuals with patellofemoral pain (PFP) present with altered movement patterns and muscle activity during functional tasks. Individuals with PFP often have a heterogeneous presentation of symptoms during various pain provoking activities, such as a single leg squat (SLS). Although pain influences both movement patterns and muscle activity in those with PFP, it is currently unknown how severity of pain influence lower extremity kinematics and muscle activity in individuals with PFP during a SLS. **Objective:** To determine the effect of pain on lower extremity kinematics and muscle activity during a SLS. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 15 females with PFP (Age = 26.7 ± 9.1 years; Height = 172.1 ± 6.3cm; Mass = 71.3 ± 8.3kg) participated. Participants had non-traumatic peri- or retro-patellar pain for greater than 3 months during running, stair ambulation, kneeling, squatting, jumping or prolonged sitting and scored less than 85 on the anterior knee pain scale. Exclusion criteria included previous knee injury/surgery and/or other form of anterior knee pain. **Interventions:** Participants completed a baseline visual analog scale (VAS) of their current pain and then performed 5 SLS to assess lower extremity kinematics and surface electromyography (sEMG). Pain immediately following the SLS was assessed with VAS. Individuals were grouped dependent on change in pain between baseline and during SLS; high change in pain >1.3cm (n = 8) and low change in pain<1.3cm (n = 7). **Main Outcome Measures:** Frontal and sagittal kinematics of the hip, knee and ankle and normalized sEMG for the vastus lateralis (VL), vastus medialis oblique (VMO), biceps femoris (BF), and gluteus medius (GMed) were collected, filtered, and reduced to 100 data points across the entire SLS. Group means and associated 90% confident intervals were plotted for the entire task. Significant differences were determined where confidence intervals did not overlap for 3 or more consecutive data points. **Results:** No differences were seen in initial kinematic or sEMG values between groups. Increased hip adduction (between 7-60% of the task) and knee abduction (between 56-68% of task) were noted in the high pain group. No other statistical differences were seen in the remaining frontal or sagittal kinematics. Greater sEMG activity was noted in the low pain group, with a statistically significant difference in GMed activation (12-19% and 41-46% of the task) and VL activation (3-16% of the task). No differences were seen between groups in the VMO or BF muscle activation during the SLS. **Conclusions:** Differences in lower extremity kinematics and muscle function exist in individuals with PFP depending on severity of pain experienced during a SLS. Clinicians should continue to manage pain in chronic conditions prior to progressing to functional activities, such as the SLS.

### Immediate Effects of Therapeutic Tapings on Pain, Muscle Activation, and Kinematics in Patellofemoral Pain During Stair Descent

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**Context:** Chronic Patellofemoral pain (PFP) may result in persistent decreases in physical activity level and self-reported function. Although therapeutic taping techniques have been used to treat PFP, the influence of patellofemoral taping on muscle function and lower extremity movement patterns in individuals with PFP remains unclear. **Objective:** To compare the immediate effects of therapeutic taping on knee pain, muscle activation (EMG), and 3-dimentional (3D) lower extremity kinematics during stair ascent and descent. **Design:** Cross-over trial. **Setting:** University 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 history of PFP participated in this study. **Interventions:** Participants were randomly assigned to one of the following taping techniques on separate testing days: McConnell taping (MT) for lateral tracking, kinesiology taping (KT), or sham taping (ST) with no tension and direction. **Main Outcome Measures:** Perceived knee pain was reported using a 10-cm visual analogue scale (VAS) during stair descent. 3D lower extremity kinematics and muscle activation were assessed during loading phase while participants descended from our customized stairs at a self-selected pace. An 8 camera motion analysis system was utilized to

capture abduction/adduction and flexion/extension of hip and knee while EMG of Vastus Medialis (VM), Vastus Lateralis (VL), Gluteus Medius (GM), and Biceps Femoris (BF) was collected using a wireless EMG system. Root mean squared EMG was then calculated and normalized using maximal isometric contractions (nRMS_EMG). All measurements were conducted before tape application and 60 minutes following application of each taping condition. Separate 3 (Tape) X 2 (Time) repeated measures ANOVAs were used to assess differences in pre- and post-taping pain, normalized RMS of EMG of VM, VL, GM, and BF, and angle of hip and knee on frontal and sagittal planes (flexion/extension and abduction/adduction) between taping conditions. Also, Sidak's post-hoc analysis was used to determine significant interactions. **Results:** VAS was significantly decreased in the post-taping condition (KT: 3.37 ± 1.42, MT: 3.25 ± 1.06, ST: 3.92 ± 1.19) regardless of taping technique compared to the pre-taping condition (KT: 4.53 ± 0.23, MT: 4.75 ± 0.28, ST: 4.66 ± 0.41; $F(1,12) = 19.23$, $P < 0.001$). No differences in nRMS_EMG of VM ($F(2,11) = 0.32$, $P = 0.728$), VL ($F(2,11) = 0.81$, $P = 0.458$), GM ($F(2,11) = 0.2$, $P = 0.76$), or BF ($F(2,11) = 1.2$, $P = 0.319$) were observed during loading phase of stair descent. Also, the ensemble curve analysis showed no significant differences in the 3D kinematics of hip and knee during loading phase of stair descent. **Conclusions:** A reduction in pain was reported during stair descent across all conditions while both KT and MT had no significant impact on either lower extremity biomechanics or muscle activation while stair descent. Clinicians may consider using therapeutic taping techniques in order to reduce pain during rehabilitation in order to facilitate a treatment window.

## Quadriceps Activation Deficits Alter Sagittal-Plane Lower Extremity Biomechanics in Subjects With Anterior Knee Pain

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**Context:** Anterior knee pain (AKP) is a common clinical problem. Knee pain is an underlying mechanism of quadriceps muscle inhibition and weakness. AKP may be defined by using self-reported assessments such as a Visual Analog Scale (VAS), Tampa Scale for Kinesiophobia (TSK) and Kujala Anterior Knee Pain (KAKP). However, all patients with AKP who are identified with these questionnaires do not exhibit evidence of quadriceps muscle inhibition. Little is known about the relationship between muscle inhibition and movement patterns in people with AKP. **Objective:** To investigate if subjects with quadriceps activation deficits (QD) demonstrate different sagittal-plane lower extremity biomechanical patterns during a forward-side jump when compared to subjects with non-QD (NQD). **Design:** Single cohort, descriptive. **Setting:** Controlled, laboratory. **Patients or Other Participants:** 30 AKP patients (M = 16, F = 14) participated: 15 QD (CAR < 0.95; CAR = 0.91 ± 0.04, VAS = 3.87 ± 1.3, KAKP = 82.9 ± 6.6, TSK = 37.9 ± 4.7) and 15 NQD (CAR > 0.95; CAR = 0.97 ± 0.01, VAS = 3.93 ± 0.7, KAKP = 79.3 ± 7.9, TSK = 36.9 ± 5.2). **Interventions:** Subjects performed three quadriceps maximum voluntary contractions (MVC) with an isokinetic dynamometer while superimposed burst was transmitted to two electrodes placed on their quadriceps to calculate central activation ratio. Fifty-nine reflective markers were placed over anatomical landmarks to calculate joint angles and moments. Subjects performed five trials of a forward-side jump on the force plate, which was to jump forward 1 m to the center of the force plate, land with the dominant leg, and then immediately jump to the contralateral side. A functional analysis ($p < 0.05$) was used to compare the entire stance phase of QD subjects to NQD subjects (function). This analysis allowed us to compare variables as polynomial functions rather than discrete values. We plotted our estimates of pairwise comparison functions of each condition as well as 95% confidence interval (CI) bands to determine significant differences. If these 95% CI bands did not cross the zero line, we considered the difference significant. **Main Outcome Measures:** Joint angles (°) and moments (N·m) were measured from initial foot contact (0%) to take-off (100%). Group-difference curves were obtained by subtracting the NQD mean curve from QD curve. **Results:** The QD group showed decreased knee flexion during 15-85% of stance compared to NQD subjects. Plantarflexion and knee extension moments were decreased during initial landing phase. Hip extension moments were decreased between 0-80% of stance during a forward-side jump. **Conclusions:** QD subjects decreased knee flexion angles, likely a result of reduced lower extremity joint moments due to quadriceps muscle inhibition in an attempt to control landing motion. AKP patients with QD may alter lower extremity biomechanics in a way that could increase injury risk during functional activities.

## The Relationship Between Acute Pain and Dynamic Postural Stability Indices in Individuals With Patellar Tendinopathy

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**Context:** Patellar tendinopathy is a degenerative condition resulting in persistent pain in physically active individuals. Although pain is frequently reported during activity, the relationship between dynamic postural stability and pain in these individuals is unclear. **Objective:** Identify the relationship between acute pain and dynamic postural stability indices in individuals with patellar tendinopathy. **Design:** Cross-sectional. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Twenty-two (10 male, 12 female: age = 21.6 ± 3.6 years, height = 175.0 ± 10.0 cm, mass = 73.2 ± 13.0 kg) recreationally active individuals with patellar tendinopathy participated. Inclusion criteria were current signs and symptoms of patellar tendinopathy, including self-reported pain solely within the patellar tendon during recreational activities for a minimum of the previous 3 months, continuing to practice and perform their preferred activities despite their pain, and ≤80 on the Victorian Institute of Sport Assessment Scale-Patella (VISA-P = 64.5 ± 9.0) indicating poorer knee function. **Interventions:** Baseline pain was assessed utilizing 100mm visual analogue scales (VAS). Participants jumped 70cm horizontally onto a force platform, performed a two-legged jump to a target height set at 50% of their maximum vertical jump, and landed on a single test-limb on the force platform. Participants were instructed to "stick" the landing with the single-limb, steady themselves, and maintain the position for 10 seconds. Participants completed another VAS for pain immediately after completing 5 landing trials, blinded to previous VAS scores. **Main Outcome Measures:** Ground reaction force (GRF) data were collected at 1200Hz. The first 3 seconds of data, post-contact (>10 N) were examined. GRF's were initially scaled to body-weight. Anterior-posterior (APSI), medial-lateral (MLSI), vertical (VSI), and composite (DPSI) stability indices were calculated. A paired t-test ($p \leq .05$) and change scores were used to assess differences in baseline and post-testing VAS pain scores. The relationship between stability indices and VAS's for pain as well as change scores were assessed via Pearson's correlational coefficients ($p \leq .05$). **Results:** Participants indicated significantly more pain post-landing (42.7 ± 22.9 mm) compared to baseline (15.7 ± 14.7 mm, $t = 7.2$, $p < .001$). Baseline pain was not significantly correlated with any stability indices. Post-landing pain was significantly correlated with MLSI (MLSI = .04 ± .01, $r = .55$, $p = .004$), VSI (VSI = .38 ± .07, $r = .37$, $p = .05$) and DPSI (DPSI = .17 ± .05, $r = .38$, $p = .04$). Pain change scores (mean pain change = 27.0 ± 17.6 mm) were significantly correlated with MLSI ($r = .58$, $p = .002$). **Conclusions:** As pain increased in individuals with patellar tendinopathy, dynamic postural stability indices values increased, indicating more difficulty transitioning from a dynamic to static state. Although balance deficits are not typically associated with patellar tendinopathy, it appears pain and dynamic postural stability may be related in these individuals. Reducing pain in individuals with patellar tendinopathy may improve their dynamic postural stability. Correspondingly, incorporating balance activities into rehabilitation programs in individuals with patellar tendinopathy may also be warranted.

## Characteristics of Static and Dynamic Lower Extremity Posture in Patients With Patellofemoral Pain: A Meta-Analysis

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**Context:** Even though the lower extremity static and dynamic posture have been reported to be a risk factor of PFPS, contradictory results are still reported in various studies. **Objective:** Identify characteristics of static and dynamic lower extremity alignment in patients with PFPS. **Data Sources:** PubMed, SPORTDiscus, CINAHL, and Web of Science until 2015 October were used to search relevant studies using patellofemoral pain syndrome, alignment, static, and dynamic as keywords. **Study Selection:** Studies were selected if they aligned with the following criteria: (1) subjects with PFPS, (2) results of studies included lower extremity alignment characteristics and kinematic data during dynamic task, (3) appropriate mean, standard deviation, and number of subjects were reported and (4) written in English. **Data Extraction:** Three authors evaluated the quality of relevant study on the Physiotherapy Evidence Database (PEDro) scale (4.4±1.2). A total of eighteen articles were reviewed—nine for kinematic data in static posture and nine for kinematic data in dynamic posture. Mean values and standard deviations were extracted for each set of data. **Data Synthesis:** Meta-analyses were performed for static and dynamic posture. The Cohen's d and 95% confidence intervals (CI) was implemented to calculate pooled effect sizes for each variables. For static posture, the results yielded large effect sizes for ND (pooled SD = 0.35, ES = 2.33, CI: 2.27 to 2.39), standing rearfoot angle (pooled ES = 1.88, pooled SD = 3.45, CI: 0.56 to 1.88), femoral anteversion (pooled ES = 3.65, pooled SD = 4.75, CI: 2.93 to 4.37); and a moderate effect size for the subtalar joint neutral position (STJNP) angle (pooled ES = 0.78,

pooled SD = 3.47, CI: 0.35 to 1.22). For dynamic posture, we observed a large effect size for contralateral pelvic drop (CPD) (pooled ES = 1.14, pooled SD = 2.30, CI: 0.78 to 1.50) and a moderate effect size for hip adduction (pooled ES = 0.78, pooled SD = 3.47, CI: 0.35 to 1.22). All of the significant effect sizes had a positive value, signifying that PFPS subjects displayed a higher tendency than the control group in all variables. **Conclusions:** Strength of recommendation for this study is A with consistent results. This review presents that PFPS patients have a greater ND, standing rearfoot angle, femoral anteversion, and STJNP angle in the static posture, with increased CPD and hip adduction in the dynamic posture. Since these characteristics were found among PFPS patient, proper intervention to amend these problem may prevent PFPS.

### Musculoskeletal Injury Incidence in Army Basic Trainees

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**Context:** Musculoskeletal injury (MSK-I) is one of the largest contributing factors to discharge from military basic training. Up to 25% of those who sustain an MSK-I during basic will proceed to early medical discharge. **Objective:** To determine gender-specific MSK-I incidence, MSK-I incidence rate and training outcomes in a cohort of military applicants entering Army Basic Combat Training (BCT). **Design:** Prospective Cohort Study **Setting:** Fort Jackson, South Carolina **Patients or Other Participants:** U.S. Army Basic Trainees (Male = 196, Female = 85) training at Fort Jackson **Interventions:** U.S. Army Applicants (Male: n = 196; 22.1 ± 4.3 yrs; 176.6 ± 7.4cm 76.7 ± 12.8kg; and Female: n = 85; 22.5 ± 4.3 yrs; 163.6 ± 6.8cm; 60.7 ± 8.4kg) were enrolled at the Baltimore Military Entrance Processing Station the day prior to heading to Fort Jackson for 10-week military basic training as part of a larger study. MSK-I and training outcomes were obtained for enrolled participants via existing mechanisms, including the Defense Medical Surveillance System and a memorandum of understanding between the Consortium for Health and Military Performance and U.S. Army Public Health Command. All study procedures were approved by involved Institutional Review Boards and Commands. **Main Outcome Measures:** MSK-I incidence as determined by ICD-9 codes, MSK-I incidence rate, training outcomes, Fisher's Exact test significance values **Results:** During the 10 weeks of basic training, 30 males (15.6%) and 31 females (36.5%) sustained a reported MSK-I. Three females (3.5%) sustained lower extremity stress fractures, while the remaining MSK-I for both sexes were overuse in nature. Females sustained MSK-I at a rate of 7.9 injuries per 1,000 training days, whereas males sustained MSK-I at a slower rate: 2.5 injuries per 1,000 training days. Mean time to injury was also slower by five days for males 31.4 days, 95% CI 24.3-38.6) than for females (26.3 days, 95% CI 19.7-32.9). MSK-I led to training delays in 16.7% (5/30) and 22.6% (7/31) of injured males females, respectfully; these delays did not statistically differ by gender (Fisher's exact p = 0.76). Additionally, MSK-injured males and females were discharged at approximately the same rate: 13.3% (4/30) of MSK-injured males and 12.9% (4/31) of MSK-injured females proceeded to early BCT discharge (Fisher's exact p = 0.57). **Conclusions:** Females have a higher incidence of MSK-I during Army basic combat training and also sustain MSK-I at almost three times the rate of males. However, once injured, the percentage of males and females who proceed to early discharge were similar. The cost of basic training is high, with $75,000 already invested in each trainee upon arrival at basic training sites. These results are part of a broader initiative to identify prospective, modifiable risk factors for MSK-I in those entering military basic training, including movement screening and general health data. Once available, these data will be combined to inform the development of prevention strategies prior to entering basic training.

### Examination of Energy Cost Among College Marching Musicians

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**Context:** Expended energy cost associated with collegiate marching, to date, have been discreetly studied. Empirical results vary in conclusion due to confounders such as heart rate, instrument type, marching style and performance scenario (practice vs. show). **Objective:** To evaluate the physiological demands of performing in elite collegiate marching band members using heart rate and pedometry counts. By quantifying the physicality of marching, it can be appropriately cataloged as light, moderate or vigorous activity. **Design:** Cross-sectional analysis conducted at the beginning of the collegiate marching band season. **Setting:** The study was performed at a southeastern university. **Patients or Other Participants:** A convenience sample was recruited from the 2015-2016 band roster (age = 19.31 ± 1.2 year, mass = 73.8 ± 17 kg, height = 171.5 ± 9.1 cm). **Interventions:** The independent variables were heart rate, steps counted and metabolic equivalent task (MET). Descriptive statistics were used to compare group mean for average heart rate, average steps taking, average MET and body mass index (BMI). Statistics test included a univariate analysis of variance to analyze the physiological difference between instrument type (percussion, woodwind and brass). Inverse-normal transformation was used to improve normality of the data distribution. Steps counted was tabulated by the Actigraph wGT3X-BT (Pensacola, FL) accelerometer and heart rate was tracked using the Polar Team System (Lake Success, NY). Data was processed using ActiLife (version 6), Team Polar Software and IBM SPSS Statistics. **Main Outcome Measures:** Critical outcome measures include

average heart rate, average step taken and METs. **Results:** The analysis revealed the average group heart rate was 107 bpm (sd = 19.2); percussion instrumentalists having the highest (m = 112, sd = 8.9) and brass the lowest (m = 106, sd = 19.9). For average steps taken, the group total was 759 (sd = 279); percussion instrumentalists having the highest (m = 987, sd = 235) and woodwind the lowest (m = 739, sd = 307). Analysis of the between-subjects revealed non-significance (p = .873) when comparing average heart rate and instrumental section. Indicating instrumental section had no statistical significance for how marching affects heart rate. Additional between-subjects also revealed non-significant (p = .523) among section and average MET (m = 1.7). **Conclusions:** Marching band does not qualify as an activity to meet the American College of Sports Medicine (ACSM) recommendations for physical activity in adults. Given the average MET recorded (m = 1.7), marching is associated with very-light activity levels, akin to merely standing. Therefore, collegiate marching musicians are encouraged to pursue other means of more moderate to vigorous physical activity outside practice and performances to meet ACSM guidelines.

## Injury Epidemiology and Risk Factors for Injury in CrossFit

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**Context:** CrossFit is strength and conditioning that emphasizes functional and constantly varied exercise performed at a relatively high intensity. Because of its unorthodox combination of power movements and endurance training, CrossFit has become a controversial sport. With its increase popularity concerns regarding its safety have arisen; however, there is a lack of research on injury rate and risk factors for injury in CrossFit athletes. **Objective:** To examine injury epidemiology and risk factors for injury in CrossFit athletes and to compare the rate of injury in competitors and non-competitors. **Design:** Cross-sectional. **Setting:** Four owner-operated CrossFit facilities in South Florida. **Patients or Other Participants:** 191/215 (75%) CrossFit athletes (94 males, 97 females) completed the survey. Key characteristics were: age = 31.7 ± 9.4 y, height = 66.5 ± 3.8in, weight = 163.9 ± 34.1lb, and length of CrossFit participation = 2.0 ± 1.7 y. **Interventions:** Paper-based surveys were administered over one day at each facility. The survey inquired about athletes' CrossFit participation, CrossFit-related injury history in the preceding six months, and personal characteristics. Content validity was established. The survey was piloted at one CrossFit facility and changes were made based on feedback. **Main Outcome Measures:** Number of injuries and location of injury were examined. Injury rate per 1000 athlete-hours was calculated. Chi-squares examined differences among frequencies and independent t-tests compared injured athletes to uninjured athletes and competitors to non-competitors. **Results:** 50/191 athletes sustained 62 injuries during CrossFit participation in the preceding six months. The most frequently injured locations were the shoulder (14/62), knee (10/62), and low back (8/62). Injury rate was 2.5 per 1000 athlete-hours (95% CI = 1.9, 3.1). Competitors were more likely to be injured (40% v 19%, OR = 2.83, p = 0.002) and had greater weekly athlete-hours (7.1 ± 6.8 v 4.7 ± 2.3, p = 0.008) than non-competitors. Rates of injury for competitors and non-competitors were 2.8/1000 athlete-hours (95% CI = 1.5, 3.1) and 2.1/1000 athlete-hours (95% CI = 2.0, 4.0), respectively. Athletes who reported injury also reported significantly higher values for the following risk factors: years of participation (2.7 ± 1.8 v 1.8 ± 1.5, p = 0.001), weekly athlete-hours (7.3 ± 3.8 v 4.9 ± 2.1, p = 0.020), weekly athlete-exposures (6.4 ± 3.8 v 4.7 ± 2.1, p = 0.003), height (67.7 ± 3.5in v 66.1 ± 3.8in, p = 0.011), and weight (172.5 ± 37.2lb v 160.7 ± 32.6lb, p = 0.037). Males and females were equally likely to sustain an injury (53.8% v 46.2%, p = 0.358). **Conclusions:** While being a competitor was related to injury, increased exposure may have confounded this association. Increased exposure to injury (greater weekly athlete-hours and athlete-exposures) may contribute to injury. Increased height and weight were also related to injury. Biomechanical factors associated with greater height and ability to lift greater loads may increase risk of injury. Athletic trainers caring for athletes who use CrossFit to train in the off-season should instruct larger (by height and weight) athletes to take extra precautions and should advise all athletes to limit their hours training CrossFit to minimize risk factors related to injury.

## Effect of an 8-Week Static and Dynamic Exercise Program on Older Adults in Reducing Fall Risk

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**Context:** Older adults in the United States have a high morbidity and mortality rate due to a high incidence of falls. Rising rate of falls and the subsequent injuries and medical costs are a growing public health problem that needs to be addressed. More preventable treatment options need to be provided to older adults to reduce the rate of falls and resulting injuries. Athletic Trainers whose traditional setting is working with athletes have transferable skills that they can use with this non-traditional population of older adults. Studies have assessed various exercise interventions to preserve proprioception, balance and increase strength in older adults. However, few studies have assessed the effects of static and dynamic balance exercises in older adults using a stable surface. **Objective:** To assess the effect of an 8-week static and dynamic balance-training fall prevention program on older adults in reducing risk of falls. **Design:** A single group pre-post test study. **Setting:** This study was performed at two local community senior centers. **Patients or Other Participants:** 25 older adults (4 males, 21 females) with a mean age of 77.05 years, SD = 6.74 years. **Interventions:** 15 minutes of static and dynamic balance exercises; standing bilaterally, standing tandem, calf raises, standing unilaterally, standing leg abduction, ball toss (standing bilaterally and unilaterally); 3 sets of 10 repetitions or 3 sets of 30 seconds and progressively increased repetitions, progression from exercises performed with eyes open (EO) to eyes closed (EC). **Main Outcome Measures:** Fall risk was measured using the Berg Balance Scale (BBS) containing 14 items each scored from 0-4 for a total score of 56. Total scores of 0-20 = high fall risk, 21-40 = medium fall risk and 41-56 = low fall risk. Pre-test and post-test measurements were taken 1-week pre-intervention and again at 1-week post-intervention. Paired t-tests were conducted on BBS with statistical p-value set at less than .05. **Results:** Participants' BBS (total) were significantly higher post-test (M = 53.32, SD = 2.824) compared to pre-test (M = 50.04, SD = 5.248), $t(24) = -2.818$, $p = .010$. Participants' scored statistically higher for three of the fourteen items of the BBS post-intervention compared to baseline. Turning 360 degrees, pre-test (M = 3.72, SD = .458), post-test (M = 4.00, SD = .000), $t(24) = -3.055$, $p = .005$; Placing alternate foot on stool, pre-test (M = 3.44, SD = .917), post-test (M = 3.92 SD = .277), $t(24) = -2.613$, $p = .015$; Standing with one foot in front, pre-test (M = 2.64, SD = 1.186), post-test (M = 3.36 SD = .952), $t(24) = -2.979$, $p = .007$. **Conclusions:** Fall prevention is an opportunity for athletic trainers to expand their professional role in the healthcare arena. The 8-week static and dynamic balance training fall prevention program was effective in reducing fall risk in older adults. Future research should be done focusing on strengthening the muscles about the hip to see if improvements in hip strength decrease fall risk in older adults after a static and dynamic balance training program.

## Comparison of Landing Biomechanics Between Dancers and Non-Dancers

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**Context:** Anterior cruciate ligament (ACL) injury often occurs in jump-landing athletes, and results in both short- and long-term detrimental effects on function and quality of life. Dancers have a lower ACL injury incidence-rate than other jump-landing athletes. Landing training and footwear are possible reasons for the injury rate differential between dancers and non-dancer athletes. Still, evidence is lacking examining lower body biomechanics during landing between dancers and non-dancer athletes. **Objective:** To compare landing biomechanics of dancers and non-dancer athletes during a drop-vertical-jump. **Design:** 3 (group: dancers, male non-dancers, female non-dancers) x2 (activity: planned, unplanned) x2 (footwear: shod, barefoot) mixed model. **Setting:** Research laboratory. **Patients or Other Participants:** Female dancers (N = 12, 20.9 ± 1.8 years, 63.2 ± 16.4kg, 166.4 ± 6.7cm), female non-dancers (N = 14, 20.2 ± 0.89 years, 61.6 ± 7.7kg, 168.9 ± 5.0cm), and male non-dancers (N = 13, 22.2 ± 2.7 years, 80.8 ± 13.2kg, 180.6 ± 9.7cm). **Interventions:** Participants performed drop-vertical-jump in both planned and unplanned conditions while shod and barefoot in a randomized order. **Main Outcome Measures:** Sagittal and frontal plane ankle, knee, and hip joint angles at initial contact and peak knee flexion during the landing were compared across group, activity, and footwear using MANOVAs followed by pairwise-adjusted Bonferroni comparisons ($p < .05$). **Results:** At initial contact, a three-way interaction (p

= 0.008) existed for hip frontal plane, with the unplanned condition eliciting more abduction than planned ($p < 0.001$). At initial contact, a two-way groupactivity interaction ($p = 0.01$) existed for ankle frontal plane, with female non-dancers landing in eversion compared to dancers ($p = 0.061$) and male non-dancers ($p = 0.021$); barefoot conditions resulted in more inversion than shod ($p < 0.001$). At peak knee flexion, a three-way interaction ($p = 0.047$) existed for ankle sagittal plane, revealing more dorsiflexion in barefoot than shod ($p < 0.001$) and planned to unplanned ($p = 0.04$) conditions. Main effects for footwear revealed more ankle inversion ($p < 0.001$) and plantarflexion ($p = 0.008$) in barefoot than shod and more hip flexion ($p = 0.018$) in shod than barefoot at initial contact. At peak knee flexion, more ankle eversion ($p < 0.001$) was present in shod and more hip adduction ($p = 0.019$) was present in barefoot; ankle was dorsiflexed in barefoot and plantarflexed in shod ($p < 0.001$). Main effects for activity at initial contact revealed more hip abduction ($p < 0.001$) and ankle plantarflexion ($p < 0.001$) in unplanned than planned conditions. At peak knee flexion, there was more hip ($p = 0.019$) and knee ($p = 0.001$) flexion and knee abduction ($p = 0.004$) in unplanned than planned conditions; the planned condition had more hip adduction ($p = 0.002$) and ankle dorsiflexion ($p = 0.04$) than unplanned. **Conclusions:** Overall, female non-dancers landed in positions that are associated with increased ACL injury risk (e.g., increased ankle eversion). Further, barefoot landing had more ankle inversion and plantarflexion at initial contact moving into dorsiflexion at peak knee flexion. Dancers may train in positions more similar to barefoot conditions. As dancers' landing technique did not worsen in the unplanned condition, their specific landing technique may be translatable into sport activity.

### Comparison of Y-Balance Test Performance Between Female Collegiate Dance Students and Field Hockey Athletes

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**Context:** The Y-Balance Test is a functional movement assessment designed to measure dynamic postural control. Poor performance on this test has been associated with an increased risk of lower extremity injury. There is limited normative data for Y-Balance Test performance from different populations, particularly from physically active individuals in nontraditional sport settings. It is also unclear how Y-Balance Test performance differs in adults from nontraditional sport settings and collegiate athletes. **Objective:** To compare maximal reach distances on the Y-Balance Test between female collegiate dance students and Division-I field hockey athletes. **Design:** Cross-sectional. **Setting:** Field setting. **Patients or Other Participants:** Thirty female dance students (age = 20.86 ± 2.61 years; height = 158.16 ± 31.55cm; mass = 57.59 ± 18.73kg) and 21 female collegiate field hockey athletes (age = 19.57 ± 1.33 years; height = 156.88 ± 36.29cm; mass = 59.61 ± 14.43kg) volunteered to participate. All individuals were fully participating in dance or sport related activities and were free from current lower extremity injuries. **Interventions:** Participants completed the anterior direction followed by the posterolateral direction of the Y-Balance Test on each limb while barefoot. Participants were instructed to maintain balance on the stance limb while maximally reaching with the opposite limb in the anterior or posterolateral directions. Four practice trials were directly followed by three test trials in each direction. If an error occurred during a test trial, the trial was repeated. Errors included the hands coming off the hips, failing to return to the starting position, touching down with the non-stance limb, lifting the heel of the stance limb, applying too much weight to the push board, and slinging the push board. Maximum reach distance was recorded for each trial and normalized to leg length (%). **Main Outcome Measures:** Normalized reach distances were averaged for each limb and each direction. Independent t-tests were performed to examine group differences in normalized reach distances for the left and right limb separately. Alpha-level was set a-priori at $p < 0.05$. **Results:** There was a significant difference between groups for right posterolateral reach distances (dancers = 96.14 ± 7.22%, field hockey = 102.18 ± 10.0%, $p = 0.02$).There was no significant difference between groups in anterior reach distances for the right (dancers = 61.95 ± 5.64%, field hockey = 63.52 ± 3.99%, $p = 0.30$) or left limb (dancers = 64.10 ± 7.61%, field hockey = 63.89 ± 4.34%, $p = 0.91$) and posterolateral reach distances of the left limb (dancers = 96.87 ± 7.16%, field hockey = 99.84 ± 8.57%, $p = 0.19$). **Conclusions:** Field hockey athletes demonstrated greater reach distances in the posterolateral direction on the right limb when compared to dancers. This finding indicates there may be activity specific movements that translate into differences in performance on the Y-Balance Test between different athletic populations. Therefore, normative reach values may not be generalizable to all physically active adults. Additional research should be performed examining performance on the Y-Balance Test in unique physically active populations to further examine the generalizability of normative values.

## Quantitative Measures to Determine Pointe Readiness in Youth Ballet Dancers

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**Context:** An increased risk of injury often occurs when a dancer begins pointe training. Some believe that screening protocols are needed to confirm if the dancer is physically-prepared for the increased demands. Evidence is needed to discover what physical characteristics should be included in the screening protocols. **Objective:** To evaluate the attributes of ballet dancers who are pre-pointe compared to those who have recently begun pointe training, in order to create more effective pointe-readiness screening techniques. **Design:** Cohort Study **Setting:** Three ballet studios **Patients or Other Participants:** Forty-nine female ballet dancers with at least one year of ballet training volunteered for the study. Based on their current level of ballet training: 28 participants were classified as pre-pointe dancers (10.2 ± 1.2 years, 124.1 ± 13.5 cm, 39.1 ± 13.2 kg, 6.0 ± 1.8 years dance experience) and 21 were classified as novice pointe dancers (11.4 ± 0.8 years, 136.9 ± 16.0 cm, 40.8 ± 8.8 kg, 6.5 ± 2.1 years dance experience). Dancers were excluded if they had an injury in the last two weeks which caused them to miss a day of training. **Interventions:** Participants performed six clinical tests in a randomized order during a single test session. Non-weight bearing (NWB) range of motion (ROM) was tested in plantarflexion and dorsiflexion using a digital inclinometer (ACUMAR Single Digital Inclinometer). Weight-bearing dorsiflexion was measured with a lunge test using a digital inclinometer. Plantarflexion strength was measured using a handheld dynamometer (LAFAYETTE Manual Muscle Testing System). For each of these tests, three trials were completed and the mean was recorded for statistical analysis. The Star Excursion Balance Test (SEBT) was performed to measure dynamic balance. Three reach directions were used (anterior, posteromedial, posterolateral) and reach distance was standardized to the limb length. The composite score was used for statistical analysis. Relevé endurance was evaluated by counting the total number of successful repetitions. The airplane test was evaluated by asking the dancer to attempt five trails. The total number of successful trials was recorded. **Main Outcome Measures:** The dependent variables were combined into three categories: three ROM tests (NWB plantarflexion(°), NWB dorsiflexion (°), lunge test (°), two strength tests (Relevé endurance(number of repetitions) and plantarflexion isometric strength (Newtons)), and two balance tests (Airplane (number of successful trials), SEBT (% limb length). Each category was examined separately using a MANOVA, and follow-up ANOVAs were completed on any significant findings. **Results:** The pointe group performed significantly better than pre-pointe group on strength and balance testing($p < .01$). The pointe group was able to achieve more repetitions compared to the pre-pointe group on the relevé endurance test (17.1 ± 5.4 vs.11.6 ± 5.0) and the Airplane test (2.2 ± 1.6 vs. 0.8 ± 0.9). There was no significant difference in the ROM testing between the groups ($p = 0.19$). **Conclusions:** The relevé endurance test and the Airplane test appear to be appropriate tests to include in pre-pointe screening procedures.

## Effects of Maximal Cushion Shoes on Running Biomechanics


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**Context:** Running shoes with extra cushioning on the heels and midsoles have become increasingly popular for providing optimal force absorption and support. However, very few empirical evidence exists on how running biomechanics change while wearing them. **Objective:** To investigate the effects of maximal cushion shoes on running biomechanics including ground reactions forces, rate of initial loading, and knee and ankle kinematics. **Design:** Crossover trial. **Setting:** University research laboratory. **Patients or Other Participants:** Sixteen recreational runners (8M/8F, age = 27.9 ± 13.13 yrs, height = 174.7 ± 6.51cm, mass = 71.23 ± 10.14kg, weekly running mileage = 28.6 ± 21.3miles) participated in a single data collection session. **Interventions:** After warm-up, each participant ran at a self-selected pace across the laboratory space wearing either the standard (New Balance) or maximal cushion shoes (HOKA ONE ONE). After the first shoe condition, the participant received a rest period, and repeated the warm-up and running trials wearing the other type of shoes. The order of the shoe conditions was randomized. Biomechanical data were obtained during the running trials for each foot, using force plates and a 3D motion capture system. **Main Outcome Measures:** Independent variables included the shoe conditions (HOKA, Standard) and sides (Right, Left). Dependent variables included impact peak (IP), loading rate to IP in seconds (LR), active peak (AP), knee sagittal plane kinematics at initial contact (IC) and AP, ankle sagittal plane kinematics at IC and AP, and ankle frontal plane kinematics at IC and AP. Positive kinematics values indicated knee flexion, ankle dorsiflexion, and ankle inversion. For each DV, a repeated measures ANOVA was used for statistical analysis ($\alpha = 0.05$). **Results:** Running with HOKA shoes resulted in a significantly higher IP than running with Standard shoes ($F1,13 = 6.371$, $p = 0.025$, HOKA = 1.67 ± 0.31 Newton/Body weight [N/BW], Standard = 1.59 ± 0.28N/BW). For IP, there was a significant shoe-by-side interaction ($F1,13 = 6.486$, $p = 0.024$). Post-hoc comparison with Bonferroni correction revealed that the IP on the left leg was higher with HOKA shoes (1.69 ± 0.28N/BW) than Standard shoes (1.56 ± 0.25N/BW). Additionally, HOKA shoes resulted in a significantly lower AP compared to Standard shoes ($F1,14 = 5.042$, $p = 0.041$, HOKA = 2.50 ± 0.21N/BW, Standard = 2.52 ± 0.22N/BW). No significant effect of shoes was observed for LR ($p > 0.05$). There was a significant shoe-by-side interaction for the ankle dorsiflexion at AP ($F1,11 = 6.406$, $p = 0.028$). The post-hoc comparison revealed that for the left leg, HOKA shoes (19.06 ± 4.24°) resulted in less dorsiflexion at AP, compared to Standard shoes (21.63 ± 4.01°). Other kinematics at AP or IC did not yield any statistical significance ($p > 0.05$). Conclusions: No change in LR may indicate that HOKA shoes allowed sufficient time to control the landing impulse despite the slightly increased initial force. Reduced AP with HOKA shoes may suggest that maximum cushioning is effective in reducing overall exerted force. The slight decrease in dorsiflexion at AP may indicate that HOKA shoes allow smoother transition into heel-off and toe-off during the running gait, without affecting force.


## Relationship Between Ankle Dorsiflexion and Jump Landing Biomechanics in Intercollegiate Female Athletes


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**Context:** Poor lower extremity movement technique is associated with injury risk. Ankle dorsiflexion may be impaired following an ankle sprain, and thus may affect movement mechanics. Women often demonstrate poor jump landing mechanics and have a higher rate of non-contact lower extremity injury. There is limited research on the relationship between ankle dorsiflexion and lower extremity movement technique in intercollegiate female athletes. **Objective:** To assess the relationship between ankle dorsiflexion and jump-landing mechanics in female intercollegiate athletes. **Design:** Observational cross-sectional study. **Setting:** Athletic facilities. **Patients or Other Participants:** Forty-five collegiate female athletes volunteered to participate (age = 20 ± 2 years, mass = 68.7 ± 11.1kg, height = 171.6 ± 9.4cm). Participants were members of a Division I NCAA basketball, soccer, or volleyball team. **Interventions:** Ankle dorsiflexion was measured bilaterally in non-weight bearing (NWB) knee extension (Ext) and knee flexion (Flex), and a weight bearing lunge test (WBL). Participants performed three trials of a standardized jump-landing task, which was videotaped from the front and side. **Main Outcome Measures:** The jump-landing task was graded using the Landing Error Scoring System (LESS) by a single rater and the three trials were averaged for one composite score. The

relationships between LESS score and dorsiflexion were estimated through linear correlation. Participants were classified as "High Risk" if they had a LESS composite score of 5 or greater, or "Low Risk" if they had a composite score of less than 5. Differences in ankle dorsiflexion based on risk classification were identified with MANOVA and planned comparisons. **Results:** Twenty-one participants were classified as "High Risk", and 24 as "Low Risk". There was a small but statically significant association between LESS and NWB ankle dorsiflexion range of motion (R NWB-Ext r2 = .091, L NWB-Ext r2 = .081, R NWB-Flex r2 = .096, L NWB-Flex r2 = .154), and LESS and WBL Test (R Lunge r2 = .133, L Lunge r2 = .079). However, significantly less dorsiflexion was observed in "High Risk" athletes as identified on the LESS in all positions ($F = 646.1$, $p < .01$). Mean differences in NWB measures ranged from 3.4º (right NWBE; 95% CI = .74 - 6.17º) to 5.01º (left NWBF; 95% CI = 1.94 – 8.20º). Differences in lunge measures were 5.08º (95% CI = 1.95 – 8.20º) on the left and 4.39º (95% CI = .58 – 8.20º) on the right. **Conclusions:** These findings reveal a low association between less ankle dorsiflexion range of motion and poor lower extremity movement technique, as measured by the LESS. However, these results suggest that those at highest risk may demonstrate less ankle mobility. Further investigation is warranted to determine if the magnitude of these differences is clinically meaningful, and whether improving ankle dorsiflexion may improve LESS scores and decrease injury risk in those at highest risk for lower extremity injury.

### Bilateral Comparison of Lower Extremity Joint Energetics During Drop-Jumping

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**Context:** Functional asymmetries between limbs are evident and thought to be partly due to limb preference. Since jumping and landing activities are characterized by high ground reaction forces, a lessened ability of one limb to dissipate landing forces may make that limb more susceptible to unilateral injuries, such as non-contact ACL injury. Athletic performance may also be affected if there is asymmetry in power production capabilities. Lower extremity asymmetries in energy absorption (EA) and power production (PP) have been demonstrated during gait, but little is known regarding these behaviors during dynamic activities such as jumping and landing. **Objective:** To investigate asymmetry in the lower extremity energetics during a bilateral drop jump (DJ) landing task. We hypothesized that side-to-side asymmetries would be evident during the DJ. Specifically, we expected the preferred (i.e. kicking) limb to exhibit greater power generating behavior, whereas the non-preferred limb would exhibit greater energy absorption behavior. **Design:** Descriptive Cohort. **Setting:** Controlled laboratory. **Patients or Other Participants:** 44 athletes (22 M, 22 F: 1.71 ± 0.08m; 69.3 ± 12.1kg; 22.3 ± 2.3 yr). **Interventions:** Lower extremity biomechanics were assessed via 3-D motion analysis and 2 force platforms during a 0.45m DJ. **Main Outcome Measures:** Energy absorption (EA; J/Nm-1) and power production (PP; J/Nm-1) were measured bilaterally during the landing and subsequent propulsive phase of the DJ, respectively. Separate 2x3 repeated measures ANOVAs compared EA and PP between limbs and joints. **Results:** For EA, main effects were identified for limb ($F1,43 = 17.9$, $P < 0.01$) and joint ($F2,86 = 15.3$, $P < 0.01$), with no limb by joint interaction ($F2,86 = 0.7$, $P = 0.51$). The preferred limb absorbed more energy during the landing phase (-18.8 vs. -16.9 J/Nm-1; $P < 0.01$). The hip absorbed more energy than the knee (-7.4 vs. -6.0 J/Nm-1) and ankle (-7.4 vs. -5.4 J/Nm-1) (both $P < 0.01$). For PP, there were main effects of limb ($F1,43 = 10.1$, $P < 0.01$) and joint ($F2,86 = 24.0$; $P < 0.01$). The preferred limb produced more power than the non-preferred limb (12.4 vs. 11.5 J/Nm-1; $P < 0.01$). The hip produced more power than the knee (4.9 vs. 3.7 J/Nm-1) and ankle (4.9 vs. 3.8 J/Nm-1) (both $P < 0.01$). There was also a limb by joint interaction ($F2,86 = 5.0$; $P < 0.01$) whereby the preferred knee (3.7 vs. 3.2 J/Nm-1) and ankle (3.8 vs. 3.4 J/Nm-1) produced more power than the non-preferred limb (both $P < 0.01$). **Conclusions:** Bilateral asymmetries in EA and PP were present during the drop jump task. It appears that the preferred limb is more heavily relied upon to absorb landing forces and also to propel the body upwards during jumping and landing. This could place the preferred limb at a greater risk of injury due to the greater demands placed upon it. These findings may indicate that bilateral asymmetries should be addressed during rehabilitation and training programs in order to reduce injury risk and increase performance.

## The Effect of Load Carriage and Lower Extremity Strength on Plantar Pressures Obtained in the Barefoot Condition

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**Context:** The foot offers primary support and flexibility for appropriate force transfer during dynamic activities. It is important to diagnose any foot problems early for injury prevention. Plantar pressure measurements provide information on foot and ankle function during gait and weight bearing activity. Abnormalities in these areas due to additional weight (military gear, equipment intensive sports) or lack of muscular support may predispose an individual for injury. **Objective:** The primary purpose of this study was to establish if the addition of external load affects plantar pressure distribution in the barefoot condition. The secondary purpose was to determine if isometric hip and ankle strength affects plantar pressure distribution. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty-five physically active men (n = 10) and women (n = 15) between 18 and 40 years of age (age: 24.6 ± 4.8 yrs, height: 171.0 ± 9.8cm, mass: 69.9 ± 11.9kg) participated in this study. Participants were excluded if they had a current unresolved lower extremity injury or previous ankle surgery. **Interventions:** Bilateral isometric hip and ankle strength were measured. Participants were asked to walk barefoot across the emed®-x platform (Novel GmbH, Munich, Germany) in an unloaded and loaded (9.5kg weighted vest) condition. **Main Outcome Measures:** Isometric strength was recorded as percent of body weight (%BW). The Novel Database Medical software package was used to obtain geometric variables (foot progression angle, subarch angle and arch index) and average maximum force as a percent of body weight (MF%BW) and peak pressure (PP) for select regions of each foot. An alpha level of 0.05 was set a priori as a significance level for all statistical analyses. For changes in plantar pressure variables between an unloaded and loaded condition, a paired t-test calculation or Wilcoxon signed-rank test was used. To determine if there was a correlation present between foot or hip strength and changes in plantar pressure, a Pearson Correlation Coefficient or Spearman's Rank Correlation Coefficients were used. **Results:** Significant differences were found in the majority of geometric variables and plantar pressures between the unloaded and loaded conditions. Significant negative correlations were found between changes in unloaded and loaded plantar pressures of right MF%BW of the second toe ($p = 0.016$), total contact time ($p = 0.013$), total maximum force ($p = 0.011$) and right foot evertor strength. No significant correlations were found within the left side. **Conclusions:** Changes in plantar pressure have been shown to contribute to lower extremity injury. Significant correlations suggest that increasing ankle evertor strength may offset some of the changes in plantar pressure due to external load. Early intervention utilizing an ankle strengthening program may help diminish the negative effects of carrying additional load and prevent future injury. Future research can examine the effects of heavier load carriage after fatigue on changes in plantar pressure.

## Comparison of Lower Limb Muscle Activation During a Traditional Heel Raise and a Quarter Heel Raise

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**Context:** The peroneus longus (PL) is important for controlling the foot and ankle during functional activities; however, there is minimal research identifying the best means of functionally strengthening PL. Some authors suggest placing a quarter under the 1st metatarsal head during a heel raise may promote PL stabilization of the 1st ray and elicit greater activation of PL. **Objective:** To examine the peak muscle activation of the PL, tibialis anterior, and the medial and lateral heads of the gastrocnemius during a traditional heel raise (THR) and a QHR. **Design:** Cross-sectional study. **Setting:** Controlled research laboratory. **Patients or Other Participants:** A convenience sample of 38 healthy participants (12 males [weight = 89.99 ± 18.36 kg, height = 179.27 ± 6.53 cm], 26 females [weight = 66.00 ± 8.83 kg, 165.84 ± 6.15 cm]) with a mean age of 23.75 + 1.54 years and the ability to perform a pain-free single leg heel raise with the heel clearing the floor. **Interventions:** The independent variables were the exercise (QHR, THR), the participants' heel position (everted, inverted, neutral) as determined by observation during the THR and consensus from 3 researchers, and the participants' great toe extension (GTE) ROM (limited, normal, excessive) as measured by goniometer. All subjects performed 5 trials of the QHR and the THR and the order of testing was counterbalanced. **Main Outcome Measures:** Surface electromyography (EMG) was used to measure mean peak muscle activation of heel raise trials 2-4 (trials 1 and 5 were excluded) and was recorded as a percentage of each participant's maximum voluntary isometric contraction (MVIC). Separate repeated-measures

analyses of variance were used to examine the effects of the independent variables on peak muscle activation for each of the muscles examined. **Results:** The mean peak EMG activity of the PL was significantly greater during the QHR (140.30 ± 68.88 % MVIC, [95% CI 116.98, 163.60]) when compared to the THR (117.83 ± 54.96 % MVIC, [95% CI 99.21, 136.45]) regardless of calcaneal position ($p = 0.003$, ES = 0.36). Similarly, mean peak EMG activity of the PL was significantly greater during the QHR (125.37 ± 91.67% MVIC, [95% CI 94.28, 156.45]) when compared to the THR (103.32 ± 72.26 % MVIC, [95% CI 78.82, 127.82]) regardless of GTE ROM ($p = 0.03$, ES = 0.31). No other significant interactive effects or main effects were identified for any of the muscles tested. The PL demonstrated 12% greater peak muscle activation during the quarter heel raise when normalized to the traditional heel raise. **Conclusions:** This research provides preliminary evidence suggesting a QHR may elicit greater activity from PL when compared to a THR. Future research is needed to validate these findings and examine if the QHR facilitates greater strength and functional gains.

## Validity of Clinical Outcome Measures to Evaluate Ankle Range of Motion During the Weight-Bearing Lunge Test

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**Context:** Valid strength measures are needed to direct patient care, determine progress towards rehabilitation goals, and make informed decisions about evidence-based practice. To date, there have been no concurrent validity studies comparing clinical measures and video motion capture analysis during the weight-bearing lunge test (WBLT). **Objective:** To determine the concurrent validity of standard clinical outcome measures compared to laboratory outcome measure while performing the WBLT. **Design:** Cross-sectional study. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Fifty participants between the ages of 18-35 were eligible to participate in this study (25 males, 25 females, 24.2 ± 3.5 years, 172.8 ± 10.3 cm, 76.4 ± 16.6 kg, 43 right foot dominant, and 7 left foot dominant). Participants were excluded is they answered yes to any questions on the Physical Activity Readiness Questionnaire or if they were unable to perform the test without pain or discomfort. **Interventions:** Participants performed the WBLT on their dominant limb. Participants lunged forward trying to touch their knee to a vertical line on the wall knee while maintaining heel contact with the ground. The weight-bearing lunge test (WBLT) was performed using four different measurement techniques: digital inclinometer (Acumar, Lafayette Instruments, Lafayette, IN) placed at the tibial tuberosity, digital inclinometer placed 15cm distal to the tibial tuberosity, distance from the wall, and a two-dimensional video camera (MAXTraq 2D, Innovision Systems Inc, Columbioville, MI). Outcome measures were recorded concurrently during each trial. To establish concurrent validity, Pearson product-moment correlation coefficients (r) were conducted, comparing each dependent variable to the 2D motion capture analysis (identified as the reference standard). Correlation coefficients were interpreted as weak ($0.0<r<0.25$), fair ($0.25\leq r<0.50$), moderate to good ($0.50\leq r<0.75$), or strong ($0.75\leq r\leq 1.0$). A stronger correlation indicates strong concurrent validity. **Main Outcome Measures:** Dorsiflexion angle with inclinometer at 15cm distal to the tibial tuberosity (°), dorsiflexion angle with inclinometer at tibial tuberosity (°), maximum lunge distance (cm), and dorsiflexion angle using the motion capture system (°). **Results:** There was a strong correlation between the inclinometer placement at 15cm below the tibial tuberosity (44.9° ± 5.5°) and the motion capture angle (27.0° ± 6.0°) ($r = 0.76$, $p = 0.001$). A moderate to good correlation was identified between the inclinometer placement at the tibial tuberosity angle (39.0° ± 4.6°) and the motion capture angle ($r = 0.71$, $p = 0.001$) as well as between the distance from the wall clinical measure (10.3 ± 3.0cm) to the motion capture angle ($r = 0.74$, $p = 0.001$). **Conclusions:** This study determined that the clinical measures used during the WBLT have a good to strong correlation with the reference standard for assessing dorsiflexion range of motion. Therefore, obtaining maximum lunge distance and inclinometer angles are both valid assessments during the weight-bearing lunge test.

### Pitching Without an Ulnar Collateral Ligament of the Elbow in Division I Collegiate Baseball

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**Background:** A 23 year-old (190 cm, 91 kg) male NCAA Division I baseball pitcher reported acute medial elbow pain after pitching in his second-to-last start of the season in May 2014. Ligamentous and special tests yielded negative findings and patient had full strength and range of motion with no instability. There were no visible deformities or tenderness with palpation of shoulder, elbow, forearm, and wrist. The patient reported that pain was greatest during the late cocking/early acceleration phase and rated the pain at a 6/10. There was no history of injury to this elbow/arm. The patient was given rest and Methylprednisolone for 6 days. A week after the initial complaint he made his final start of the season and threw a no-hitter through 7 innings at his normal velocity and accuracy, but still felt medial elbow pain. Evaluation yielded the same results as the initial evaluation. He was diagnosed with common flexor tendonitis and was instructed to avoid activities that irritated the injury over the summer; so he did not pitch or lift weights while treating the tendinopathy. When returning to school in August, he continued rehabbing and started a throwing progression, which went well until mid-October. The patient threw in the first game of a scrimmage "tournament" with no complaints but had to pull himself out of the second game due to medial elbow pain. Orthopedic tests were again negative and all parts of evaluation yielded insignificant findings. Pain was rated at a 7/10. The sports medicine staff suspected something more serious than common flexor tendonitis and ordered an MRI. **Differential Diagnosis:** Flexor/pronator strain, ulnar collateral ligament (UCL) sprain, common flexor tendonitis, medial epicondylitis. **Treatment:** The MRI revealed a grade 3 UCL tear proximally caused from chronic microtrauma. After consultation with a physician specializing in UCL tears, the patient chose not to undergo UCL reconstruction due to going into his last season of eligibility for collegiate baseball. Instead, the patient elected to do a platelet-rich-plasma (PRP) injection in November 2014 to promote enough of a healing process to get the pitcher through the season. Daily rehabilitation focused on the entire kinetic chain and included hand, wrist, forearm, elbow, and shoulder stretches and strengthening exercises. Emphasis was placed on increasing strength in internal rotation and pronation because these contribute greatly to the varus counter torque at the elbow. Therapeutic modalities including heat, ice, massage, sensory TENS, and ultrasound were utilized for pain modulation. The patient made his first mound appearance in February 2015 and remained active for the remainder of the season while continuing daily rehabilitation that was more modality intensive. **Uniqueness:** This case is unique because a UCL tear is usually a career ending injury for a pitcher not undergoing reconstructive surgery. However, this patient was able to pitch with a complete tear of the ligament and was able to reach high pitch velocities (89mph) and throw accurately. **Conclusions:** The surrounding musculature of the elbow and continued ability to pitch made diagnosis of the UCL tear difficult through orthopedic tests. The MRI was crucial to properly diagnosing and treating the injury. The PRP injection combined with conservative treatment was a successful alternative to reconstructive surgery. These findings can be used in the clinical setting to help recognize that a UCL tear can be present despite negative results of orthopedic tests depending on the musculature of the patient. These findings also imply that the use of PRP injections along with conservative treatment can be seen as an alternative for throwing athletes if surgery is not an attractive option.

### Juvenile Articular Cartilage Allograft for Treatment of a Lateral Femoral Condyle Defect in a High-Performance Athlete

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**Background:** A healthy 20 year old female, NCAA Division I soccer midfielder, presented in clinic with right knee pain. Pertinent medical history included prior right knee arthroscopy, partial lateral menisectomy and surgical microfracture of a lateral femoral chondral defect after a non-contact, twisting knee injury while playing soccer on a turf field. The patient reported worsening pain when she returned to soccer after surgery. Sixteen months after the initial injury, she sustained another injury, which was treated conservatively with physical therapy and injections. Conservative treatment provided no relief. The athlete reported to an orthopaedic clinic for a second opinion. Upon evaluation, the patient's symptoms were 5/10 pain at rest and 10/10 pain with activity. The pain was described as aching and sharp stabbing that was progressively worsening. The patient also reported grinding and mechanical symptoms. Physical examination revealed trace knee effusion, lateral-sided tenderness upon palpation, mostly on the femoral condyle, as well as slight tenderness on the lateral joint space. Passive flexion and extension were negative for mechanical symptoms or pain and the patient had no notable varus/valgus shift with double or single leg squats. The patient was ligimentously intact and patellar mobilization was within normal limits. Muscle tone was excellent. **Differential Diagnosis:** Meniscus tear, chondral defect, bone contusion, impaction fracture, patellofemoral pain syndrome. **Treatment:** The physician's physical examination revealed similar findings. Anteroposterior, lateral, and sunrise radiographs appeared normal and

the athlete's longstanding view displayed normal alignment with a central weight-bearing axis. MRI showed a lateral meniscus tear and a moderate-sized chondral defect down to bone on the lateral femoral condyle with underlying marrow edema. Arthroscopic evaluation further revealed this lesion as a 18x13 mm stellate, oblong shaped chondral defect. Following failure of conservative treatment, the patient consented to surgical intervention. Surgery performed included arthroscopic lysis of adhesions, partial lateral menisectomy, and open particulated juvenile allograft chondrocyte (PJAC) implantation procedure. Of note, the PJAC implantation procedure included first debriding the chondral lesion with a curette while ensuring not to completely destabilize the subchondral bone. Next, fibrin glue was placed along the base of the lesion and the juvenile allograft cells were scattered throughout the defect. Another layer of fibrin glue was placed over the top of the allograft cells to seal them. Care was taken not to place too many cells to prevent overgrowth, and there was no notable prominence of the graft or of the cells. At 10 month follow-up, the athlete had successfully returned to full participation in Division I collegiate soccer. **Uniqueness:** Other techniques for treating focal chondral defects in the knee, such as microfracture, autologous chondrocyte implantation, and osteochondral auto/allografts, have been described extensively in the literature; each indicated for particular sized lesions. However, this case is unique due to the use of the relatively new PJAC implantation technique to treat this athlete's lateral femoral chondral lesion. It is also unique due to the fact that the athlete returned to a high level of activity following this procedure after a microfracture technique failed previously. **Conclusions:** This case report is important to athletic trainers because as active members of the sports medicine team, we must be aware of different treatments and surgical procedures for common injuries we encounter. Additionally, we must continue learning and expanding our differential diagnoses to carry out proper treatment/referral processes and to better assist our physicians.

## A Novel Rehabilitation Protocol to Reduce the Incidence of Chronic Costochondral Rib Dislocations in a Collegiate Softball Player

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**Background:** A 21-year-old female softball catcher with no prior history of chest pain, rib injury, or heart condition, got hit in her left shoulder by a foul ball while catching during a game in March 2015 resulting in immediate chest pain. The following day she complained of difficulty breathing, and tenderness and swelling over the left border of her sternum. Upon palpation, rib was discovered to be protruding anteriorly at the costochondral junction. The team physician was contacted and he suggested the athlete see a physical therapist (PT) for reduction. PT confirmed closed dislocation/inspiration of left 5th and 6th ribs, performed reduction, and advised she focus on rehabilitation to help stabilize the ribs. Chest and core rehabilitation exercises were implemented, but the athlete continued to participate in the remainder of her season and ceased rehabilitation over the summer months at home. The athlete continued to experience dislocations and associated symptoms over the summer and decided to see a physician at home. The physician ordered a radiographic exam that revealed no fracture but indicated a shift in left ribs 4-6, so referral to chiropractor was made. **Differential Diagnosis:** Rib fracture, costochondritis, Tietze syndrome **Treatment:** Despite chiropractic manipulations at home, upon return to Asbury University in August 2015, athlete reported worsening symptoms and extreme discomfort with any functional activities, as her ribs had begun to dislocate with sneezing, coughing, and other slight movements of daily living. The athlete was referred back to the original PT for reduction and return to rehabilitation. PT reported that left ribs 2-6, 9, and 11 were stuck in a position of inspiration. The significant number of impaired ribs, tenderness, intermittent numbness/tingling, and strength/ROM deficits on her left side discovered during evaluation led to a referral to team physician who felt costochondritis could explain athlete's symptoms. He prescribed 7mg of Diclofenac 2x/day and she was put on a 7-day rest period with no softball workouts. Muscle energy techniques and chest and core rehabilitation exercises began that same week to assist with stabilization of the ribs while slowly progressing back into softball. Rehabilitation began with 2x10 seated thoracic extensions and theraband rows daily. Week 2, these exercises progressed with 2x10 theraband T's and low V's, and 2x10 CoreAlign push-up plus exercise every other day. Week 3, 2x10 D1/D2 chops and reverse chops with a 10-pound weight along with 2x10 core stabilization exercises (supermans, bird dogs, inverted crunches) were added to the existing regimen. Sport-specific tasks involving 2x10 plyometric 4-way 4-pound medicine ball passes and a basic, functional softball throwing program (20 throws each at 30, 60, and 30 feet) were also included. After 8 weeks of this progression, the athlete has only had one instance of a rib dislocation. Despite that one reoccurrence, her ribs have stayed in place for the longest period of time since the initial injury in March. **Uniqueness:** Costochondritis is often not associated with just one known etiology. Here, trauma-induced costochondritis was exacerbated by the pull of the surrounding musculature. Costochondritis in athletes is a self-limiting condition, with conservative management often presenting a challenge for both the athlete and AT. Therefore, an aggressive rehabilitation progression targeting efficient activation in core and trunk musculature was developed to help reduce the incidence of reoccurring dislocations and allow the athlete to continue participation in her sport. **Conclusions:** For cases involving costochondritis, focusing treatment on reducing inflammation initially and then implementing a rehabilitation protocol that includes trunk and core rehabilitation can significantly decrease the incidence of dislocations. Once dislocations become less frequent and symptoms are more manageable, patients can then work towards returning back to their previous activity level.

## An Acute Multiligament Knee Repair Versus a Staged Reconstruction: An Accelerated Recovery

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**Background:** A healthy 38 year old Caucasian male, recreational snowboarder, presented with an acute injury to the emergency department and associated orthopaedic clinic. The patient reported a right knee dislocation occurring that day while backcountry snowboarding. He described a dislocation of his knee laterally, noting a concurrent patellar dislocation after a clothesline type injury to his distal medial quadriceps. The patient reported no prior history of knee pathologies. Physical exam noted joint effusion, pain, knee ROM lacking 10 degrees of extension, limited to 85 degrees of flexion, 2/5 manual muscle test and was neurologically intact. Positive special tests included Lachman, posterior drawer, posterior sag sign, and valgus stress. **Differential Diagnosis:** Multiligament tears, patellar dislocation, quadriceps tendon injury, tibiofemoral fractures, popliteal neurovascular bundle injury. **Treatment:** Physician physical exam, CT and MRI demonstrated acute full-thickness tears of the proximal ACL, PCL and a proximal MCL avulsion fracture off the medial femoral epicondyle. Avulsed fracture measured 20x18x5mm. The fracture was displaced inferiorally into the medial joint space. Medial patellofemoral ligament(MPFL), vastus medialis obliques(VMO), and meniscofemoral ligament tears were also confirmed. Surgery was performed with patient consent and involved primary repair of the ACL, PCL and MCL avulsion fracture with suture anchors. Concurrently, the MPFL, VMO, and a patellar stabilization were also performed. Forty-eight hours following surgery, the patient was discharged and instructed to begin using a continuous passive motion(CPM) machine from 0-30 degrees of flexion until his next appointment. At the 2 week follow-up appointment, ROM on the CPM was increased to 0-60 degrees, increasing ROM 2 degrees per day as the patient was progressing. Physical therapy was prescribed for muscle re-education and progressive weight-bearing. At 6 weeks post-op the patient was progressing well with 58 degrees of flexion and full extension. At that time, ROM on the CPM was increased to 0-90 degrees and patient began light quadriceps strengthening and 30-50% weight-bearing. At 10 weeks post-op the patient had 110 degrees of flexion with full extension and was full weight-bearing as tolerated. At 4 months post-op, progression to outdoor cycling with mild-to-moderate hill climbing was initiated. At 7 months post-op the patient had no sensations of instability and had returned to normal recreational activities (non-contact soccer activity, recreational road cycling competitions). **Uniqueness:** Treatment for the ACL, PCL and MCL was a primary repair rather than a staged reconstruction. Within 4 months the patient had returned to moderate outdoor activity and training with reported high satisfaction. This is a unique finding compared to even an isolated ACL reconstruction as the recovery process could take 6-months minimally. Treatment utilizing ligamentous primary repair may lead to a rapid recovery due to decreased need for graft tissue revascularization. Revascularization of reconstructed tissue has been a well documented time-limiting factor for return to play(RTP) and repairing native tissue may alter this process. **Conclusions:** This case presents a unique progression through the rehabilitation process of a primary repair compared to that of a modern ligament reconstruction. The athletic trainer's understanding of the surgical procedure, and biology of the healing process specific to this procedure, is imperative to properly guide the rehabilitation progression. Limited ROM occurred 6-8 weeks after surgery to protect the repair compared to normal aggressive ROM after a reconstruction. ROM may have been restricted longer than a traditional reconstruction, however, due to tissue regeneration versus that of tissue revascularization, stresses placed on the ligaments were permitted earlier in the rehabilitation of the repair compared to that of a reconstructed ligament. Clinicians may need to alter their rehabilitative goals, specific to the patient, to match their progressions through a RTP process following a primary repair.

## Open Bankart Repair With Iliac Crest Bone Graft to the Glenoid, SLAP Lesion Repair, and Biceps Tenodesis in a Collegiate Football Player

Oglesby LW, Gallucci AR: Baylor University, Waco, TX

**Background:** A 21-year-old male collegiate football player reported recurrent episodes of glenohumeral pain and instability after returning to play from a SLAP lesion repair in his right shoulder. His previous surgery occurred after suffering multiple glenohumeral subluxations and a dislocation that required reduction, all of which occurred during football activities. Despite being cleared to return to full activity, the patient continued to have subluxations. Rehabilitative exercises to strengthen the rotator cuff and other surrounding musculature were ineffective in reducing the reoccurrence of instability, culminating in another dislocation that required reduction during a game. **Differential Diagnosis:** Possible diagnoses included multidirectional glenohumeral instability, SLAP lesion, rotator cuff strain, Bankart lesion, Hill-Sachs lesion, glenohumeral arthritis, and glenoid bone deficiency. **Treatment:** An MRI revealed a recurrent SLAP lesion, Bankart lesion, and evidence of significant glenoid bone loss. A CT scan revealed greater than a 30% loss of the anterior inferior glenoid. Arthroscopic surgery was conducted to debride the superior labrum as well as remove loose articular cartilage of the humeral head and glenoid. Unstable sutures from the previous SLAP repair were also removed arthroscopically and a biceps tenotomy was performed. A deltopectoral approach to the glenoid was performed to replace the glenoid bone loss and repair the Bankart lesion. A bone graft from the anterior right iliac crest was harvested and fixated with screws to the glenoid to replace the deficit. Suture anchors were then placed in the bone graft and through the anterior capsule to perform a Bankart repair. The subscapularis, previously dissected for the open

repair, was sutured and a biceps tenodesis was performed by suturing the biceps tendon into the bicipital groove. Due to soreness of the iliac crest, the patient initially used one crutch and was instructed to progress to full weight bearing as tolerated, which took less than one week. The patient was placed in an abduction sling for 4 weeks and instructed to only remove it for rehabilitation and showering. The initial stage of rehabilitation consisted of 4 or more sessions per week focusing on decreasing pain and swelling while increasing range of motion. The patient was not allowed to perform active shoulder internal rotation or elbow flexion until week 4 due to the open repair and tenodesis, respectively. Shoulder external rotation was regained at a rate of 10-20 degrees per week as tolerated. To allow the bone graft to heal properly, closed chain exercises such as push-ups were not incorporated until week 8. **Uniqueness:** While some research suggests that glenoid deformity is a common predisposing factor for glenohumeral instability which can worsen over time, posterior glenoid deformity is more common than the anterior deformity presented in this case. Glenoid deformity of this magnitude is also less common in younger populations with decreased time for degeneration. Older techniques for correcting glenoid deformity such as the Latarjet and Bristow procedures involved transferring a portion of the coracoid process, which may result in loss of motion. Using a graft from the iliac crest has been shown to remove this risk. **Conclusions:** Glenohumeral instability is common in athletics, but the cause of instability may vary greatly. Identifying and correcting all causes of glenohumeral instability is essential. Glenoid deformity is a predisposing factor for glenohumeral instability and may worsen over time due to degeneration and subsequent dislocations/subluxations. Correction of this condition with bone grafting in conjunction with other needed procedures is an effective method of restoring glenohumeral stability.

## Playing From the Baseline: Data Driven Interval Sport Programs in Tennis

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**Background:** Interval sport programs (ISP) have existed for decades. ISPs have mainly focused on throwing programs designed to return baseball or softball players from injury. ISPs aim to sequentially improve an individual athlete's deficits according to the type of injury, location of injury, sport, and skill level. In contrast, there is limited information on how to progress groundstrokes and serving skills with tennis athletes. To date, only one published ISP exists for tennis athletes and it is frequently implemented by allied health professionals. In order to develop an evidence-based ISP for hitting and serving skills in collegiate tennis, the certified athletic trainer (ATC) utilized player film to provide an analysis of average workload. The ATC completed this process for three athletes. **Treatment:** To create the individualized ISPs, the ATC watched three, previously-recorded tennis matches involving each injured tennis athlete from the semester prior to the athlete's injury. The ATC selected three recorded matches to mimic the minimum number of matches an athlete would play in a fall collegiate tournament. The purpose of watching film was to determine the athlete's average point length, or the average number of tennis strokes performed during one point. Once the athlete's average was established, the ATC created an interval hitting program of groundstrokes which progressed from 5% to 90% of the athlete's total load over six weeks, or the length of time prescribed by the physician. **Results:** The involved athletes completed the hitting program requirements three times per week for the first four weeks, and four times each week thereafter. Serving and overhead slams were reintroduced in the fourth week upon physician approval. Additional limitations were considered for each athlete which included playing in shortened court widths to limit reaching backhands for an athlete with a rotator cuff repair, or no terminal extension (slice backhands) until the fifth week for an athlete recovering from an elbow debridement. In an effort to emulate the sport modifications seen in other ISPs (ex. baseball's long toss), the ATC restricted athletes to fed ball tennis for the first two weeks, introduced live hitting the third week, and transitioned to only live tennis at the start of week five. The ATC also incorporated felt tennis balls for introductory serving and overheads to decrease the impact on contact. All athletes completed the provided IRPs and returned to competition at the start of the seventh week. **Uniqueness:** This pilot approach allowed the ATC to generate an advanced, efficient program for athletes to safely return to competition from various injuries. The ATC's workload calculations and program development, for each athlete and injury respectively, show the potential for future adaptability and implementation across the sport of tennis. **Conclusions:** The use of data driven ISPs offers many benefits to tennis athletes. It provides an objective measure of workload that allows the athlete to follow a linear progression toward return to play. Most importantly, future programs can be tailored to an individual athlete's injury, severity, and style of play. Furthermore, ISPs based on observed workload could be applicable for return to play decisions in other settings and sports. Future research might consider how to best address and rehabilitate the limitations and on-court deficits of various injuries sustained by collegiate tennis players.

## Low Back Pain With Hip Weakness in a Masters Golf Athlete

Jaasko O, Craddock J, Felton SD: Florida Gulf Coast University, Fort Myers, FL

**Background:** The patient is a 60 year-old right-sided golf Masters Athlete. Patient has previous history of low-back pain approximately 9 months prior. Patient currently presents with low-back pain that started 3 weeks ago on the 13th hole of a golf game during a downswing when the patient felt a twinge and sharp pain on his right low back that "disabled" him for 2 days. Examination showed tenderness to palpation over right side quadratus lumborum and paraspinals with palpable spasming. Sign and symptom provocation exhibited with left thoracolumbar lateral flexion, left thoracolumbar rotation, and flexion with AROM and passive range of motion (PROM). Left hip AROM and PROM within normal limits (WNL) and left hip extension manual muscle testing (MMT) 4/5. Right hip extension AROM 5° with thoracolumbar compensation and symptom replication, PROM WNL and pain-free. Right hip abduction AROM 35° with thoracolumbar compensation and symptom replication, PROM WNL and pain-free. MMT for above right hip motions 3-/5 and 4/5, respectively. (-) SLR test. No previous imaging. **Differential Diagnosis:** Lumbar disc herniation, lumbar jt. sprain, paraspinal strain, quadratus lumborum strain. **Treatment:** Since initial injury, patient has seen significant improvement with golf performance and ADL through conservative treatment, including hip musculature strengthening with a functional approach. Current approach to the present injury includes active treatment with hip and abdominal musculature strengthening through functional motions. Patient experienced significant reduction in pain and an increase in functional ability in one week. Imaging was ruled unnecessary due to progression with functional ability and decrease in signs and symptoms after a relatively short time period of treatment. **Uniqueness:** The relationship between recurrent low-back pain and poor hip musculature strength and endurance has been previously investigated. Non-specific mechanical low-back pain in adults is often sporadic and intermittent in onset with discomfort lasting from a few days to week(s). In such cases, hip musculature strengthening and neuromuscular re-education through functional treatment may be preferred for improved outcomes when compared to imaging. However, in cases which the signs and symptoms including radiculopathic symptoms persist for more than a week, imaging may be indicated. When the patient exhibits no significant neurological deficits such as foot drop, numbness and tingling, complete loss of sensation, or impaired deep tendon reflexes, conservative treatment may be indicated. Thus, hip musculature strengthening through functional rehabilitation program may be preferred and imaging may not have a positive implication on the outcome of the treatment but may even affect the rehabilitation process negatively. However, research concerning appropriate functional rehabilitation programs for non-specific low-back pain is limited. This case highlights the effect of hip strengthening through functional rehabilitation on treatment outcomes and establishes a model program. **Conclusions:** Previous research has established a connection between recurring, intermittent, non-specific mechanical low back pain and hip musculature weakness. This case highlights the importance of conservative treatment through hip strengthening with a functional approach in a patient with persistent low-back pain and hip pain and weakness. Through functional rehabilitation, the patient was able to significantly improve golf performance and ADL and reduce signs and symptoms. In cases of non-specific mechanical low-back pain without significant neurological involvement, imaging has been found to reduce outcome of treatment. Thus, lack of imaging may have a positive effect on the outcome of treatment and thus imaging may not be appropriate in patients without significant neurological involvement. Thus, this case study reinforces the positive effect of conservative, functional rehabilitation on low-back pain with minimal neurological involvement.

## Low Back Pain Due to Sacroiliitis, Leg Length Discrepancy, and Disc Pathology in a Female Collegiate Athlete

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**Background:** The athlete is a 21 year-old female NCAA Division 1 Basketball player. Her previous medical history includes concussion and low back pain, and a family history of low back pain, with one family member with disc pathologies; otherwise healthy with no other injuries. The athlete first reported to the athletic trainer during competition season, complaining of low back pain without radiating pain in the lower extremity. Athlete reports no specific mechanism. Initial evaluation indicated no gross deformity, but did note an apparent leg length discrepancy. The athlete was referred to a physician for imaging, and to a physical therapist for further evaluation. **Differential Diagnosis:** Low back strain, spondylosis, spondylolysis, lumbar disc herniation, SI joint dysfunction, sacroiliitis. **Treatment:** The athlete was rested from activity for the duration of her initial physician and physical therapy evaluations, but experienced little significant relief. The MRI imaging indicated a few bulging intervertebral discs and sacroiliitis (inflammation of the sacroiliac joint). X-Ray did not display a fracture. A physical therapist's evaluation revealed a leg length discrepancy of approximately 5 centimeters, which is believed to derive from discrepancy in femur length and from muscle inequalities. After a period of complete rest, the athlete began a very conservative treatment plan guided by the physician, physical therapist and athletic trainer. This included NSAID's, a cortisone injection, and light lower extremity stretching, as tolerated. The athlete progressed to basic lumbar ROM exercises and eventually light strengthening as per physical therapist's orders, but she continued to experience low back pain. She has still not been cleared to

bike or progress in her rehabilitation. The athlete has not participated in any physical activity, including basketball, since onset. The athletic trainer provided the athlete with a heel lift for the shorter extremity. The physical therapist has utilized manual therapy, stretching and light rehabilitation exercises. **Uniqueness:** General low back pain is relatively common among college athletes, but many cases are able to be resolved with modality treatments, lower extremity and lumbar stretching and rehabilitation exercises including core stability exercises. Many cases of low back pain in athletes are muscular in nature rather than joint and disc-related. It is less common for low back pain in collegiate athletes to be derived from significant leg length discrepancy, sacroiliitis and disc pathology. The hereditary nature of the athlete's disc pathology also adds uniqueness to the case. The goal with this athlete is to be able to return her to play for her fourth and final season as a collegiate basketball player, to begin to correct her leg length discrepancy, to relieve her low back pain and to provide the athlete with a successful management plan. Altering the athlete's treatment and rehabilitation plan until she can progress without symptoms, according the best practices indicated by research, although the current research on this specific issue is scant, is the ideal course of action. This case could provide insight on treatment plans and pain management for other young athletes with similar conditions and goals. **Conclusions:** While low back pain is common in athletics, non-traumatic disc pathology, leg length discrepancy and sacroiliitis are a few of the less common causes. This case demonstrates how complicated cases of low back pain can be, and the need for individualized intervention based on each case, plus better risk factor screening in pre-participation physical examinations.

## Asymptomatic Cam Impingement in a Male Collegiate Basketball Player: A Case Report

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**Background:** A 21 year-old (178 cm, 81 kg) NCAA Division I, male basketball player suffered from hip pain. During the conclusion of one competition, he presented with pain in his groin and on the posterior side of his hip after taking a hard fall during a game. The patient was kneed in the thigh and fell to the ground landing on his posterior hip. In addition, he had developed a large contusion as a result of the play. The Hip Scouring test, FAIR, and FADIR tests were all performed and all showed positive findings. **Differential Diagnosis:** Bone contusion on the Illium and Ischium, groin strain, trochanteric bursitis, ischiogluteal bursitis. **Treatment:** After Radiographs and an MRI were taken of the patient's hip, it was concluded that he suffered from a nondisplaced fracture of the superior pubic ramus. In addition, a cam impingement was found, as well as, herniation pits along the anterior Femoral head and neck junction. However, there were no signs of labral or ligamentous abnormalities as there are in the vast majority of cam impingement cases. The patient decided to take a conservative route for his treatment instead of surgery as he was cleared to play by the team physician and he wanted to finish the remainder of the season. He was limited to stretching during practice in hopes of reducing the inflammation that had developed as a result of the fracture and prevent ossification from the thigh contusion. He saw the team physical therapist two times a week for three weeks where he attempted to restore range of motion and decrease swelling. After three weeks with little to no progress, it was decided he would take anti-inflammatory shots in addition to the stretching for the remainder of the season. **Uniqueness:** Hip impingement routinely causes labral and/or ligamentous abnormalities and often decrease the patient's ability to perform activities of daily living. Our patient had no labral or ligamentous abnormalities, and while he experienced pain during all activities, he was still able to compete in his sport at an effective level. Additionally, the popular theory for the development of cam impingement is repetitive injuries to the femoral head and neck junction. Our patient had no history that would indicate his impingement as a development of repetitive injury which is a current alternative theory. **Conclusions:** Hip impingement can be difficult to diagnose without the proper imaging required to see the growth on the bone. Often hip impingements are found only after the patient has an x-ray or MRI for a different reason. Our patient chose a conservative method for his therapy and we thus showed that conservative treatment is not always the correct method as our patient had no success without anti-inflammatory shots. While it is rare to see a patient with hip impingement who does not also have labral or ligamentous deformities, our patient showed that it is possible. Hip impingement is becoming increasingly known and diagnosed. More research needs to be done in order to fully understand the development and the proper treatment for a patient with hip impingement. Athletic trainers, specifically those involved with men's sports, should be aware of hip impingement. Hip impingement is most common in males, specifically in those who are active in athletics, especially in running and jumping sports. While taking a conservative approach to treatment may show some improvement, surgery is often necessary. However, an athlete could be living with hip impingement, but is asymptomatic. Early detection is important, as hip impingement may lead to Osteoarthritis later in life.

## Conversion Disorder in a Collegiate Football Player

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**Background:** Athlete is an 18 year old Division 1 football defensive lineman. During preseason camp, the athlete was stepped on and stepped awkwardly immediately after. The athlete stated that he heard a pop in his Achilles Tendon. Findings included a (-) Thompson test, (+) dropfoot (but at some points dorsiflexed the foot slightly), unable to dorsiflex or plantarflex when asked to, and a decrease in sensation in foot or distal Achilles tendon. Stated that he could not move foot at all, but when distracted fired his FHL and EHL well. Babinski Test normal. **Differential Diagnosis:** Achilles tear, neuropraxic injury, Gastrocnemius rupture/ Grade 3 strain, conversion disorder. X-Ray, MRI and EMG were completed. **Treatment:** All results with X-Ray, MRI, and EMG study were negative. Nothing was found to be structurally wrong with the athlete. However, the athlete still presented with severely decreased sensation, drop foot and lack of range of motion within the ankle. Athlete was referred to a psychologist, who eventually diagnosed the athlete with conversion disorder. A diagnosis of Conversion Disorder takes into account social, biological and psychosocial factors as well as comorbidities . The athlete was prescribed triweekly visits with the mental health specialist, which was ongoing as of the end of December 2014. In the Athletic Training Room, the athlete was taken through light range of motion and slow progression of walking when the athlete felt up to it. He was given light rehab exercises dealing with walking and range of motion until his departure from the University in May 2015. The athlete is no longer attending the university or playing football. However, he does have full use of his foot with full strength and range of motion. **Uniqueness:** a wide variety of statistics exist, with incidence from 1.1 in 10,000 to 1 in 200 cases. Either way, the disorder is often linked to childhood abuse and mood disorders. In this case, it was a combination of moving away from home for the first time, the athletes relative being a star linebacker on the team and the possibility of something from his childhood. **Conclusions:** Athlete presented with symptoms of an Achilles rupture, although everything structurally was in tact and functioning as shown with three different diagnostic imaging studies. Upon consultation with a psychologist, the athlete was diagnosed with conversion disorder. Even through re-evaluation in the ATR, the athlete continually presented with all symptoms associated with an Achilles rupture without the imaging to confirm. Clinically, this is important on a higher level. An Athletic Trainer needs to always realize and take into account an athlete's psychosocial state of mind in an evaluation or presentation of symptoms. This is not to be construed to mean that every athlete is faking symptoms or has a diagnosable psychological disorder. However, when aspects of an evaluation do not support underlying differential diagnoses, a referral to additional specialists may be warranted, as was the case with this athlete. **Relevant Evidence:** No research at this time.

1. Ali S, Jabeen S, Pate RJ, et al. Conversion Disorder: Mind versus Body: A Review. Innovations in Clinical Neuroscience. 2015;12(5-6):27-33.

## Hip Pain in an Interscholastic Soccer Player

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**Background:** A 16 year old male interscholastic soccer player with no medical history was participating in a game and fell to the ground unable to get up secondary to planting his left foot, turning, and jumping in the air to contest a ball. During the AT on-field examination, the patient complained of severe left hip pain and reported feeling a "pop". Physical examination did not reveal any visual abnormalities; however, palpation elicited moderate tenderness over the left ASIS. MMT provoked increased pain and apprehension, but revealed 4/5 strength with knee and hip flexion. **Differential Diagnosis:** tensor fasciae latae strain, sartorius strain, quadriceps strain, iliacus strain, psoas strain, inguinal ligament sprain, and anterior superior iliac spine (ASIS) avulsion fracture. **Treatment:** After calming the patient down, he was able to walk off of the field on his own but demonstrated an antalgic gait. The patient was disqualified, iced, and monitored on the sideline. Upon attempting to ambulate post-game, the patient was unable to weight bear. During the follow-up evaluation, the patient reported that the pain had decreased substantially and was not present with sitting; however, the patient had significant pain while weight bearing and subsequently was referred to the emergency department. Radiographs were ordered which revealed a displaced ASIS avulsion fracture. The patient was prescribed NSAIDS and crutches, instructed to follow up with an orthopedist, and discharged. Status-post three days, the patient was seen by an orthopedist who confirmed the diagnosis and recommend conservative treatment. The patient was instructed to continue with the NSAIDS and crutches, and prescribed rehabilitation. The rehabilitation program focused on controlling inflammation and pain and restoring soft tissue mobility, neuromuscular control, range of motion, and the ability to weight bear and consisted of cryotherapy, manual therapy,

non-weight bearing therapeutic exercises, and touchdown weight bearing gait training with the use of crutches as tolerated by pain. Over the next few weeks, weight bearing crutch walking was progressively increased until the patient was able to ambulate without crutches. Status-post three weeks, the patient was instructed to discontinue using crutches and a more aggressive rehabilitation program was implemented consisting of weight bearing therapeutic exercises focusing on muscular strength, muscular endurance, and postural control and stability. Status-post four weeks, the patient was cleared by the orthopedist to gradually return to activity. The patient continued with rehabilitation focusing on functional progressions, agility, and speed. The patient participated team conditioning drills and modified practice sessions, participating in only non-contact drills. Status-post five weeks, the patient was cleared for unrestricted activity. His full participation did not elicit any pain or apprehension. The patient was able to finish the competitive season without incident. **Uniqueness:** Non-contact ASIS avulsion fractures are rarely seen in adolescent interscholastic athletes, and especially not in participants without a history of previous injuries to the involved structure or surrounding area. This case is also unique because the patient was able to resume full athletic participation without pain or apprehension in five weeks rather than the traditional eight weeks. **Conclusions:** Avulsion fractures occur from tensile loading at ligament or tendon attachment sites. Sudden loads to ligaments or tendons can avulse a fragment of bone. As a result, an initial evaluation for an adolescent patient experiencing an ASIS avulsion fracture can be challenging. With the clinical presentation being similar to a variety of common hip pathologies, it is essential to consider that pain level is not an important indicator for distinguishing between pathologies and results of physical examinations can be inconclusive. As such, the importance of physician referral for diagnostic imaging, specifically radiographs, were of critical significance to definitively diagnose this patient.

## The Effects of Medial Patellofemoral Ligament Reconstruction Using an Autograft Vs. an Allograft: A Systematic Review

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**Context:** The medial patellofemoral ligament (MPFL) is one of the major static medial stabilizing structures of the patella. Recurrent patellar instability is a common problem after dislocation. The literature recommends the use of MPFL reconstruction when addressing patellofemoral instability; however, the efficacy of MPFL reconstruction using an autograft is unclear when compared to an allograft. **Objective:** To systematically review the literature and evaluate the effectiveness of the autograft compared to the allograft for MPFL reconstruction for patellofemoral instability. **Data Sources:** Research articles were identified from the following electronic databases: Cumulative Index Nursing and Allied Health Literature, Medline, and Pubmed from June 2007 through December 2014. Search terms consisted of: "MPFL reconstruction AND autografts OR allografts"; "MPFL reconstruction"; "MPFL reconstruction AND allograft"; and "MPFL reconstruction AND autograph" resulting in 199 studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed, (2) randomized controlled trials, controlled or comparative trials without randomization, (3) written in English, (4) available full report or abstract, and (5) included outcomes measuring patient comfort and stability. **Data Extraction:** Two reviewers independently assessed and graded each study on the Physiotherapy Evidence Database (PEDro) scale. Data of interest were methodological assessment and descriptive data (e.g. means, median, frequency, and 95% CI (when available) of participant demographics (e.g. patellar instability, age, gender, and surgical intervention) and the main outcome measure (e.g. Kujala, Lysholm, and Tegner Scales). **Data Synthesis:** Six studies met the inclusion criteria; 2 full reports, 4 abstracts. The PEDro scores for the 6 studies ranged from 4 - 7 points (maximum score = 10 points; mean = 5.5 ± .94). Data, where available, was collected on subjects with a history of patellofemoral instability (n = 119), age (mean = 21.5 ± 3.9 years (range = 15-38). Males accounted for 43% (n = 51) of subjects; women accounted for 57% (n = 68). All studies examined patient comfort and assessed the Kujala Subjective Knee Scale. Two studies focused on the Kujala as well as the Lysholm Scale and one study included the Tegner Scale. All studies (6/6) demonstrated excellent stability and functional outcomes for both autograft and allograft for patients without recurrent dislocation episodes. Four patients (3%) experienced postoperative patellar apprehension and/or pain. The mean Kujala scores for all patients improved statistically significant from 53.3 points to 85.7 points ($p < .001$); however, there was no statistical significance found between graft types as measured by the Kujala Subjective Knee Scale. **Conclusions:** MPFL reconstruction using an autograft compared to an allograft showed no significant differences between groups. Few recurrent dislocations were reported postoperatively for both groups. Both graft types demonstrated improvements in patient comfort (e.g. pain, irritation, and apprehension) and function (e.g. ADL, work, and sport activities).

## Terrible Triad in a High School Athlete: A Case Report

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**Background:** A 15-year old healthy high school wide receiver went down during a football game at the beginning of the season. The athlete stated he fell to the ground with his right arm fully extended and that it did not feel normal and he could not move it. During the on-field evaluation, no complaint of neck, shoulder, or wrist pain was noted and motion was within normal limits. The athlete stated that he had not previously received an injury to this right elbow. No signs of swelling or discoloration were present at or around the right elbow joint. Neurovascular testing revealed full sensation in the right arm, with a radial pulse and capillary refill less than 2 seconds. Dermatome and myotome tests were negative. The athlete was splinted and immediately transported to the emergency room. **Differential Diagnosis:** Elbow dislocation, humeral, radius/ulna fracture, collateral ligament rupture. **Treatment:** Upon arrival at the emergency room, the athlete underwent radiographs which revealed a clear posterior elbow dislocation with associated fractures. Following the radiographs the athlete underwent several attempts at a closed reduction. A follow-up CT scan post closed reduction revealed that the athlete had a comminuted radial head fracture and a coronoid type 2 fracture. The athlete was scheduled for surgery four days later to address the complex dislocation. Open reduction internal fixation (ORIF) of the radial head and ulna coronoid fractures, and repair of the medial and lateral collateral ligaments of the right elbow was conducted. Post-surgery the athlete was placed in a posterior splint with 90 degrees of flexion and neutral rotation. The athlete underwent a standard post-surgery protocol and started a rehabilitation program. During a follow up appointment two and half months later, diagnostic imaging revealed nonunion and limited healing of the radial head, but the coronoid fracture had healed. There was noted forearm supination and extension positioning due to an elbow contracture. At this time, the athlete was scheduled for his second surgery two weeks later. Autograft placement, arthrotomy and capsulectomy for the contracture, as well as hardware removal from the ulna were completed. The athlete again underwent a standard post-surgery protocol and started a rehabilitation program. The athlete reported for follow-up appointments every 6 weeks post-surgery. On a check-up four months later diagnostic imaging revealed a chip on the end of the radial head. The athlete is now scheduled for a third surgery of radial head prosthesis. **Uniqueness:** This case is unique in that there was an attempt at repairing the radial head with two different surgeries, but the radial head failed to fully heal. This highlights the complexity of this injury and surgical management. There are many cases in literature that examine the management of a terrible triad of the elbow, but few cases report nonunion of the radial head after repair. **Conclusions:** Management of the terrible triad has been found to be difficult. Clinical recommendations suggest repair of the radial head in an active young athlete is crucial for stability as well as long-term prognosis. This case provides insight into the variations and complications that may occur with the terrible triad at the elbow, specifically management of the radial head in a young athlete. Further, this case study provides the athletic trainer with awareness of the potential serious complications associated with elbow dislocations.

## Evaluation of a Carpal Boss in a Division I Baseball Player: A Case Study

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**Background:** Athlete is a 21-year-old-male who plays first base for a Division I institution. The athlete catches and bats left handed. During an off-season scrimmage, the athlete was pulled off the base in order to make a defensive play. He applied a tag to the runner and his left wrist was forced into hyperflexion. The athlete felt an immediate pop and reported his pain 6/10. No reported numbness or tingling in fingers, hand, or forearm. There was obvious deformity and swelling at the base of the 3rd metacarpal. Palpations revealed tenderness over the abnormality; however, no tenderness was reported over surrounding structures. Upon further evaluation, the athlete had full AROM and RROM when compared bilaterally. Initial evaluation included the following Special Tests: Long Bone Compression of 2nd & 3rd Metacarpal (-), Tap Test on distal Radius and Ulna (-), Tap Test on all eight carpal bones (-), Murphy's Sign (-), Valgus Stress Test (-), and Varus Stress Test (-). The only pertinent positive finding was a decrease in grip strength when compared bilaterally. Because the evaluation revealed no obvious fracture and the athlete was able to conduct sport-specific activities, the athlete was allowed to finish practice and participate in all team activities without complications. 10 days post-injury, the athlete reported an increase in pain and a decrease in grip strength. The team orthopedic physician ordered a complete set of x-rays and cleared the athlete to participate in all pain-free activities. **Differential Diagnosis:** Differential diagnoses include dislocated Lunate or Ganglion cyst. **Treatment:** Initial diagnosis of the physician was thought to be a dorsal, left hand contusion. Upon further evaluation by a hand specialist, the diagnosis was a carpal boss. A wrist brace allowing for full pollicis ROM was placed on the

left hand and 500 mg of Naproxen was prescribed BID for ten days. One month following the initial injury, the athlete was cleared to discontinue the brace and return-to-play as long as the athlete was pain free. **Uniqueness:** The diagnosis of a carpal boss is uncommon and the etiology of such is also unknown. In addition, the athlete complained of increased pain as time went on rather than with the acute mechanism of injury. **Conclusions:** Accurate diagnosis of the carpal boss required x-rays as well as multiple referral sources. Certified Athletic Trainers should be aware of the signs and symptoms of a carpal boss as well as conservative treatment. Finally, this case also demonstrates that the formation of a carpal boss may not require a restriction from sport-specific movements.

### A Comparison of Muscle Activation During Crossover Symmetry and Traditional Thrower's Ten Exercises


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**Context:** Thrower's Ten (TT) has been a traditional shoulder rehabilitation program. Crossover Symmetry (COS) is a recently developed program, which utilizes elastic bands and exercises that are performed bilaterally, with the aim of enhancing muscle functions for rehabilitation. However, it is unclear whether TT or COS is more effective at activating muscles during exercise. **Objective:** To compare the effects of the two exercise programs on activation of supraspinatus (SS), infraspinatus (IS), middle trapezius (MT), and serratus anterior (SA) muscles, in healthy population. **Design:** Crossover Trial. **Setting:** University Athletic Training Center. **Patients or Other Participants:** Nine college-aged students with experiences in overhead sports (6F/3M, 21 ± 1.3 yrs, 170.4 ± 8.6cm, 72.8 ± 13.1kg) volunteered. **Interventions:** Subjects performed three exercises in random order from each program (COS, TT), while electromyography (EMG) data were collected for SS, IS, MT, and SA bilaterally. Maximum voluntary isometric contractions (MVICs) were measured against the examiner's resistance for all muscles and used to normalize the muscle activity during exercises. The exercises for TT program included Scaption with weight, External Rotation (ER) at 90° abduction with resistance band, and prone Row with weight. Exercises for COS included COS Row, COS 90-90 (similar to external rotation), COS Scaption. Exercise sessions were separated by at least one week, and the order of the exercise programs was randomized. For comparison purposes, exercises from the two programs were matched as following: COS Scaption and TT Scaption; COS Row and TT Row; and COS 90-90 and TT ER. **Main Outcome Measures:** The independent variable included the exercise programs (COS, TT). Dependent variables included EMG activity (%MVIC) of eight muscles (SS, IS, MT, SA on right and left sides). For each exercise pair, a separate repeated measures ANOVA was utilized ($\alpha = 0.05$). **Results:** For comparison between COS Scaption and TT Scaption, no effects of exercise, muscles or interaction were found ($p > 0.05$). For comparison between COS Row and TT Row, there was a significant effect of exercise ($F_{1,8} = 8.24$; $p = 0.021$). Also, there was a significant exercise-by-muscle interaction ($F_{7,56} = 7.70$; $p < 0.001$). Post-hoc pairwise comparisons revealed that COS Row displayed higher Left MT (COS = 62.98 ± 23.44%, TT = 38.45 ± 11.90%, $p = 0.024$), Left SS (COS = 61.01 ± 22.94%, TT = 17.82 ± 11.67%, $p = 0.001$) and Right SS (COS = 61.42 ± 22.94%, TT = 19.40 ± 12.24%, $p = 0.001$) activity than TT Row. Comparison between COS 90-90 and TT ER yielded a significant exercise-by-muscle interaction ($F_{7,56} = 2.528$, $p = 0.037$). Post-hoc pairwise comparisons revealed that for Left SA, COS had lower activity than TT (COS = 31.52 ± 21.46%, TT = 44.77 ± 22.45%, $p = 0.016$). Also, COS yielded higher Right MT (COS = 74.50 ± 44.19%, TT = 49.45 ± 26.50%, $p = 0.043$) and Right SS (COS = 73.50 ± 32.70%, TT = 39.90 ± 17.70%, $p = 0.001$) activity than TT. **Conclusions:** Overall, COS generated higher muscle activity compared to TT, except for the SA activity during Row. The results may indicate that COS may be beneficial for more comprehensive activation of multiple upper extremity muscles.

### Muscle Activation During Downward Dog Push-Up


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**Context:** Push-ups are a common closed-kinetic chain, upper extremity exercise, used to activate scapular stabilizers including the upper trapezius (UT), middle trapezius (MT), lower trapezius (LT) and serratus anterior (SA). However, activation levels of the SA may be diminished due to hand placement during the standard push-up. Alternative hand placements that increase glenohumeral flexion may provide increased activation of SA while still maintaining activation of other scapular stabilizers. **Objective:** To measure and compare scapular muscle activation during the standard push-up and downward dog push-up. **Design:** Randomized crossover study. **Setting:** Research laboratory. **Patients or Other Participants:** Participants (n = 19; male = 18, female = 1; age = 21.5 ± 1.6 y; body mass = 83.6 ± 11.2kg; height = 183.3 ± 8.8cm; Quick DASH-9 = 3.5 ± 7.2/100pts; left-handed = 2, right-handed = 17) were physically active with no current or recent shoulder injury (within the last 6 months lasting longer than one week of restricted activity). **Interventions:** Participants completed maximum isometric voluntary contractions (MVIC) on the muscles of interest followed by 5 repetitions of the standard push-up or the downward dog push-up at a rate of 1 push-up per second metered by a metronome. Kinematic data were recorded to identify the beginning and end of each repetition. Participants performed standard push-ups with feet shoulder-width apart, hands directly below the shoulders gripping dumbbells parallel with the line of the body, and hips in line with the shoulder and feet. Trials were approved if the participant

reached a minimum 90 degrees of elbow flexion. Participants performed downward dog push-ups with feet shoulder-width apart, hands flat on the floor, and hips flexed to achieve a minimum of 120 degrees of glenohumeral forward flexion. Trials were counted if participants maintained 120 degrees of glenohumeral forward flexion and if they reached a minimum of 90 degrees of elbow flexion. **Main Outcome Measures:** Root mean square percent MVIC (%MVIC) of the four muscles of interested measured using wireless, surface EMG. Data were compared using five separate dependent t-tests, one for each muscle and one for UT/SA ratio. Significance was set at $p < 0.05$ a-priori. **Results:** The downward dog push-up resulted in significantly greater muscle activation of both UT ($t18 = -4.447$, $p < 0.001$, ES = 1.02) and SA ($t18 = -4.145$, $p = 0.001$, ES = 0.95). In addition, the downward dog push-up resulted in a significantly larger UT/SA ratio ($t18 = -2.299$, $p = 0.034$, ES = 0.53). **Conclusions:** Previous research has focused on the push-up and push-up plus, with emphasis on hand position, foot position, surface-type, etc., but to our knowledge, this is the first study to investigate the effect of increasing glenohumeral flexion angle in the push-up. The change in glenohumeral angle increases UT and SA activity, and also UT/SA ratio. This exercise would not be recommended for individuals with symptomatic muscle imbalances, but could be useful in advanced rehabilitation or prevention programs in healthy, asymptomatic populations.

## The Effects of Wearing a Portable Media Armband on Muscle Activation of the Biceps Brachii

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**Context:** Portable media armbands (PMAB) are commonly used among the physically active population. The effect of a PMAB on muscle function during exercise has not been established. **Objective:** To determine if muscle activation of the biceps brachii is influenced by wearing a PMAB during an elbow flexion exercise. **Design:** Within subject. **Setting:** Controlled laboratory. **Patients or Other Participants:** Eighteen volunteers with no history of upper extremity injury (11 males: age = 22.5 ± 2.1 years, height = 178.3 ± 5.2 cm, mass = 85.0 ± 6.5 kg; 7 females: age = 22.9 ± 2.5 years, height = 168.3 ± 5.7 cm, mass = 72.3 ± 12.2 cm). **Interventions:** Participants performed three 5-second trials of a maximum voluntary isometric contraction (MVIC) for the biceps brachii against manual resistance. Participants were then seated with their throwing dominate arm resting on a padded incline table so that their elbow was fully extended and shoulder flexed to 45°. Participants performed an 8-10 repetition maximum (RM) of elbow flexion with a dumbbell weight through full range of motion. Velocity of the RM was 2-seconds and controlled with a metronome set to 60 bpm. Following a 5-minute rest, participants performed five separate elbow flexion trials through full range of motion with a PMAB and five trials without a PMAB. Testing trials were performed using the same position and weight determined by the 8-10 RM. There was a 1-minute rest between each trial. The PMAB was placed over the muscle belly of the biceps brachii at a tightness that allowed the primary investigator to fit two fingers between the armband and skin. The order of condition (with-PMAB, without-PMAB) was counterbalanced. Mean electromyography (EMG) data were recorded during the MVIC and testing trials at 1000 Hz. An event marker was placed within the EMG data to separate the concentric and eccentric phases for each trial. For each participant, the average concentric and eccentric phases for the five trials for each condition were normalized to the average of the three MVIC trials. The independent variable was condition (with-PMAB, without-PMAB). **Main Outcome Measures:** The dependent variable was the muscle activation of the biceps brachii. Mean data for each condition were analyzed using separate paired-samples t-tests for the concentric and eccentric phases with an alpha level of $P < 0.05$. **Results:** Statistical analysis revealed a significant difference for the concentric phase ($t17 = 2.905$; $P = 0.010$), in that the with-PMAB condition elicited greater muscle activation (72.57 ± 36.31) compared to the without-PMAB (63.67 ± 26.2). There was no statistical difference for the eccentric phase ($t17 = 1.964$; $P = 0.066$). **Conclusions:** The muscle activation of the biceps brachii is affected by the use of a PMAB during the concentric phase of an elbow flexion exercise. This is likely due to the location of the compressive force at the muscle belly. Future studies should investigate the effects a PMAB has on force production, strength gains and blood flow.

## Exercises Tailored to Meet the Unique Needs of Submarine Pitchers

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**Context:** Pitching accounts for approximately 75% of all collegiate baseball shoulder injuries. A pitcher's throwing style is determined by lateral trunk flexion angle at ball release and the amount of shoulder abduction of throwing. Limited research exists addressing rehabilitation of injuries for submarine style pitchers. **Objective:** Study investigated difference in activation patterns of posterior deltoid, infraspinatus, middle trapezius, and lower trapezius muscles for subjects conducting two exercises: cable retraction with external rotation and modified version of the same exercise, tailored to submarine pitchers. **Design:** Descriptive cohort **Setting:** Research laboratory. **Patients or Other Participants:** 16 healthy males aged 18-35 height: 167.4 ± 20.0 cm; mass: 61.3 ± 18.6 kgs with previous high school, college, and/or professional baseball experience volunteered to participate through convenience sampling. **Interventions:** To determine differences in muscle activation between two similar upper extremity exercises each subject was observed performing five repetitions of the two exercises while motion and muscle activity were captured using Qualisys Motion Capture System® in conjunction with Noraxon® SEMG system. **Main Outcome Measures:** Independent variables were the two different exercises. Dependent variables were muscle activity readings of each individual muscle and angle of glenohumeral abduction at peak EMG activity. Pearson's correlation analysis was performed to determine relationships between dependent variables. Paired-samples t tests compared mean difference of the peak %MVICs of the muscles and the mean difference of the glenohumeral abduction angle. **Results:** Strong positive correlation for peak muscle activation of the posterior deltoid ($r(10) = .913$, $p < .001$), infraspinatus ($r(10) = .749$, $p < .001$), middle trapezius ($r(10) = .765$, $p < .001$), and lower trapezius ($r(10) = .850$, $p < .001$)b were found. Paired-samples t test of the mean peak %MVIC between the two exercises was .0749 (sd = .553, p =.648) for the posterior deltoid, .4329 (sd = 1.17, p =.228) for the infraspinatus, .02914 (sd = .771, p =.898) for the middle trapezius, and .08810 (sd = .302, p = .334) for the lower trapezius. Paired-samples t test was further calculated to compare mean difference of glenohumeral abduction angle of the peak muscle activity. The angle of abduction was significantly less during the modified exercise for the posterior deltoid (13.2°, sd = 13.7°, P = 0.007), middle trapezius (17.45°, sd = 24.0°, p = .029), and lower trapezius (14.1°, sd = 18.0°, p = .020). **Conclusions:** There were no significant differences between % MVIC of the muscles of interest and the exercises being tested, therefore; this study suggested that modifying the traditional exercise is unnecessary. However, three of the four muscles of interest achieved peak activation at a lower angle of abduction during the modified version of the exercises. This suggested the utilization of the modified exercise to still achieve peak muscle activation and limit possibility of subacromial impingement.

## Scapular Muscle Activation During a Suspended Push-Up and Push-Up Plus

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**Context:** Push-up (PU) and push-up plus (PUP) are common exercises for developing strength of the primary scapular movers: upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), serratus anterior (SA). **Objective:** To determine the differences in muscle activation between PU and PUP in suspended and stable positions. **Design:** Single-cohort crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** 19 individuals (age 21.5 ± 1.6 years; height 183.3 ± 8.8cm; weight 83.6 ± 11.2kg; females = 1, males = 18; Quick DASH-9 = 3.5 ± 7.2 pts) who were able to perform a PU and PUP. **Interventions:** We measured muscle activation of UT, MT, LT, and SA using wireless, surface EMG. Participants completed maximum isometric voluntary contractions (MVIC) on the muscles of interest followed by 5 repetitions for each exercise: suspended PU, stable PU, suspended PUP and stable PUP. For suspended exercises, we utilized the TRX® suspension system. Kinematic data were recorded to identify the beginning and end of each repetition. Participants performed stable PU/PUPs with feet together, hands shoulder-width apart gripping dumbbells, while maintaining a neutral spine. Participants performed suspended PU/PUPs with feet together on a platform at a height consistent with the handles of the suspension system, hands shoulder-width apart gripping the suspension handles, while maintaining a neutral spine. Trials were approved if the participant reached a minimum 90 degrees of elbow flexion at the depth of the exercise by two raters (inter-rater reliability ICC = 0.79, intra-rater reliability tester 1 ICC = 0.90, tester 2 ICC = 0.87).

**Main Outcome Measures:** We calculated root mean square percent MVIC (%MVIC) of the four muscles of interest during each stable and suspended PU and PUP. We used two separate 2x2 one-way analyses of variance to evaluate %MVIC. Significance was set at $p < 0.05$ a-priori. **Results:** When we compared the PU to suspended PU, we did not identify significant different muscle activation in the LT ($p = 0.103$) or MT ($p = 0.067$). However, UT became significantly more activated ($t18 = -4.395$, $p < 0.001$) in the suspended condition (mean difference = 22.83%), while SA was less activated ($t18 = 3.637$, $p = 0.002$) in the suspended condition (mean difference = -11.37%). When we compared the PUP to the suspended PUP, we did not identify significant difference muscle activation in the LT ($p = 0.527$), SA ($p = 0.056$) or MT ($p = 0.134$). However, UT became significantly more activated ($t18 = -2.519$, $p = 0.021$) in the suspended PUP condition. **Conclusions:** Over activation of the UT has been associated with scapular dyskinesis and concommittant shoulder pathologies. The results of the study suggest that the use of the suspended PU and PUP elicit increased activation of the UT, which, in a symptomatic population, could exacerbate the condition. When treating patients with scapular dyskinesis and related pathologies, consideration should be made for selecting exercises that focus on coordinated activation of the scapular stabilizers and those exercises that do not require over compensation of one muscle over the others.

## Youth Swimmers With Shoulder Pain Exhibit Deficits in Scapular Upward Rotation

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**Context:** "Swimmer's shoulder" is a general term that applies to multiple pathologies that cause pain and affect swimming performance in athletes as young as 8 years old. Pain in overhead athletes has been linked to a variety glenohumeral and scapular adaptations, but how these changes relate to pain in youth swimmers remains unknown. **Objective:** To determine whether 8-10 year old swimmers with and without a history of shoulder pain display differences in range of motion or tissue development. **Design:** Post-test only **Setting:** Research laboratory **Patients or Other Participants:** 20, 8-10 year old swimmers (8 male, 12 female; age = 8.8 ± 0.7 years, height = 138.7 ± 12.4cm, weight = 34.0 ± 9.5kg, years swimming = 3.2 ± 1.4) who had been competing in swimming meets for at least one year were recruited from the local community. Participants were excluded if they had undergone upper extremity surgery within the past year. **Interventions:** History of shoulder pain was the independent variable in this study. If pain (>0/10 on a modified Penn Shoulder Score) was reported at any point during a swimmer's career, he/she was placed into the pain group (n=7, 4 male, 3 female). Swimmers with no history of pain were placed into the healthy group (n = 13, 4 male, 9 female). The investigators used musculoskeletal ultrasound to examine glenohumeral tissue adaptations and a digital inclinometer to measure range of motion. **Main Outcome Measures:** The dependent variables of scapular upward rotation at three different angles (60°, 90°, 120°) of glenohumeral elevation, posterior capsule thickness, humeral retrotorsion, and glenohumeral range of motion were measured bilaterally. Since all participants did not identify the shoulder in which pain occurred and measurements were not significantly different compared bilaterally, within subject data for each dependent variable were averaged and analyzed using independent samples t-tests. **Results:** Youth swimmers with previous pain had significantly less scapular upward rotation at 90° (19.3 ± 2.1°, $P = 0.07$) and 120° (33.1 ± 2.2°, $P = 0.02$) of glenohumeral elevation than healthy participants (90°= 23.3 ± 3.1°, 120° = 36.7 ± 3.3°). A similar trend ($P = 0.054$) was also noted at 60° (pain = 9.4 ± 2.1°, healthy = 11.9 ± 2.8°). No significant differences were observed for posterior capsule thickness ($P = 0.767$), humeral retrotorsion ($P = 0.363$), external rotation ($P = 0.916$), internal rotation ($P = 0.337$), or posterior shoulder tightness ($P = 0.349$) between groups. However, the pain group displayed approximately 3° more internal rotation (pain = 68.9 ± 5.4°, healthy = 65.7 ± 7.5°) and 3° less humeral retrotorsion (pain = -13.3 ± 6.1°, healthy = -10.3 ± 7.2°), which may be clinically significant. **Conclusions:** Limited scapular upward rotation may differentiate youth swimmers who have a history of pain and those who do not. Clinicians who work with youth swimmers should screen for scapular upward rotation and begin appropriate stabilization exercises at a young age to potentially prevent and treat shoulder pain. The small differences in range of motion and bony adaptation in youth swimmers also warrants further investigation into the progression of humeral retrotorsion as swimmers age.

### Development of a Volume-Based Stroke Interval Training Program in Elite Level Tennis Players

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**Context:** Serve volume per match and per set for elite tennis players are unknown. The only known metric specific to the volume of tennis serves is that male professional players serve approximately 8 times during a single game. This leaves a knowledge gap regarding typical tennis serve volume to train a tennis player for sport specific demands. **Objective:** To determine the average serve volume in professional and elite junior tennis players in order to create a data based interval-training program. **Design:** Retrospective review **Setting:** N/A **Patients or Other Participants:** 135 male and 122 female professional serve volume data was reviewed from the 2013 and 2014 US Open. 134 male and 136 female junior elite serve volume was reviewed from the 2014 Metropolia Orange Bowl. **Interventions:** Game day statistic scorecards were provided to the research team from the United States Tennis Association (USTA) from both events. Two members of the research team extracted serve volume data from the scorecards for both male and female players. These data were then used to construct an interval stroke program. **Main Outcome Measures:** The median value for serves performed was utilized for players participating in more than three rounds of tournament play. These median values were then averaged to represent each of the dependent variables. The dependent variables were total serves per match and per set. **Results:** Professional male players served 62 more total serves per match than junior male players due to the greater number of sets played ($P < 0.001$). Professional female players served 10 more total serves per match than junior females playing the same number of sets ($P = 0.01$). All male players hit 2 more total serves per set than all female players ($P = 0.005$). Regardless of sex, professional players served 4 more total serves per set than junior players ($P < 0.001$). The typical amount of serves per set was 40 serves in both elite level players, resulting in a 3-to-1 ratio of first to second serves. An interval-training progression was constructed with these service variables in mind along with forehand and backhand volume from a previous study. With these variables a 21-step stroke progression was devised to prepare elite level athletes for 120 serves and 210 groundstrokes per match. The progression was split into 3 phases. The average progression in total stroke volume at each step in phase 1, 2, and 3 was 16%, 20%, and 36%, respectively. **Conclusions:** These data establish the "unit dose" of serves per match and per set. Coaches and health care providers may use these data in estimating loads per tournament or per season on the tennis player's body. This volume-based program can be initiated at different phases depending on the training and injurious factors contributing to each individual player.

### The Effects of Open Kinetic Chain Vs. Closed Kinetic Chain Exercises on Patients With Vastus Medialis Oblique Atrophy: A Systematic Review

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**Context:** The vastus medialis oblique (VMO) is the first muscle to atrophy following knee injury. The clinicians often recommend both open kinetic chain exercises (OKCE) and closed kinetic chain exercises (CKCE) to strengthen the VMO; however, the effectiveness of OKCE compared to CKCE is unclear. **Objective:** The purpose of this research is to systematically review the literature and evaluate the effectiveness of OKCE compared to CKCE in strengthening the VMO. **Data Sources:** Research articles were identified from the following electronic databases: Pubmed, Medline, SportDiscuss, and Cumulative Index to Nursing and Allied Health (CINAHL), from January 1985 through December 2014. Search terms consisted of: "open kinetic chain exercises" AND "closed kinetic chain exercises", "vastus medialis oblique" AND "strengthening" resulting in 127studies. **Study Selection:** Studies were included if they met the following criteria: (1) peer-reviewed, (2) randomized controlled trials, controlled or comparative trials without randomization, cohort studies, or case series, (3) written in English, (4) full text reports or abstracts, and (5) included outcome measures. **Data Extraction:** Two reviewers independently assessed and graded each study based on the Physiotherapy Evidence Database (PEDro) scale. Data of interest was analyzed on the main outcome measures which included VMO strength and electromyography to assess VMO muscle activation during OKCE and CKCE treatment exercises. **Data Synthesis:** Five studies met the inclusion criteria; 3 full text reports and 2 abstracts. The PEDro scores for the five studies ranged from 5-10 points (maximum score = 10; mean ± SD = 7 ± 1.67. Data, where

available, was collected on healthy participants and participants with patella femoral pain syndrome (PFPS) and had a history of knee pain and VMO weakness. The mean age for participants was 24.9 ± 3.6 years (range 15 - 28) with a mean height of 66.1 ± 4.9 cm, and a mean weight of 60.65 ± 3.5kg. Males accounted for 47% (n = 68) of participants; women accounted for 53% (n = 78) of participants. All studies examined VMO strength and electromyography to assess VMO muscle activation during OKCE and CKCE treatment exercises. All studies (5/5) found participants experienced significant increases in VMO muscular strength and activation. Three studies (60%) identified that CKCE were more effective in increasing VMO strength with no differences in muscle activation ($p = .033$), one study (20%) identified that both CKCE and OKCE were equally effective ($p = .623$), and 1 study (20%) identified that OKCE was more beneficial for VMO strengthening and muscle activation ($p = .05$). **Conclusions:** Both types of exercises demonstrate improvements in muscular strength and activation; however, CKCEs appear to be a slightly more effective therapeutic intervention in activating the VMO. To enhance patient outcomes both CKCE and OKCE should be incorporated into a therapeutic intervention program.

## Non-Surgical Management of a Subscapularis Rupture in a Collegiate Baseball Player


Krohn HM, Warner BJ, Ranucci AC, Goza JP, Cage SA: University of Texas at Tyler, Tyler, TX; Grand Canyon University, Phoenix, AZ; Schreiner University, Kerrville, TX


**Background:** A 22-year-old male collegiate baseball player with a previous history of arthroscopic SLAP repair on the involved shoulder reported to the athletic training staff during competition complaining of diffuse posterior shoulder pain. The pain presented after the athlete felt a pop while taking a practice swing. The athlete was evaluated in the dugout and allowed to continue playing. Following another at bat, the athlete was forced to withdraw from participation due to pain. **Differential Diagnosis:** Glenohumeral subluxation, disruption of adhesions from previous surgery, rotator cuff strain, labral tear. **Treatment:** Day 3, the athlete complained of popping and clicking with activities of daily living. At this point, the athlete was referred to the team physician for further evaluation. Day 4, upon physician evaluation, the athlete was diagnosed with a Glenohumeral subluxation and advised to undergo a treatment and rehabilitation protocol to regain strength, stability, and range of motion. Day 6, the athlete was experiencing minimal gains in strength, stability, and range of motion, but expressed concern that the post season was less than two weeks away. The team physician administered a hydrocortisone injection in the subacromial space and placed the athlete on two days of complete rest. Day 8, athlete reported an increase in the sensation of intraarticular pressure, but an overall decrease in pain. Light resistance exercises were reinitiated for the rotator cuff and scapular stabilizers. Day 10, the athlete failed function testing despite strength, stability, and range of motion gains and was with-held from the conference tournament. Day 16, following kinesiology tape application, the athlete was able to participate in functional testing and batting practice with significantly less pain. Day 18, the athlete participated in the team's regional tournament and was able to participate with minimal difficulty. Following the team's final game, the athlete was instructed to follow up with the team orthopedic surgeon upon his return. Day 41, the athlete met with the team orthopedic surgeon and upon evaluation was scheduled for an Arthrogram MRI. Day 51, MRI revealed a midsubstance rupture of the Subscapularis along with a superior labral tear. Day 55, athlete was given full disclosures regarding his prognosis with or without surgery. The athlete chose to attempt conservative rehabilitation before making a decision regarding surgery. **Uniqueness:** Subscapularis strains rarely occur in isolation. There are only two previously reported Subscapularis strains within baseball, with neither falling into this athlete's demographic or mechanism. The athlete was able to return to full participation for a short time with a ruptured rotator cuff muscle. **Conclusions:** When caring for a patient, it is important to take into account patient values as part of your treatment and rehabilitation plan. A patient who is able to pass functional testing and fully participate may be within their rights to consent to playing with a significant injury provided they understand the consequences.

## Osteosarcoma of the Thoracic Vertebrae in a 22-Year-Old Baseball Player: A Case Study


Cage SA, Ranucci AC, Foster AL, Warner BJ: University of Texas at Tyler, Tyler, TX, and Grand Canyon University, Phoenix, AZ


**Background:** A 22-year-old student assistant baseball coach reported to the athletic training staff with pain along the paraspinal muscles throughout the thoracic distribution. The patient was treated conservatively with ice, electrical muscular stimulation, massage and stretching with good initial results. Following the conclusion of the season, the patient reported weakness and tingling in his legs, warranting a referral to the team physician. **Differential Diagnosis:** Disc herniation, facet joint sprain, erector spinae muscle strain. **Treatment:** Upon consultation with the team physician, the patient underwent a lumbar and lower thoracic x-ray that revealed a compression fracture of the T 10 vertebrae. An MRI was ordered at this point, revealing a large growth (8.5 x 4.5 cm) at the T 10 level that warranted immediate hospitalization for diagnosis. A CT-guided biopsy identified the mass as a high-grade spindle cell osteosarcoma. A follow up CT scan of the patient's brain revealed no signs of cancer or tumor at that level of the central nervous system. The patient was then transferred to a cancer treatment facility for further evaluation and initiation of treatment. Upon arrival at the treatment facility the athlete was consented for an extensive surgery process to remove the cancerous bone and soft tissue, followed by stabilization of the thoracic spine with the patient's left fibula. Following surgery and chemotherapy, the patient was diagnosed as cancer free. 5 months later, a follow up Petscan revealed a recurrence of sarcoma. The patient was consented and

began chemotherapy that is currently ongoing. **Uniqueness:** While osteosarcoma is one of the more common forms of adolescent cancer, it typically manifests in long bones (Over 70% occurring in the femur, tibia, and Humerus). Due to the involved erector spinae muscle symptoms, diagnosis was delayed until neurological symptoms manifested. Furthermore, benign bone tumors are more common, whereas this patient suffered from a malignant tumor. **Conclusions:** It is important to perform a thorough musculoskeletal evaluation when evaluating patients from any population. Treatment and rehabilitation outcomes must be evaluated and re-evaluated at regular intervals to determine the need for changes. If conservative treatment fails, it is important to continue pursuing the root cause of the patient's symptoms until pathology can be identified. While pain is a symptom athletic trainers work to mitigate, it can be a sign of conditions far more severe than musculoskeletal injuries. Prior to a patient returning to activity, the pathology causing pain should be adequately identified to allow for a safe and healthy return to activity minimizing potential secondary injuries.

## Chest Pain in a Male Interscholastic Wrestling Participant

Kinahan T, Rothbard M, Occhiboi E: Southern Connecticut State University, New Haven, CT, and Wilton High School, Wilton, CT

**Background:** A 15 year-old 70.44 kg male wrestling participant sustained a thoracic injury secondary to his chest being slammed onto the mat by a teammate during practice. He reported immediate and severe chest and medial shoulder girdle pain. On-site AT examination revealed right sternoclavicular joint deformity and altered scapular movements. Palpation produced moderate point tenderness over his right sternoclavicular joint, proximal sternum, right ribs two and three, and coracoid process. Active ROM testing elicited full but painful right glenohumeral extension; compensated scapular protraction, retraction, elevation, and depression causing scapular diskinesis; and limited and painful glenohumeral flexion, horizontal abduction and horizontal adduction. MMT revealed 4/5 for deltoid, pectoralis major, and pectoralis minor. Special tests provoked a positive sternoclavicular joint stress test and AP rib compression test. Functionally, the patient could perform a shoulder-width pushup, but was unable to perform a similar maneuver with narrow grip. The patient's medical history is significant for a right pectoralis major strain three week prior with return to full participation two weeks after. **Differential Diagnosis:** Sternoclavicular joint sprain, rib contusion, rib fracture, clavicle contusion, clavicle fracture, pectoralis major strain, and sternal fracture. **Treatment:** The patient was disqualified from wrestling, iced, provided with home care instructions, and referred to his physician. Status-post one day, the patient was seen by his orthopedist who confirmed AT findings and ordered an MRI, which revealed mild osseous mineralization and soft tissue density along the posterior aspect of the manubrium consistent with early callus formation and small hematoma. The orthopedist diagnosed the patient with an isolated non-displaced fractured sternum, further disqualified the patient from PE and wrestling for two weeks, and prescribed rest and ice. Status-post two weeks, the patient was cleared for rehabilitation; however, he was disqualified from wrestling by the orthopedist for the remaining seven weeks in the wresting season. Status-post three months, following rehabilitation, which consisted of progressive shoulder girdle motion and strengthening exercises, the patient was cleared for full activity. His return to team activities which included weightlifting and conditioning did not elicit pain or apprehension. **Uniqueness:** Although incident rates for sternal fractures have not been well characterized from national trauma databases, they are rare. Epidemiological studies approximate a .33% incident rate and are considered even rarer in athletics. Additionally, the patient's age puts him at a lower risk of sustaining a sternal fracture due to the increased pliability and elasticity of his chest wall. Lastly, the clinical evaluation findings did not indicate a sternal fracture as a high possibility because of the lack of subsequent comorbidities and associated symptoms. **Conclusions:** Chest wall trauma causing a fracture is uncommon both in athletics and in children. The mechanism of injury in sports is less likely to cause sternal fracture than the most common causes of sternal fractures including motor vehicle accident, being hit by a car, and falls, which account for 96% of sternal fractures. Sternal fractures typically present with subsequent comorbidities, including rib fracture, clavicle fracture, cardiac or pulmonary contusions, and other soft tissue injuries. Other associated symptoms include chest pain, ecchymosis, abnormal heart rate, and abnormal blood pressure. Lastly, patients presenting with sternal fractures may still be able to function despite pain and weakness. Because of severity of this injury, it is important for clinicians to be able to recognize and refer patients with chest wall injuries and consider sternal fracture within a differential diagnosis. Although subsequent injuries are common with a sternal fracture, it is important for a clinician to not rule out a sternal fracture in the absence of other symptoms and physical examination findings.

## Cervical Spine Injury in High School Football Player

Shea ME, Bonnell CB, Jutte LS: Xavier University, Cincinnati, OH, and Norwood High School, Cincinnati, OH

**Background:** A seventeen-year-old football receiver reported pain in his cervical spine after two weeks of preseason, two-a-day practice. He had no history of cervical spine injury or complaints, and denied any known mechanism of injury. During the initial evaluation, the athletic trainer found no physical deformity upon cervical palpation. However, palpation elicited pain in the C5/C6 and C6/C7 joint spaces, localized on the spinous and transverse processes of C6 and the surrounding left trapezius musculature. The patient expressed intense pain (9/10) with all cervical spine active range of motion (ROM), and discomfort (3/10) with all cervical passive ROM. Due to pain, resistive ROM was not tested. The patient was referred to a sports medicine physician to rule out fracture. **Differential Diagnosis:** C6 spinous or transverse process fracture, C6 subluxation, C6 dislocation, ventral wedge compression fracture, Clay - Shoveler's fracture, C6 spinous process avulsion fracture, acute torticollis, cervical paraspinal strain, posterior longitudinal ligament sprain, osteophyte fracture **Treatment:** The sports medicine physician ordered x-rays, which were normal, followed by a CT Scan, which found a well-corticated ossification posterior to the C6 spinous process with a small linear lucency traversing it. The radiologist, in conjunction with the sports medicine physician, diagnosed the patient with a fractured osteophyte on the spinous process of the C6 vertebrae. Due to the fracture's stability, the sports medicine physician ordered the injury be treated as a trapezius strain and the patient's symptoms addressed with therapeutic modalities and manual therapy, fully avoiding use of muscle strengthening exercise in the upper body. The physician also cleared him to continue to participate as long as he maintained treatment and his symptoms were tolerable. Daily treatment included 15 minutes of high-volt electrical stimulation with thermotherapy on the left upper and middle trapezius, manual trigger point release throughout the upper and middle trapezius and erector muscles, massage throughout the previously mentioned areas with the addition of the lower trapezius and latissimus dorsi as needed, manual cervical traction, active and passive cervical stretching (flexion, bilateral lateral flexion & rotation), and 20 minutes cryotherapy post practice. Occasional tension headaches were addressed with craniosacral release therapy and 600mg over-the-counter ibuprofen tablets provided by the patient's parents at home. To avoid compromising fracture stability, strengthening was contraindicated until the fracture healing was complete. The patient maintained strength through football activity, but could not participate in upper body team resistance training due to fracture avulsion risk. For lower body exercise, the patient could not hold any weight with his upper body and terminated activity if symptoms increased. The sports medicine physician's main concerns of patient comfort and attenuating muscle tension to prevent avulsion were achieved. The patient participated without limitations for the entire season. Once fracture healing was complete, he was cleared to resume upper body resistance training. **Uniqueness:** The literature is void of any cases of cervical spine osteophyte growth or deformity in adolescent patients. Cervical spine osteophyte growth is most commonly reported in 60-year-old male patients with degenerative joint changes. **Conclusions:** Spinal fractures are commonly season- or career-ending injuries. However, this patient was able to continue to participate due to the stability of the fracture and the management of his symptoms with a focus on diminishing muscle tension. In special cases, cervical spine fracture may not always constitute termination of athletic contact activity. Maintaining fracture stability by combatting surrounding muscle spasm can enable a patient to continue to participate. It is important to note as long as the fracture margins remain stable, healing will occur regardless of participation in physical activity.

## Nasal Fractures in Three Collegiate Women's Soccer Players: A Case Series

Isham AN, Patel AB, Hosey RG, Mattacola CG: University of Kentucky, Lexington, KY

**Background:** During the 2015 women's soccer season, three athletes sustained blows to the nasal bone. Two of the injuries occurred during matches, while the other occurred during practice. All instances occurred while the athletes were going to head the ball and while in the air they either hit the opposing player's head or elbow. The athletes denied any previous history of nasal pain. The symptoms common amongst the athletes included epistaxis, visible nasal deformity, tender to palpation on the nasal bridge and a headache. All athletes were oriented after the initial impact. None had previous history of nasal issues. Athletes were evaluated by the athletic trainer and later referred to the physician on site and denied any numbness to the face, visual complaints, or breathing issues. The physician referred them for a CT scan and then a follow up with ENT physician. **Treatment:** All athletes opted to forgo surgery through the season. Full go participation was allowed however, the athletes all needed to wear a custom mask for 4-6 weeks. A physician referral was needed for the mask and it was a two part process. In part one, the athlete met with a specialist who made a mold of their face and secondly the athlete returned to finalize the mask customizing. Two of the three athletes opted for surgery at the conclusion of the season. One athlete, a senior, would not continue play post season, and expressed her unhappiness with the appearance of her nose. The ENT felt she would benefit from a closed rhinoplasty with osteotomies. The other athlete is a freshman who was also unhappy with the appearance of her nose. The ENT's typical approach for managing subacute nasal fractures is to wait one year after the injury if a closed reduction was not performed. However, in her case the trauma was limited to the bony vault and could be treated with

a closed approach. **Results:** The CT scan confirmed nasal fractures in all three athletes. One athlete had a comminuted fracture non-displaced, another had a displaced comminuted nasal bone fracture with a shift of the bony vault towards the left hand side, and the third had a shift of the bony vault to the right. All athlete's septums appeared to be straight and not causing any further complications. **Uniqueness:** The likelihood of having three nasal fractures in one season is unusual, which revealed the lack of a standardized protocol of acute nasal fracture care. The athletes listed above elected not to reduce their fracture initially in order to ensure they would not miss any practice or matches. However, upon consultation with the ENT physician, it was recommended that nasal fractures be reduced immediately after incident or within a seven to ten day period, even if nasal airway was not compromised. Acute care is recommended to reduce the need of a future rhinoplasty. Although a nasal fracture is not indicative to loss of function, the cosmetic repercussion in female athletics is an important consideration. The swelling that occurred post fracture led two of the athletes to delay ENT consult because visible deformity was masked. Our protocol was to ensure that cognitive function was WNL, protect the fracture, consult with team physician, and then allow athlete to participate in their path of care. The athletes all elected to consult the ENT weeks after initial injury. The suggested protocol is to have the ENT on call, if possible reduce the fracture immediately, or refer the athlete to an ENT within seven days for a reduction. **Conclusions:** We have modified our protocol to include early consultation with an ENT, a recommendation of early reduction to limit potential deformity with the use of a customized mask.

## Wrist Pain in a Collegiate Baseball Player

Gilfeather D, Rothbard M, Dale J: Southern Connecticut State University, New Haven, CT, and University of New Haven, West Haven, CT

**Background:** A healthy 22 year-old male outfielder presented to the AT post-practice with left ulnar fovea pain secondary to swinging. Physical examination identified diffuse tenderness over the left ulnar fovea and a positive ulnar fovea sign. **Differential Diagnosis:** TFCC tear, ulnar artery aneurysm, carpal sprain, wrist tendinopathy, extensor capri ulnaris (ECU) subsheath tear, and hook of the hamate fracture (HHF). **Treatment:** After initial evaluation, the patient was instructed to have his wrist taped and was cleared to return to baseball. Status-post two weeks, the patient continued to report pain but only when making contact during swinging. Follow-up examination revealed continued tenderness, clicking with ulnar deviation and wrist flexion MMT, and a positive TFCC lift test. The patient was iced and referred to the team orthopedist. Radiographs were ordered, revealing no bony abnormality. An MRI was ordered and the patient was preliminarily diagnosed with ECU and flexor carpi ulnaris (FCU) tendinopathy. The patient was cleared to continue with baseball and prescribed rehabilitation, a wrist orthosis to be used when not playing baseball, NSAIDs, and was instructed to follow up after the MRI. Status-post three weeks, the patient reported pain with throwing and swinging. Physician examination elicited tenderness over the hypothenar eminence and pain with combined active wrist flexion and adduction. The MRI revealed a thickened ECU tendon, a torn ECU subsheath, and bone marrow edema within the hamate without a discrete fracture line. The patient's diagnosis went unchanged and he was prescribed additional NSAIDs and rehabilitation and underwent two corticosteroid injections. Status-post five weeks, with no improvement, the patient was referred to a hand specialist who performed an US guided corticosteroid injection into the ECU. The patient was withheld from baseball and splinted for two weeks. Status-post seven weeks, the patient reported mild improvement; however, during rehabilitation the patient reported pain and was referred back to the hand specialist. Status-post nine weeks, the hand specialist ordered additional radiographs which included a carpal tunnel view, revealing a HHF. The patient was definitively diagnosed with an HHF, transcarpal ligament sprain, and FCU and ECU tendinopathy secondary to an ECU subsheath tear. The patient underwent a hook of the hamate excision, median nerve decompression, ECU subsheath repair, wrist flexor tensosynovectomy, and was casted for three weeks. Status-post three months, the patient was prescribed rehabilitation for four weeks. Status-post four months, the patient was cleared to gradually begin throwing and hitting. Status-post six months, the patient reported being pain free. He was cleared and quickly adjusted to unrestricted team activities without incident. **Uniqueness:** With numerous mechanisms and wrist pathologies that may account for a patient's symptoms, evaluation and treatment of wrist pain is often complex, requiring the appropriate selection of and correlation between physical examination and diagnostic imagining. HHF and ECU subsheath tears can be recognized, but are often poorly understood causes of such pain. **Conclusions:** Ulnar sided wrist pain may require surgical intervention, and physical examination results should be combined with appropriate imagining to increase diagnostic impact. Specifically, radiographs should include a carpal-tunnel view to visualize the hook of the hamate when clinical findings suggest the presence of a fracture that is not visible with standard radiographs and MRI. Patients who experience HHF and/or ECU subsheath tears can present with pain secondary to swinging, rather than falling on an outstretched hand. Swinging causes an increased angulation of the anatomical structures relative to the ulna. HHF and ECU subsheath tears create altered mechanics and chronic stress upon the ulnar nerve and ECU tendon. Over time, if left untreated, stress may also lead to ulnar nerve damage, tendon degeneration resulting in disability, tendinosis, and osseous erosion.

## Clavicular Stress Reaction in a Collegiate Cheerleader

Lock KA, Lamborn LC, Uhl TL: University of Kentucky, Lexington, KY

**Background:** A 19 year old, right-hand dominant female collegiate cheerleader reported to the athletic training room complaining of a "bump" on her left clavicle. She reported general shoulder girdle soreness beginning three days prior and attributed this to increased activity since she was just beginning practice for the season. In addition, this athlete was returning to tumbling following an anterior cruciate ligament (ACL) reconstruction from the previous fall. Physical examination revealed an obvious visible and palpable deformity at the mid-clavicular region and tenderness upon palpation over the deformity. Horizontal abduction active range of motion (AROM) was within normal limits but discomfort in the clavicle was reported at 90 degrees and throughout the remaining ROM. Shoulder flexion AROM was also within normal limits but discomfort in the clavicle was again reported beginning at 90 degrees. No pain or laxity was present when assessing the integrity of the acromioclavicular joint. No laxity was present at the sternoclavicular joint but passive overpressure in axial load caused pain at the site of deformity. The athlete was referred to the team physician that day **Differential Diagnosis:** Apophysitis, tumor, stress reaction/fracture **Treatment:** Two-view bilateral radiographs revealed no obvious fracture or tumor. The athlete was limited to half of her normal weight-bearing upper extremity volume for two weeks and received follow-up radiographs at that time. During this period of relative rest, the athlete was counseled on ingesting the adequate amount of nutrients and calories through her diet, a calcium supplement was recommended, and she completed a dietary recall. Soft tissue mobilization, active release techniques, and electrical stimulation were used on the surrounding posterior musculature as muscular soreness/spasm persisted throughout her shoulder. Two weeks later, follow-up radiographs showed a subtle periosteal reaction and thickening of the bone at the point of tenderness. The deformity was less tender to palpation but not completely resolved. Continued activity limitation was recommended until the athlete experienced no tenderness to palpation. She was gradually integrated into full cheerleading activities after a seven week period. She had one setback caused by a blow to the shoulder but recovered quickly in a few days. She returned to full activities once she demonstrated her ability to perform 20 handstand pushups and was completely pain-free upon palpation **Uniqueness:** Limited information exists on clavicular stress reactions/fractures; usually more direct weight-bearing bones receive the stress from increased activity. Athletic trainers should be aware of sport demands to gymnasts and cheerleaders and incorporate gradual lower and upper extremity training procedures as they return to sport following a significant time loss period **Conclusions:** Repetitive actions are a part of training and competition; therefore, stress fractures should be considered when an athlete reports with bony tenderness. Stress reactions or fractures are associated in athletic competitions in which weight control is often emphasized such as gymnastics and cheerleading. These athletes are at greater risk when they return to sport following a significant time loss injury such as an ACL reconstruction. Athletic Trainers need to incorporate training regimens that address both upper and lower extremities and progress them gradually back to full activity.

## Chronic Posterior Dislocation of the Sternoclavicular Joint: Delayed Diagnosis and Clinical Outcome After Autograft Reconstructive Surgery

Magness HA, Martin BM, Millett PJ: The Steadman Clinic, Vail, CO, and Steadman Philippon Research Institute, Vail, CO

**Background:** A 19-year-old female professional BMX rider presented for evaluation of her right shoulder. Her chief complaint was pain at her right sternoclavicular (SC) joint with dyspnea and dysphagia. She had fallen directly on her right shoulder during a BMX accident three months prior. At the time of injury, she was diagnosed with a fracture of the right hand and an acromioclavicular joint separation, both of which were treated non-operatively. The patient noted progressively worsening medial clavicular pain with symptoms of painful swallowing and stridor that were exacerbated with forward shoulder elevation. These symptoms prevented her return to BMX riding. She denied previous injuries to the shoulder or SC joint. Musculoskeletal exam of the right upper extremity revealed tenderness of the medial, right clavicle with some asymmetry from the contralateral side. There was no tenderness to palpation of the right shoulder structures and she had full ROM and strength on the affected shoulder. During active and passive forward flexion, she reported tenderness with clicking and popping medially over the SC joint. Protraction and retraction of the scapula exacerbated this. Cross-body adduction of the right arm caused SC joint pain with a sensation of choking and difficulty breathing. The patient's right upper extremity was neurovascularly intact. **Differential Diagnosis:** SC joint instability, medial clavicular fracture, post-traumatic SC joint arthritis, chronic posterior subluxation/dislocation of the SC joint. **Treatment:** Radiographs indicated no apparent fracture or dislocation of the right SC joint or the clavicle, but there was a slight asymmetry to the SC joints. MRI and CT angiogram demonstrated a chronic locked, posterior dislocation of the

right SC joint with tracheal and mediastinal compression. The patient underwent an open, right SC joint reconstruction using a gracilis tendon autograft and partial, medial claviculectomy. Patient was allowed early passive ROM during the first six weeks of recovery with progression to full active and active assisted ROM in physical therapy after that. Patient began rotator cuff and periscapular strengthening exercises with restrictions from axial loading exercises of the SC joint. By three months post-operatively, the patient reported that all pre-surgical symptoms had resolved. At 5 months postoperative the patient was allowed to return to full activities and was able to return to competitive BMX racing. **Uniqueness:** SC joint dislocations are reported as approximately 1% of all joint dislocations, most of which are anterior. Posterior SC joint dislocations are rare, easily missed (as in this case), and can be life-threatening due to the associated compromise of mediastinal structures. Multiple publications have documented cases of SC joint dislocations most commonly in males and in contact sport athletes. This case is unique in that the patient was a female who participated in a non-traditional, non-contact sport. She suffered from the uncommon, locked, chronic, posterior SC joint dislocation with potentially life-threatening symptoms that were exacerbated by simple shoulder range of motion. **Conclusions:** It is appropriate to raise awareness among athletic trainers of the risk for SC joint injuries and, in particular, locked, posterior SC joint dislocations with the incurrent complications that can result from such injuries in any sport with opportunity for high-energy trauma. Extreme sports have grown in popularity and athletic trainers may be exposed to caring for athletes in these high-risk, non-contact sports. In this case, there was a delay in diagnosing the dislocation and the injury not only prevented a return to sport but also caused significant pain and symptoms of dysphagia and dyspnea. Once the decision was made to proceed with surgical treatment to stabilize the SC joint using a gracilis tendon autograft, the patient had pain relief and resolution of her symptoms from mediastinal compromise.

## Orbital Trauma and Macular Damage in a Collegiate Baseball Player

Bazink A, Rooks Y: University of Maryland, College Park, MD

**Background:** A 20-year-old male collegiate baseball pitcher was struck by a line drive in the face during a baseball game. Athlete presented immediately with lacerations to both the supra-orbital and suborbital rims of the left eye, edema and deformity of the zygomatic bone. The scene was assessed and the Emergency action plan was activated. The athlete was transported by ambulance to the nearest trauma center for further care. **Differential Diagnosis:** Concussion, Supra/Suborbital Fracture, Blunt trauma to Eye, Zygomatic Fracture, "Blowout" fracture. **Treatment:** The athlete had an X-ray and CT scan performed at the hospital where it revealed a displaced zygomaticomaxillary and orbital floor fracture aka "blowout" fracture. Once stable, he was transported to a different local trauma center. There it was determined that there was too much swelling in the area and he was sent home after 24 hours in the hospital to allow for the swelling to dissipate. One week later, plastic surgery was performed to repair the fractures. At the follow-up appointment, he reported having some impaired and distorted vision, and he was referred to Ophthalmology. At this appointment, a three-dimensional image of the eye revealed a macular hole and 20/200 vision. A retinal specialist met with the family and athlete and presented option to help him regain full sight. Because he was young individual, she tried first with injecting a small amount of anti-inflammatory to the hole in hopes that it will close when the swelling dissipated. One week later it was determined that this was unsuccessful. The next option was pneumatic retinopexy, where the eye was drained and filled 25% with gas to hold the two flaps of the hole down. With this procedure, the athlete was required to lie face down for 7 days straight while only being allowed to lift his head 10 minutes out of every hour. At the one week follow-up it was determined that the procedure was not successful and the final option was to do a complete pneumatic retinopexy with 100% gas bubble. 7 days later, the follow-up appointment revealed that the hole was closed and he now need to wait to allow for the gas to dissipate. About 3 weeks later the gas dissipated and it revealed a drastic improvement in eyesight. Once at 20/200 vision, the athlete was now at 20/25. Two weeks later he was cleared to participate in slight cardio and weight lifting exercises. At 1 month post-surgery, He was cleared to partake fully in team lifts with no limitations, and only required to give daily check-ups on self-felt eye pressure. 8 weeks post-surgery he was given the clearance to start slowly working back to pitching. It was determined that for comfort and mental satisfaction we would get the athlete a custom mask that he would wear for the upcoming season. **Uniqueness:** The resolution of vision and full return to activity after an injury involving so much damage to the eye and surrounding area is what makes this case so unique. The prevalence of macular injury is much higher in an older population (60+) where they are most likely not returning to a high level of activity. **Conclusions:** Only 1 in every 300,000 pitches are hit back at the pitcher. Statistically, it is a rarity but it is important to take swift action with an emergency action plan and be evaluated by the proper specialists to ensure that the athlete can return to full health.

## Olecranon Epiphyseal Fracture and UCL Tear in College Baseball Athlete

Rodriguez ER, Craddock J, Felton SD: Florida Gulf Coast University, Fort Myers, FL

**Background:** Athlete is a 19 year-old male NAIA baseball outfielder. Athlete's prior medical history includes olecranon epiphyseal stress fracture in right elbow two years prior. Athlete reported to athletic trainer following completion of normal long toss throwing during baseball practice two weeks prior. Athlete reports sudden onset of sharp pain following the last throw of long toss program in posteromedial aspect of right elbow. Initial evaluation revealed no obvious deformities or evidence of acute injury. Athlete was point tender over medial epicondyle and ulnar collateral ligament (UCL). Full, pain-free, active ROM of elbow flexion, extension, supination, and pronation. Full strength of elbow flexors, extensors, pronators, and supinators. (+) valgus stress test, (+) valgus extension overload test. Physician ordered MRI and determined a UCL rupture was present. Athlete was scheduled to undergo UCL reconstruction surgery for 4 weeks after the injury and was ordered to discontinue baseball activities. Three weeks after scheduling UCL reconstruction surgery, athlete reports back to athletic trainer after hearing an audible "pop" in the right elbow joint while doing a handstand push-up activity. Evaluation revealed diffuse edema and point tenderness of olecranon and posterior elbow. ROM and strength testing was contraindicated due to possible fracture. Radiographs determined athlete sustained displaced fracture of previous nonunion of olecranon epiphyseal plate. **Differential Diagnosis:** UCL sprain, nonunion olecranon epiphyseal fracture. **Treatment:** Athlete was initially scheduled for UCL reconstruction surgery. Following nonunion fracture, UCL reconstruction was cancelled and ORIF was scheduled to repair nonunion. Athlete underwent rehabilitation for 4 months. Athlete was then rescheduled for UCL reconstruction and underwent rehabilitation for 8 months before returning to full baseball activities without complaints. **Uniqueness:** UCL injuries are common in baseball athletes. Olecranon epiphyseal injuries are less common than UCL injuries and are typically seen in adolescent athletes engaged in repetitive overhead activities. Upper extremity stress injuries are less common than lower extremity stress injuries. Olecranon stress fractures are the 4th most common behind tibial, costal, and metatarsal stress fractures. However, stress fracture of the epiphyseal plate can predispose the individual to a nonunion fracture, which is exemplified in this case. This case is unique because the literature does not offer strong evidence of a correlation between UCL and olecranon epiphyseal injury. Their coinciding onset, however, does raise questions on a connection between the two injuries. There is only one other case report in the literature that notes a concurrent UCL and olecranon stress injury in a baseball player. Both injuries can be chronic in onset and caused by a valgus extension overload mechanism that naturally occurs during the baseball throwing motion. It is not possible to determine if that was the underlying mechanism in this case. Either injury would create instability in the posteromedial aspect of the joint. This can also lead to subsequent injury of the other structure. The decision to repair the nonunion fracture prior to the UCL in two separate procedures is not commonly noted in the research. This requires two separate rehabilitation protocols that will effectively decrease deficit from each surgery and safely return the athlete back to full functional baseball activity. **Conclusions:** This case highlights the diagnosis and treatment of a collegiate baseball athlete presenting with a simultaneous UCL tear and nonunion olecranon epiphyseal fracture resulting from two separate occasions. This case further highlights the incidence of concurrent injury of these two structures and the need for more research on their possible correlation. Ultimately, this case draws awareness to the possibility of simultaneous injury to the UCL and olecranon process. This should be a consideration during the evaluation of posteromedial elbow pain.

## Wrist Pain in an Intercollegiate Football Player

Murphy C, Rothbard M, Nelson C: Southern Connecticut State University, New Haven, CT

**Background:** A 20 year-old, male intercollegiate wide receiver with no history presented to the AT during practice with left radiocarpal pain and paresthesia secondary to falling on an out stretched hand as another participant simultaneously landed on the patient. On-site AT examination identified dorsal carpal deformity with diffuse swelling, radiocarpial tenderness, and intact neurovascular function. ROM, MMT, and special testing were not performed due to pain and disability. **Differential Diagnosis:** Scaphoid fracture, distal radius fracture, median neuropathy, scapholunate dissociation, lunate dislocation, and perilunate dislocation. **Treatment:** The patient was splinted, iced, and referred to the emergency department. The patient was seen by the attending physician who ordered radiographs which revealed an ulnar styloid avulsion fracture with minimal radial displacement. The patient was resplinted, stabilized, instructed to follow up with an orthopedist, and released. Status-post one-day, the orthopedist's evaluation identified severe swelling and a hematoma over the proximal wrist. Physical examination elicited tenderness over the scapholunate joint and scaphoid, inability to perform wrist AROM secondary to pain, and palmar hypoestheisia. Additional radiographs were ordered which revealed a scapholunate dissociation with a small ulnar styloid fracture. The orthopedist preliminarily diagnosed the patient with a scapholunate dissociation and median neuopathy. The patient was splinted, prescribed pain medication, and subsequently referred to a hand specialist. Status-post two days, the patient was seen by the hand specialist who definitively diagnosed the patient with a left wrist complete lesser arc dorsal perilunate dislocation and post-traumatic carpal tunnel syndrome, and scheduled the patient for surgery. Status-post three days, the patient underwent a volar and dorsal open reduction K-wire fixation and ligamentous repair, open carpal tunnel release, posterior interosseous neurectomy and was

casted. Status-post-four-weeks, the K-wires were removed and the patient was casted for an additional three weeks. Status-post two months, the cast was removed and the patient was prescribed rehabilitation which consisted of thermotherapy, manual therapy, and therapeutic exercises focusing on ROM and strengthening. Status-post four-months, the patient stated that he could write for thirty minutes before fatigue and demonstrated 75° of wrist extension, 50° degrees of wrist flexion, and 45° of ulnar and 25° radial deviation with improved grip strength. The patient was prescribed additional rehabilitation focusing on aggressive wrist flexion ROM and strengthening. Status-post six months, the patient reported continued slight paresthesia and demonstrated 70° degrees of wrist extension and flexion. Rehabilitation now focused on aggressive therapeutic exercises targeting functional strength. Status-post seven-months, the patient reported being pain free with normal sensations; however, the patient demonstrated ROM and strength deficiencies. He was unable to return to playing football due to the deficiencies. The patient was prescribed additional rehabilitation to be completed at a clinic over the summer. He never returned to campus and elected to transfer. **Uniqueness:** Given the subtlety of wrist injuries, the epidemiology is not fully appreciated and little is known about the exact incidence of perilunate dislocations. The literature identifies that perilunate dislocations are rare with even fewer occurring dorsally. **Conclusions:** Carpal injuries represent a spectrum of conditions and can take many forms, including scapholunate dissociation, perilunate dislocations, and other intercarpal instabilities. Perilunate dislocations are characterized by a dislocation of the distal carpal row while the lunate remains within the fossa with respect to the distal radius. They result from a forceful axial load, combined with wrist hyperextension and ulnar deviation, causing carpal rotation. Perilunate dislocations are challenging to diagnose and a high prevalence of patients are unable to return to pre-injury activities despite proper treatment. Accurate radiographic examination is key to definitive diagnosis. With early diagnosis and anatomical reduction, the prognosis can be positive; however, the likelihood of post-traumatic arthritis still exists.

## Latissimus Dorsi Rupture in a 23-Year-Old Male Mixed Martial Artist

Matthews JS, Kunkel LE: Texas Wesleyan University, Fort Worth, TX

**Background:** A 23-year-old mixed martial artist was at jiu-jitsu practice sparring with a teammate. The patient's shoulder was forced into abduction and partial internal rotation complimented with elbow flexion. The patient stated that he felt a ripping sensation underneath his right axilla. He reported to the athletic training clinic two days after injury with apparent ecchymosis and pain as 9/10 on a visual analog scale (VAS). He had full ROM and strength compared bilaterally. The athletic trainer made a clinical diagnosis of a teres minor rupture. **Differential Diagnosis:** Teres minor rupture, latissimus dorsi (LD) rupture. **Treatment:** The athletic trainer highly advised the patient to see a physician, but the patient opted to continue to train for one and a half months until the end of his competition season. After the competition season he continued to train as tolerated for an additional month and a half until the pain was too great for him to participate; he then opted to be evaluated by a physician. Radiographic imaging was obtained three months after initial injury and the patient was diagnosed with a full LD rupture and traumatic myositis ossificans. Surgical intervention was not considered due to the injury location in the axillary region, which is highly innervated and vascularized. Conservative treatment began three days after imaging. Weeks 1-4 consisted of exercises to maintain ROM, ultrasound to promote healing and iontophoresis for pain management. NSAIDs and light resistance training for surrounding musculature were also used. Weeks 4-12 consisted solely on muscular endurance and strength gains, and during weeks 12-16, the patient received a home exercise program and exercised at the clinic as needed. After week 16 the patient progressed slowly back to physical activity. He returned to full activity and competition with mild discomfort, but no complications reported. **Uniqueness:** LD ruptures are extremely rare. Upon a literature search only case reports were found, none of which were in a mixed martial artist. In addition, the patient continued to participate at a high level, albeit with pain. This continued participation may have contributed to myositis ossificans. **Conclusions:** Spontaneous LD ruptures are a very rare injury and in this case the patient was able to participate, despite pain. Conservative treatment is recommended for LD ruptures and health care professionals should be aware that though uncommon, these can occur and should be considered in a differential diagnosis if warranted. If LD ruptures are diagnosed and treated in a timely manner, further complications such as myositis ossificans may be prevented.

## Hand Pain in an Intercollegiate Soccer Player

Rothbard M, Sampson M, Almeida M: Southern Connecticut State University, New Haven, CT

**Background:** A 17 year-old female goalkeeper with no relevant medical history sustained severe left hand trauma secondary to her hand being stomped on by an opponent while attempting to make a save during a game. On-field, the patient reported immediate severe pain. AT examination revealed a left third phalanx deformity, significant swelling, extremely limited ROM, and was neurovascularly intact. **Differential Diagnosis:** PIP contusion, sprain, fracture. **Treatment:** The patient was taken to the sideline, iced, splinted, and referred to the emergency department. At the hospital, radiographs were ordered which revealed a left third middle and proximal phalanx fracture. The patient was re-splinted, prescribed pain medication, provided home care instructions, instructed to follow up with her health care provider, and released. Status-post two days, the patient was seen by her PCP and referred to an orthopedic hand specialist. Status-post three days, the orthopedic hand specialist diagnosed the patient with a malaligned and unstable third PIP fracture. The patient was resplinted, instructed to continue with the prescribed medication, and increase her calcium and vitamin D intake through diet and supplementation in preparation for surgery. During the consultation, surgical arthroplasty management options were discussed, but the hand specialist referred the patient to a second orthopedic hand specialist. Upon arriving at a mutual clinical decision, the patient underwent an OREF one week later and subsequent external fixation removal four weeks later. The patient was prescribed and completed rehabilitation with a certified hand specialist, supplemented by rehabilitation with the AT on intervening days. Status-post one year, after undergoing three additional revision procedures consisting of a capsulectomy, silastic arthroplasty, and tendolysis of the extensor and flexor tendons, cheilectomy, and volar plate and collateral ligament releases, the patient still complained of pain, significant PIP disability, and an inability to adequately function. She elected to undergo a third phalanx amputation and a ray transposition of the index finger to the third metacarpal base. Status-post one year and six months, with the patient's motion and strength slowly improving with rehabilitation, the patient underwent hardware removal and extensor tendolysis, and was prescribed additional rehabilitation. Status-post two years and two months, the patient was progressing and demonstrated 95° of MP motion; however, she demonstrated intrinsic tightness and could not actively flex the DIP or PIP of her index finger. She elected to undergo a lengthening of her lateral bands to improve active flexion and was prescribed additional rehabilitation. Status-post two years and six months, the patient demonstrated significant improvements and was cleared for unrestricted activity, provided the index finger was splinted in functional extension. The patient continued rehabilitation with the AT focusing on strengthening but still complained of pain and was referred to a pain management specialist. Status-post two years and seven months, the patient was referred to another pain management specialist for a second opinion and was prescribed gabapentin. Currently, the patient still demonstrates weakness and has difficulty with twisting/opening containers, grasping items tightly, and pinching objects, but the patient is able to adequately function and successfully completed the season with the assistance of the splint and kinesiotape to facilitate function. **Uniqueness:** Digital amputations as a result of athletic related injury, though rare, account for significant disability and health-related costs. Epidemiology studies estimate an incident rate of less than 1%, with only approximately one-tenth associated with sport related trauma. **Conclusions:** This case serves as a reminder that participation in athletics comes with the risk of injuries, including permanent physical impairment, paralysis, and/or death in the absence of negligence. This case also serves to highlight the necessity to collaborate and actively integrate medical expertise with other healthcare providers to enhance patient outcomes.

## Non-Traumatic Posterior Inferior Labrum Tear in a 16 Year-Old Female: A Case Report

Wise SL: Metro Nashville Public Schools, Nashville, TN

**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 in a one week period. She complained of having troubles reaching above shoulder level 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 of 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 arthrogram 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 arthoscopic 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 the Athletic trainer consisting of gentle range of motion exercises and elbow and wrist strengthening until physical therapy was scheduled. At 6 weeks she went to physical therapy, but due to having full range of motion, she did not

return until 8 weeks, when more aggressive strengthening could be performed. She has had no pain other than normal post-operative pain. She demonstrated full range of motion but did not return 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:** The 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.

## Acute Shoulder Pain in a Collegiate Football Player

Bowns A, Rothbard M, Hepner N: Southern Connecticut State University, New Haven, CT, and University of New Haven, West Haven, CT

**Background:** A 22-year-old male linebacker with no medical history presented to the AT during a game with deep and achy pain, weakness, and a popping sensation within the right axilla secondary to eccentric internal rotation while attempting to make a tackle. On-site AT examination identified no visual deformity or point tenderness. Active ROM elicited anterior shoulder pain, and the patient demonstrated extremely limited glenohumeral internal and external rotation. Passive ROM provoked mild pain with glenohumeral internal rotation with a firm end feel. The patient demonstrated 5/5 strength with internal and external rotation MMT, negative lift-off test, negative belly press test, negative Spurling sign, and intact neurovascular function. **Differential Diagnosis:** Humeral fracture, transverse humeral ligament tear, labral tear, glenohumeral dislocation, supraspinatus tear, infraspinatus tear, teres minor tear, subscapularis tear. **Treatment:** The patient was disqualified from activity and referred to the team physician on the sideline who preliminarily diagnosed the patient with a biceps brachii subluxation. The patient was iced, fit for a sling, provided home care instructions, and instructed to follow up with the AT. Status-post two days, radiographs were ordered and did not show evidence of fractures, dislocations, or bony abnormalities. The team physician continued to disqualify the patient from activity, ordered an MRI, and prescribed NSAIDs, rehabilitation emphasizing pain control, maintaining soft tissue mobility, ROM, and neuromuscular control, and the continued use of the sling for comfort. Status post four days, the MRI revealed a full-thickness subscapularis tear, long head of the biceps tendon anterior subluxation resulting from a transverse humeral ligament tear, and joint effusion. To determine participation status, an ultrasound was ordered which identified a medial biceps subluxation and a partial intrasubstance subscapularis tendon tear. The patient was definitively diagnosed with an intact subscapularis tear and a subluxating long head of the biceps tendon. The patient was prescribed additional NSAIDs and rehabilitation, and was cleared to participate with the use of a shoulder stabilizing brace. Status-post two months, the patient was able to complete the season without incident despite continued biceps popping. Post-season, the patient elected a non-operative treatment program despite the possibility of rupturing or unlikelihood of ever being asymptomatic. Status-post three months, during the post-season rehabilitation process, the patient continued to report discomfort with certain provocative maneuvers and elected to have surgery. The patient underwent a subscapularis repair and biceps tendonesis. He then completed an additional five months of rehabilitation focusing on restoring dynamic stability and muscular balance of the shoulder girdle. Status-post eight months, the patient was cleared for unrestricted activity and completed full team activities without incident. **Uniqueness:** Subscapuaris tears are characteristically non-traumatic injuries and are connected with tendon degeneration and/or impingement. The incident rate for subscapuaris tears is poorly documented, but is reported to occur in less than 10% of patients suffering from rotator cuff pathologies. **Conclusions:** Acute shoulder pain is a common complaint and given this patient's MOI a subscapuaris tear must be differentiated from a variety of conditions. Since subscapularis tears are regularly non-traumatic and commonly associated with injuries to the long head of the biceps tendon, they can be difficult to properly diagnose when presented acutely, and challenging to treat. Clinical examination findings often yield inconsistent results, given the lift-off test sensitivity of 40% and despite a belly-press test sensitivity of 88%. As such, selective tissue testing should be combined with other examination techniques. Also, this case demonstrates the necessity for involving the patient in clinical care decisions. Originally opting for conservative management, the patient gradually accepted the necessity for surgical intervention to optimize his overall outcome and allow him to return fully to his normal activities.

## Non-Traumatic Myositis Ossificans of the Teres Major in a Collegiate Baseball Player: A Case Report

Amponsah GP, Crossett ID, Mair SD, Gribble PA: University of Kentucky, Lexington, KY

**Background:** A 19-year-old male, collegiate baseball infielder (85.45 kg, 182.88 cm) complained of soreness over the right posterior shoulder and lateral border of the scapula while participating in pre-season baseball instruction on 9/21/2014. Examination by the Athletic Trainer revealed slight pain during follow through phase of throwing, no visible or palpable deformity, and pain with resisted external rotation at 0° and 90°. The patient denied any injurious mechanism or history of shoulder complications. Baseball throwing repetitions were restricted, and the patient was allowed to participate in lifting and hitting activities on an as-tolerated symptomatic basis. Cryotherapy, massage and stretching were initiated to limit pain and stiffness. Symptoms did not resolve with a week of throwing restriction and conservative treatment, and the patient was referred to the team physician on 9/29/2014. Physician examination and glenohumeral MRI revealed no scapular fracture, with a resulting diagnosis of a teres minor strain. Two weeks of further conservative treatment and throwing restrictions did not slow the progression of pain, which had become severe. The patient underwent a second MRI with dedicated scapular views on 10/6/2014, revealing significant edema surrounding the teres minor and major muscle bellies and a mass hypothesized to be a hematoma. Two additional weeks of conservative management combined with diclofenac (75 mg; BID) and tramadol (as needed for pain) did not alter pain or edema progression. A third MRI with IV contrast was performed to evaluate the hematoma, revealing the development of an unknown mass in the muscle belly of the teres major. The patient was restricted from all sport activities until the mass was evaluated. **Differential Diagnosis:** Non-resolving hematoma, isolated infection, undifferentiated rhabdomyosarcoma. **Treatment:** An orthopaedic oncology physician ordered blood labs and performed an examination on 11/3/2014. Blood lab results were inconclusive and a needle biopsy was performed on 11/11/2014. Results of the needle biopsy also returned inconclusive and were sent to a sarcoma specialist for further evaluation. The specialist evaluation revealed the biopsy was likely the early stages of myositis ossificans formation, but sarcoma could not be ruled out. The patient scheduled an appointment with a different oncologist for a second opinion, who confirmed the myositis ossificans diagnosis definitively via open biopsy on 1/8/2015. Initial treatment included 2.5 months of glenohumeral ROM and 4% acetic acid iontophoresis 3x/week to facilitate absorption of mass. Shoulder strengthening was initiated six months post-initial evaluation, following complete resolution of the myositis ossificans. An interval throwing progression was initiated at eight months post-initial evaluation and concluded at 10 months post-initial evaluation. Patient returned to full sport participation 10 months after first reporting to the Athletic Trainer. **Uniqueness:** The location of this patient's myositis ossificans is exceptionally rare, with only one case previously reported in the literature. Of clinical relevance is the lack of any obvious traumatic mechanism in a diagnostic progression eventually leading to myositis ossificans: approximately 60-70% of myositis ossificans cases occur as a result of trauma. **Conclusions:** This patient presented to the Athletic Trainer with no unusual symptoms and no obvious mechanism of injury. Progression of pain in the presence of conservative management and prescription medication resulted in a physician referral. Subsequent imaging and biopsy revealed a common orthopaedic disorder in an uncommon location. This case presents an incidence of an exceedingly rare location for myositis ossificans and highlights the importance of clinical referral and constant reevaluation early in the injury process in order to limit time loss.

### Rehabilitation and Return to Sport Following a Knee Dislocation With Associated Foot Drop: A Case Report


Binfet KM: Western Michigan University, Kalamazoo, MI


**Background:** A 20-year-old male soccer player with no history of knee injury was pushed into a shallow lake, causing his knee to hyperextend and externally rotate. Upon evaluation by the athletic trainer, the athlete complained of severe knee pain as well as numbness in his foot and lateral lower leg. The athlete lacked active eversion and dorsiflexion of his ankle as well as extension of his toes, with no appreciable muscle contraction. Knee ROM was -20 degrees of extension to 80 degrees of flexion. He had severe joint effusion and positive Lachman's, pivot shift, and varus stress tests. **Differential Diagnosis:** ACL rupture, LCL sprain, PCL rupture, meniscus tear, peroneal nerve injury, posterior lateral corner injury **Treatment:** The athletic trainer's special test findings were verified by the team physician and an MRI was ordered. The confirmed diagnosis was a knee dislocation with ACL and posterior lateral corner ruptures, bicep femoris and LCL avulsion from the fibular head, and peroneal nerve injury. An EMG showed no activity in the peroneal nerve distribution and the athlete was fitted for an ankle foot orthosis (AFO) to assist with foot drop. The athlete underwent surgery to reconstruct the posterior lateral corner and lateral compartment of the knee using semitendinosus and gracilis autografts, as well as a peroneal nerve debridement. He completed three months of rehabilitation focused on regaining ROM and quadriceps strength. A second surgery was performed to reconstruct the ACL using a patellar tendon autograft. A typical ACL rehabilitation protocol was followed, going at a slower pace with modifications to account for the severity of injury as well as the neuropathy. Balance exercises were carried out in his knee brace, without the use of the AFO, to attempt to utilize the intrinsic muscles of his foot while protecting his knee. Joint mobilizations of the foot and ankle were completed daily to assist with mobility. A point muscle stimulator was used to re-educate the muscles of his lower leg, as muscle contractions were not able to be achieved with Russian stimulation. The athlete gradually began to achieve muscle activation of his lower leg, beginning with his peroneals approximately six months post-injury and progressing to his extensor digitorum, tibialis anterior, and finally extensor hallicus longus eleven months post-injury. He began running on an unweighted treadmill six months post-injury and was able to run full weight bearing at nine months post-injury. He also began to wean out of the AFO for short durations of ADLs. Eleven months after his initial injury, he began progressing to cutting, agility, and light ball handling drills, while working out of his AFO and into a lace-up ankle brace. He was cleared to start non-contact soccer situations thirteen months post-injury, and fifteen months post-injury he was cleared for full participation and was able to complete an entire season with no complications. **Uniqueness:** The athlete was able to return to Division 1 soccer following an injury that was considered career ending. The prevalence of this severity of knee injury in athletics is low, especially with peroneal nerve injury and complete foot drop. Peroneal nerve healing was expected to take upwards of two years, but improvements were noted at six months. **Conclusions:** Multiligamentous knee injuries are complex cases. As athletic trainers, it is important to be creative with rehabilitation exercises and fit the needs to the specific athlete and their injury. When an injury is deemed career ending, the rehabilitation process is just as important and can have unexpected results. Keeping an athlete motivated lends itself well to their long term well-being and the possibility of return to sport.

### Isolated Posterior Inferior Tibiofibular Ligament Sprain in a Collegiate Soccer Player: A Case Study


Warner BJ, Foster AL, Hunter JM, Cage SA: Grand Canyon University, Phoenix, AZ, and University of Texas, Tyler, TX


**Background:** An 18-year-old collegiate women's soccer player with no significant history of lower extremity musculoskeletal injury reported to the athletic training room complaining of right ankle pain. The athlete could not recall a specific mechanism, but noticed the pain during a game the previous day. Due to increasing symptoms, the athlete reported to the athletic training staff for formal evaluation. Upon examination, the athlete exhibited a decreased range of motion with dorsiflexion and plantar flexion along with positive Anterior Drawer and Kleiger's Tests. The athlete reported mild tenderness along the sinus tarsi and retrocalcaneal tenderness, but no pain along her distal fibula. The athlete was placed in a compression wrap to minimize edema, and acetaminophen was administered for pain management. Athlete was referred to the team physician later that day during the facility's weekly clinic **Differential Diagnosis:** Os trigonum injury, lateral ankle sprain, syndesmotic ankle sprain, associated peroneal strain. **Treatment:** Day 1, the athlete was referred to the team physician and diagnosed with a suspected os trigonum/posterior talus contusion. The athlete was placed in a boot for all non-team related activities and instructed to continue treatment and rehabilitation with the athletic training staff. Day 2, x-rays revealed an os trigonum on the involved talus. The athlete was placed in a custom fitted walking boot, and instructed to continue rehabilitation. Day 7, following a week of conservative treatment and rehabilitation,

the athlete was showing no significant signs of improvement. After consultation with the team physician, the athlete was referred for an MRI. Day 11, after review of the athlete's MRI, the team physician consulted with the team foot and ankle specialist. After consultation, the consensus diagnosis was an isolated posterior inferior tibiofibular ligament sprain. At this point, the athlete's rehabilitation and treatment was progressed to align with the new assessment. Day 14, the athlete met with the foot and ankle specialist. After evaluation, the specialist concluded that the sprain was stable, and fitted the athlete for a custom brace. Day 17, the athlete was able to complete functional testing and return to play for the remainder of the season with no significant recurrence of symptoms. **Uniqueness:** The posterior inferior tibiofibular ligament is rarely injured in isolation. A posterior inferior tibiofibular ligament sprain rarely occurs without a fracture to the tibia, fibula or talus. A search of PubMed yielded no results for any cases of competitive athletes suffering from posterior inferior tibiofibular ligament sprains. Presence of os trigonum delayed the recognition of a posterior inferior tibiofibular ligament sprain. **Conclusions:** When treating a patient, it is important to listen to their signs and symptoms. Treatment outcomes need to be re-evaluated often to determine efficacy of the current plan. If treatment and rehabilitation are not yielding positive results, re-evaluation of a patient's injury can play a vital role in tailoring their course of action to their specific condition.

## Iliotibial Band Rupture Associated With Acute Knee Dislocation in a Collegiate Football Player

Casmus R, Paider B, Messick B, Guy J: Catawba College, Salisbury, NC

**Background:** An 18 year-old male football player sustained a traumatic hyperextension knee injury during a football game. He was evaluated and diagnosed with multi-ligamentous ruptures to the ACL, PCL and LCL on the sidelines. Additionally it was believed that he had partial tearing of the MCL and he presented with medial and lateral joint line pain. No neurovascular compromise was noted upon examination. The athlete was treated with RICE, placed in a knee immobilizer and given crutches for ambulation. A repeat orthopedic evaluation was performed 48 hours post-injury and re-affirmed initial findings and an MRI was ordered. X-rays showed no boney fracture. **Differential Diagnosis:** Spontaneous reduced knee dislocation involving multi-ligamentous rupture to the ACL and PCL, MCL and LCL sprain, medial & lateral meniscus tear, iliotibial band (ITB) rupture, patella subluxation, knee contusion and muscular strain to the popliteus insertion, quadriceps insertion, hamstrings insertion and the gastrocnemius origins. **Treatment:** The athlete was initially treated with rest, 400 mg ibuprofen qid, hydrocodone 325mg qid for pain, cryotherapy, and electrical muscle stimulation. MRI findings showed complete rupture of the ACL, PCL, LCL and posterior lateral corner (PLC). There was partial tearing of both heads of the gastrocnemius tendons, partial tearing of the vastus medialis and lateralis at their insertions. There was additional partial tearing of the biceps femoris insertion, semimembranosus insertion and a large tear to the medial meniscus. Surprisingly, the athlete also had complete disruption of the IT Band with 9mm of retraction. The athlete subsequently underwent his first surgical procedure to initially stabilize the posterior lateral corner (PLC) of the knee, repair of the medial meniscus and to reattach the iliotibial band. Eight weeks post-operative he underwent manipulation under anesthesia to increase knee flexion and was repeated again 10 weeks later due to adhesions. He is currently undergoing physical therapy following ACL reconstruction at 28 weeks post-trauma. **Uniqueness:** According to the literature, traumatic knee dislocations often result in multi-ligament ruptures and associated meniscal lesions. This is found to be consistent regarding knee dislocation that are self-reducing or clinically reduced in emergency room settings. Complete rupture of the iliotibial band has not been commonly recognized in the literature as a discrete structure as it relates to traumatic knee dislocation injuries. In one study of 200 knee traumas reviewed, the ITB was found to have a grade 3 tear in only 2.5% of the cases. The iliotibial band is part of the lateral soft tissue structures of the knee joint and contributes significantly to the lateral stability of the knee and aids in resisting varus stress and rotation. Because the location of the ITB to the anterolateral aspect of the knee, one must be wary injury to this structure when there is significant trauma to the posterolateral corner (PLC) and anterior cruciate ligament disruption. Regarding knee dislocation trauma, most authors recommend immediate surgical repair of the posterior lateral complex of the knee either in association with ACL reconstruction or ACL reconstruction as a follow-up surgery once the posterior lateral complex is healed. **Conclusions:** This case demonstrates the necessity of prompt recognition and treatment of a traumatic knee injury. Even though knee dislocations can reduce spontaneously one must be wary of neurovascular compromise. There should also be suspicion for iliotibial band rupture. This case supports the operative management and care of knee trauma resulting in multi-ligament injuries and associated ITB rupture. At this time the athlete has returned daily living activities and continues his ACL rehabilitation program.

## Sacroiliac Joint: Rare Pain Generator in Patients With Low Back Pain

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**Background:** A healthy 25yearold male and a member of the U.S. alpine ski team, with a BMI of 28.2, presented with acute onset of right sacroiliac(SI) joint pain after a direct fall onto his buttocks. The patient has a previous history of a right-sided microdiscectomy at L5-S1 five years ago. Four weeks after the fall his pain was described as 8/10 and progressively worsening. Symptoms were described as 90% right sided SI joint pain and 10% right buttock and posterior leg pain exacerbated with spinal flexion and right rotation with extension. Physical exam noted nonantalgic gait and positive tests included straight leg raise, Braggard's, and SI joint shear with reproduction of SI joint and leg pain. Negative tests included Gaenslens, FABER's, and IR/ER of hip. No weakness or radicular symptoms noted with dermatomes, myotomes, and reflexes intact. **Differential Diagnosis:** Sacroiliac joint dysfunction, right radiculopathy L4-S1, lumbar facet arthropathy, sacroiliitis, pars defect, sacral fracture, hip pathology. **Treatment:** MRI noted mild disc degeneration at L4-L5/L5-S1, mild scarring around the S1 root, but no recurrent disc herniation or SI joint inflammation. Right SI joint injection under fluoroscopy yielded no diagnostic or therapeutic relief. Right L5-S1 selective nerve root block under fluoroscopy also yielded no diagnostic or therapeutic relief. Patient consented to elective spinal surgery which included a lysis of adhesions around the S1 nerve root due to scarring as a possible result of an old disc herniation and previous L5-S1 microdiscectomy. Surgical findings included an extruded disc fragment found at the L5-S1 level that was not visible on MRI and non-responsive to the selective nerve root L5-S1 steroid injection. A revision-microdiscectomy was performed releasing the compressed S1 nerve root. Immediately after surgery the patient noted 100% relief of right sided SI joint pain and posterior leg pain. At one week follow up patient had continued 100% relief. Physical therapy(PT) was started one week after surgery. At six weeks physical exam indicated sustained 100% SI joint relief, full ROM without evidence of instability or pain and negative SLR, Braggard's, and SI joint shear tests. Patient continued progressively with PT and began light skiing at ten weeks post-operation and returned to professional skiing at twelve weeks post-operation with no lower back complications. **Uniqueness:** The SI joint generates pain in <3% of all patients complaining of SI pain and pain in this region is commonly misinterpreted as a true SI joint pathology. This case report assimilates a routine athlete evaluation done by an athletic trainer which may often be diagnosed as SI joint dysfunction. Commonly treatment consists of manual therapy, joint manipulations, stretching and strengthening surrounding musculature which may not respond well due to the fact that the true etiology has been misunderstood. Recognizing that the SI joint is a central referral area for other lumbar spine and hip disorders is imperative for the athletic trainer. Accurate diagnosis of underlying pathology allows for appropriate treatment strategies to be employed and thus decreasing risk of injury progression and surgical intervention. The physical examination tests for SI joint disorders performed by athletic trainers are highly variable, invalid, and unreliable. Subsequently the gold standard for diagnosis of true SI dysfunction is an intra-articular injection into the SI joint with an anesthetic agent yielding short-term relief (2-3 hours) to confirm the joint as a pain generator. **Conclusions:** The SI joint is commonly an innocent bystander secondary to referral pain from the L4-S1 region. Despite location of pain athletic trainers must carefully examine every patient, realize the rarity of true SI joint dysfunction, and understand when further lumbar spine imaging and evaluation may be necessary.

## Chronic Talonavicular and Subtalar Dislocations in a Recreational Golfer

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**Background:** The athlete is a 74 year-old male recreational golfer. Athlete's prior medical history included a right total knee arthroplasty approximately nine months ago. Athlete reported suffering from a left eversion ankle sprain while walking on an uneven, rocky surface approximately 40 years ago. Pain and instability of the left ankle continued to increase during these 40 years. Approximately five months ago the pain became unbearable, leaving the athlete unable to stand, walk, perform activities of daily living or golf. Initial evaluation revealed bilateral genu valgum and a bilateral pes planovalgus deformity. The pes planovalgus deformity on the left was excessive and indicated an obvious dislocation. **Differential Diagnosis:** Deltoid Ligament Sprain, Calcaneonavicular Sprain, Arthritis, Talonavicular Dislocation, Subtalar Dislocation. **Treatment:** Athlete was referred for X-rays and an MRI. Diagnostic Imaging illustrated dislocations of the left talonavicular joint and left subtalar joint, a left pes planovalgus deformity, a left Achilles contracture, left ankle arthritis and a left tibial exostosis. Due to the severity of these conditions, the athlete underwent surgery for his left foot and ankle. Procedures of the surgery included a left talonavicular arthrodesis, left subtalar arthrodesis, left talus osteotomy, left calcaneal osteotomy, left Achilles release, partial excision of the left tibia and lengthening of the left peroneal longus and brevis tendons. Following surgery, the athlete was placed in a NWB hard cast for 8 weeks and then in a PWB Aircast AirSelect Standard Walker protective boot for the 8 weeks following the procedure. Pain, swelling, decreased ROM, decreased strength and partial weight bearing status persisted 10 weeks following the surgery. Athlete has been

participating in physical therapy to decrease the pain and swelling and to increase ROM, strength, weight-bearing status, proprioception and function. **Uniqueness:** The athlete has predisposing risks to chronic talonavicular and subtalar dislocations such as bilateral genu valgum and a bilateral pes planovalugus deformity. His body weight was also a predisposing risk due to the forces being placed on the deformities and dislocations. The surgeon reported that this surgery case took twice as long as a typical case with this description due to the severity, which required extensive manipulation and surgical alignment. This case is also unique because there was an acute eversion ankle sprain 40 years ago that lead to progressive, chronic talonavicular and subtalar dislocations. Dislocations are generally acute injuries however in this case they were insidious in their onset. **Conclusions:** This case highlights the importance of proper biomechanics of joints, specifically the knees, ankles and feet. Due to the bilateral genu valgum, bilateral pes planovalgus deformity, the athlete's body weight and his previous history of ankle injury this athlete was at an increased risk for chronic pathologies. This case is important to athletic trainers because it highly suggests the importance of evaluating posture and the resulting biomechanics, as well as the importance of trying to correct or lessen the severity of the conditions noted. Correcting these faults when an athlete is young can help to prevent severe pathologies such as the ones present in this case.

## Foot Anomaly in an Interscholastic Soccer Player

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**Background:** 14 year-old male interscholastic soccer player presented to the AT with bilateral chronic diffuse medial foot pain that had been present for the past three years. Initial anterior NWB observations identified bilaterally excessively elevated medial malleoli secondary to pes cavus. Posterior NWB observations identified bilateral rear-foot varus with the calcaneus inverted relative to the tibia. Palpation elicited bilateral tenderness over the sesamoid bones, base of metatarsals, medial longitudinal arches, and along the tibialis posterior tendon. AROM goniometric measurements identified right foot inversion (0°-30°), eversion (0°-20°), plantar flexion (0°-40°), and dorsiflexion (0°-20°), and left foot inversion (0°-25°), eversion (0°-15), plantar flexion (0°-40°), and dorsiflexion (0°-15°). Bilateral PROM end fields were normally firm for inversion, plantarflexion, and dorsiflexion, and hard for eversion. MMT was WNL for the foot, ankle, and lower leg. Gait analysis revealed a prolonged pronation during mid-stance; however, the calcaneus remained in a supinated position bilaterally maintaining the pes cavus foot structure. The patient's medical history was not significant for traumatic injuries to the foot or surrounding area. **Differential Diagnosis:** plantar fasciitis, metatarsalgia, stress fracture, sesamoiditis, and postural fatigue. **Treatment:** The patient was diagnosed with postural fatigue and was fitted for custom foot orthotics. To manage the patient's pain, he was removed from activity and provided temporary foot orthotics. The patient was instructed to wear the temporary orthotics in a transitional period consisting of a few hours on the first day, and half-day on the second, third, and fourth days, and full days on the fifth, sixth, and seventh days. Status-post one week, the patient reported that the pain had slowly decreased and was now pain free with ADL. The custom foot orthotics arrived and the patient was cleared to slowly progress back into athletic activities and was instructed to wear the permanent foot orthotics. During the first workout back, the patient immediately reported a reoccurrence of symptoms. Post-run, he reported no pain; however, the patient reported feeling moderate soreness and a dull ache along the medial longitudinal arch and calcaneus. The patient returned the next day and reported a slight dull ache in his feet. He reported continued soreness in his medial longitudinal arch and calcaneus post-workout. The patient continued to progressively increase his workout intensity and duration slowly over the next two weeks. Status-post three weeks, the patient reported being asymptomatic during all activities and reported that the foot orthotics no longer caused pain during ADL or soccer. The patient was cleared for unrestricted activity and instructed to continue to wear orthotics and return for refitting as he outgrows his current ones. The patient was able to complete the season without further incident. **Uniqueness:** Overpronation during the gait cycle is characteristically related to a pes planus foot structure associated with either forefoot or rear foot varus; however, in this case, despite the presence of rearfoot varus, the patient presented with a pes cavus foot. Given the presence of rearfoot varus, the calcaneus would be visualized in an inverted position when the subtalar joint is in neutral position; however, during FWB, calcaneal eversion would normally be seen yet the calcaneus maintained it supinated position despite the midfoot and forefoot over pronating. **Conclusion:** AT will encounter a variety of postural deviations and gait dysfunctions requiring therapeutic intervention. Correctly evaluating and identifying postural deviations and gait dysfunctions are key to enhancing patient outcomes. The selection and utilization of custom foot orthotics assisted in correcting the postural deviation and gait dysfunction and secondary pain to help facilitate athletic participation for this patient who has had this condition for years without positive results.

## Peroneus Quartus: Clinical Applications and a Case Study

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**Background:** The following case study examines a 21 year old male Division I football offensive lineman, with a previous history of deltoid ligament injury. Primary complaints included lingering lateral ankle pain for 14 months, with the presence of "clicking" during gait and sport activity. Examination revealed tenderness and subtle fullness in the lateral retromalleolar zone, with limited dorsiflexion. **Differential Diagnosis:** Peroneal tendinopathy and lateral ankle tenosynovitis were expected. Anterior ankle impingement, given complaints of decreased range of motion and "clicking" was also discussed as a possible cause of pain and dysfunction. After conservative treatment had failed in achieving complete resolution of symptoms, more comprehensive imaging procedures were performed. **Treatment:** MRI, x-ray, CT and musculoskeletal ultrasound procedures confirmed the presence of an anterior loose bony body, as well as an accessory muscle belly, peroneus quartus, crowding the peroneal retinaculum. The ancillary muscle originated as a collection of fibers splitting off the peroneus brevis muscle belly, and inserted onto the lateral surface of the calcaneus. After conservative treatment techniques and an ultrasound guided corticosteriod injection were unsuccessful in permanently alleviating symptoms, the athlete elected surgery to remove the anterior bony fragment and explore the peroneal tendons and compartment. The aim of the procedure was to mitigate pain and inflammation through removal of the anterior bony fragment, and exploration and debridement of the lateral retromalleolar compartment including the peroneus quartus. Following the operation, the athlete was restricted from weight bearing in a cast for two weeks, and placed in a walking boot for an additional five weeks. Rehabilitation consisted of early-protected motion techniques, gradually progressing to functional weight-bearing strengthening procedures. The patient returned to full, pain free function as a football offensive lineman at the beginning of the spring season, 12 weeks post-operatively. **Uniqueness:** The literature has described the presence of the peroneus quartus muscle, with reported incidence rates as high as 22%. The peroneus quartus is generally asymptomatic, however can have functional consequences related to vague pain, chronic tendinopathy, peroneal tendon dislocation or subluxation, and instability. This particular case presented an incidence of worsening lateral tendinosis and limited range of motion over the course of about a year, following an acute medial ankle injury. Surgical intervention proved successful in alleviating symptoms associated with the presence of a peroneus quartus. **Conclusions:** The peroneus quartus muscle as a possible cause for chronic posterolateral ankle pain and dysfunction cannot be ignored. After conservative techniques have been employed without success, comprehensive imaging and advanced intervention techniques may need to be discussed. It is important for clinicians to understand the frequency and associated symptoms of this anomaly, in an effort to construct appropriate treatment avenues for their patients and clients.

## Chronic ACL Instability in a Ballet Athlete: The Effect of Improper Turnout

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**Background:** A ballet dancer was hopping backwards in an arabesque en pointe when she felt, saw and heard her right knee go into extreme valgus with two distinct "pops". While she felt immediate pain she was able to walk to the clinic for evaluation. The athlete had a history of some general knee pain due to meniscal irritation and had been on a hamstring strengthening program for 2 months. Upon evaluation ROM was full with good strength at 4/5 in all ranges, although significant pain at times was noted. Anterior drawer and Lachmans tests were inconclusive. A pivot shift recreated the "feeling" of the injury and was painful at a 10/10 though there was no dynamic subluxation visible at the time. One day post injury at reassessment there was an audible and visible "clunk" both into and out of deep knee flexion with pain at 2/10. It was suspected that this movement was due to a subluxation of the tibial plateau over the femoral condyles. She was referred immediately for an orthopedic consultation. **Differential Diagnosis:** ACL rupture, MCL rupture, meniscal tear/dislocation, knee subluxation. **Treatment:** Upon consultation, the physician confirmed chronic ACL insufficiency with instability and scheduled a surgical repair 15 days later. In the meantime the athlete worked to increase quadriceps, hamstring and gluteal strength as tolerated with a variety of rehabilitation exercises. Various modalities were used to control pain and inflammation. Measurements taken before surgery revealed 105° of external rotation of the tibia on the injured limb, while the uninjured limb measured 59° of external rotation. **Uniqueness:** Due to the nature of ballet a proper turn-out is crucial to correct form and alignment or "line" of the body. From a young age these athletes are told to "turn-out" and are not

always corrected as to where this turn out should be initiated from. Ideally turn-out is initiated from the hips, with a supported and neutral pelvis and should be achieved by using the deep rotators, sartorius and the adductor muscles (when in hip extension or standing). As is the case in many of these athletes turn-out will be forced and will then typically occur at the knee instead of the hip. As turn-out is forced at the knee the tibia is driven into excessive active external rotation and consequently places increased stress on the ACL. This chronic stretching of the ACL is what led to insufficiency and instability in this case. **Conclusions:** At present this athlete has returned to dance with no complications following a modified rehabilitation program specific to her sport of ballet. It should be noted that specific attention was given to reestablishing correct turn-out to ensure that this injury not reoccur, exercises included pelvic stability and deep external hip rotation strength work. Ballet specific rehabilitation was conducted in front of a mirror to ensure that turn-out came from the hip and not the knee. Advanced techniques were avoided until the athlete could demonstrate basic techniques with consistent form. Cardiovascular retraining was completed solely on a bike so that the foot and knee remained in neutral, this was important as the athletes gait prior to surgery included a significant whip kick motion due to the laxity at the knee joint. This type of compensatory turn-out pattern is not uncommon in these types of athletes from a clinical perspective however there is limited understanding regarding the incidence and severity of ACL insufficiency and associated instability. Further, paucity in the research setting exists with respect to teaching proper turn-out mechanics at any level and as is evident by this case there can be serious consequences of forcing turn-out incorrectly.

## Acute Femoral Articular Cartilage Fracture in a 22 Year Old Division III Football Tight End

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**Background:** Patient is a 22 year old tight end who reported to the AT clinic 2 days following a football game complaining of right knee swelling. Patient stated that during the game he sustained a direct blow to the anteriomedial aspect of his knee by an opponent's knee. Patient was able to complete the rest of the game with no reported problems. Patient's main complaint was swelling. Upon evaluation, no ligamentous laxity was present, AROM for knee extension was 0 and flexion was 125 degrees with no pain reported, and MMT revealed 5/5 for knee extension and flexion. Patient was able to practice and play in the game the following week. Following the game the next week the patient reported to the AT with moderate joint effusion, pain(1/10), and a catching sensation. Evaluation revealed no changes in AROM or MMT from the previous evaluation. **Differential Diagnosis:** Bursitis, Meniscal Tear, ACL Sprain, PCL Sprain, Bone Contusion. **Treatment:** Patient was referred to the team physician 9 days following initial injury due to moderate joint effusion. X-rays were negative and the knee was aspirated with 80mL of yellow fluid removed. No ligamentous laxity was noted on examination. An MRI was ordered at this time due to patient's knee effusion. MRI results revealed an acute full thickness fluid-filled chondral defect on the lateral femoral condyle measuring 2cm, mild irregularity along the medial patellar facet, loose bodies, and joint effusion. After consultation with the physician it was decided that the patient would have surgery to address the chondral defect. Surgery was done in 2 phases, the first occurred 4 weeks following the initial injury and included knee arthroscopy that involved the removal of loose bodies, chondroplasty, and joint exploration. Following surgery, the patient followed standard post exploratory arthroscopy rehabilitation protocol and continued to work on ROM and strengthening in preparation for his 2nd surgery that occurred 2.5 months(12/18/14) following his arthroscopy. The patient had an osteochondral autograft transplantation (OATS) performed over lesions in the lateral femoral condyle and trochlear groove. Post-surgery the patient was placed in a ROM brace locked at 0° extension and NWB on crutches. He spent 3 weeks using a continuous passive motion unit starting at 0-60° and increasing by 5° per day. After one week the ROM brace was unlocked in 10-20° increments. Rehabilitation goals for the first 4 weeks were to restore full knee extension, patella mobility, and PROM to 90° of knee flexion. During this time the patient performed OKC straight leg raises, isometric quadriceps contractions, ankle AROM exercises. After 4 weeks the patient discontinued use of his crutches and after week 6 post-op discontinued the use of his ROM brace. During this time the patient added isometric hamstring strengthening, stationary bike for ROM, proprioceptive exercises as tolerated by weight bearing status. At 8 weeks the patient began closed chain exercises as tolerated. Four months post OATS(April 2015) the patient was cleared to run and 6 months (June 2015) the patient was cleared for full football activity. **Uniqueness:** Osteochondral defects commonly accompany other twist or tear injuries to other knee structures such as ligaments or the meniscus though no other structures were involved with our patient. Despite the size and location of the lesions on the lateral femoral condyle and trochlear groove, the patient's main limiting factor in participation was joint effusion. **Conclusions:** Due to the size and location of the lesions along with the patient's desire to return to football, the OATS procedure was selected to provide the best outcome. Moderate knee effusions with unknown etiology should be further investigated to rule out all possible causative factors.

## A Unique Approach to the Non-Surgical Management of Exertional Compartment Syndrome

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**Background:** On January 22, 2015 a 20 year old NCAA Division II women's field hockey player reported to the athletic training facility complaining of the inability to pass a fitness test due to tightness, numbness, tingling, and pressure in both of her lower limbs. These symptoms began 9 minutes into the fitness test and resolved 15 minutes after she stopped activity. She reported a previous history of chronic shin pain in her junior year of high school, which continued through her freshman year of college, however she was never formally evaluated during this time. During her sophomore fall season, the tightness, numbness, tingling, and pressure began, however she did not report the symptoms because her performance was unaffected. Observation revealed discoloration of the distal extremities. No swelling or deformities were present and distal pulses were normal bilaterally. The L5 and S1 dermatomes were diminished bilaterally, with moderate deficits on the left and mild on the right. The L5 and S1 myotomes were 4/5 bilaterally. **Differential Diagnosis:** Exertional compartment syndrome, medial tibial stress syndrome, stress fracture. **Treatment:** The athlete was removed from field hockey due to the severity of her symptoms. A rehabilitation program, to include general lower extremity stretching, proprioception, and strengthening of the foot intrinsics was initiated and the athlete was referred to the team orthopedic physician. Based on the athlete's history and current symptoms the physician diagnosed her with bilateral chronic exertional anterior compartment syndrome. Treatment options were discussed with the athlete. Due to the variance in fasciotomy outcomes reported in the literature and poor conservative management outcomes, the physician recommended casting for six weeks. It was determined that the left leg (more severe) would be casted first. Although casting has not been reported in the literature, the physician felt this was an appropriate method to atrophy the involved musculature with the goal of decreasing the compartmental pressure. After six weeks the cast was removed, girth measurements were taken to ensure atrophy occurred, and the athlete was placed on a bike to jog progression. During this progression, symptoms in the left and right legs were monitored. No symptoms returned in either extremity. The athlete advanced to a running progression successfully and was therefore returned to light field hockey activities. She remained asymptomatic bilaterally, so it was determined that there was no need to cast the right extremity. The athlete remains asymptomatic today, having successfully completed the Fall 2015 field hockey season. **Uniqueness:** No other cases of utilizing casting to treat chronic exertional compartment syndrome exist in the literature. Therefore, there is now a need to study this option as a treatment. The fact that symptoms resolved in the non-casted extremity with rest only, is also unique and further suggests the need to study the treatment protocols associated with this condition. **Conclusions:** A unique management strategy for exertional compartment syndrome was presented. The athlete is asymptomatic and is participating successfully. Currently the two options for treatment of exertional compartment syndrome are conservative rehabilitation and fasciotomy. With research, casting could be a viable third option.

## Flexor Hallucis Brevis Tear in a Collegiate Football Player

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**Background:** An 18 year male football player suffered a partial tear in his right flexor hallicus brevis (FHB). During a blocking drill under the chute all of his weight was dropped onto his right foot when he felt a pop under his big toe. Athlete complained of significant pain in bottom of foot when standing. Evaluation found severe point tenderness and swelling over the sesamoid bones and hallicus flexors tendons. ROM: missing the last few degrees of hallicus flexion and positive pain throughout the whole motion. The next day the athlete reported pain present only when putting pressure on his foot so he was treated for his symptoms and swelling. Activity was discontinued due to severity of pain and inability to apply pressure to foot. Athlete was NWB with crutches and placed in a rigid cast boot and compression wrap. **Differential Diagnosis:** Interphalangeal joint dislocation, turf toe syndrome, sesamoid fracture, and flexor hallucis longus (FHL) tendonapathy, or flexor hallicus brevis (FHB) tendonapathy. **Treatment:** The athlete immediately started to rehab the injury; this consisted of decreasing swelling and pain to promote increased ROM. Modalities used included cryotherapy (ice cup massage and cryocuff), electrical stimulation, Low Light Laser Therapy, and biocompression. About a week later he was sent for an MRI where a possible partial tear was seen in the FHB distal to the sesamoid. The flexor hallicus longus was found to be irregular and thickened as well as fluid accumulation found in the MTP joint. The athlete returned to rehab where modalities to help pain and swelling were continued. Therapeutic exercises including towel drags, TheraBand exercises, and balance exercises were gradually added. Turf toe straps and dancer's pads were used to stabilize the MTP joint of the 1st ray. Progressive exercises focused on range of motion

and proprioception. Strengthening exercises, including SwimEx and elliptical routines were then added when appropriate. **Uniqueness:** FHB tears are not commonly seen in football and appear more often in sports such as dancing. As an offensive lineman, the athlete had routinely done this blocking drill many times with no problems. Having no prior injuries to this foot and no noticeable flaws in his mechanics the injury was unpredictable. In theory it would have been suspected that signs of tendinitis or overuse pain would have presented themselves as possible predisposition to further injury before an actual tear took place. **Conclusions:** It is important for athletic trainers to keep in mind that injuries do not always give you a warning before taking place. Also, you cannot rely on injuries that are considered normal for a specific sport, and sometimes must think outside the box to detect things you do not see as often. FHB tears are more commonly seen in dancers and runners because of repetitive plantar flexion, which is the most researched mechanism of this injury along with trauma such as stepping on glass. Even if the mechanism of the injury did not seem drastic enough to cause a tear, more severe injuries should be considered if pain and swelling are not decreasing. According to Mandalia and Williamson, an isolated, non-traumatic tear of the FHB is uncommon as they could only find five cases in past literature. In their case, as well as this specific case, the tear did not elicit enough pain for the patient to agree to surgical repair. Therefore, conservative management was adequate in the rehabilitation and return to normal function, while there is no evidence surgery produces better results.

## Acute L4 Pars Fractures: An Adolescent Multisport Athlete With Two Distinct Pars Injuries

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**Background:** A 15-year-old adolescent male(height: 6ft 1in, weight: 165lbs) multisport athlete (freestyle skier, high school soccer goalkeeper) presented to an orthopaedic clinic with chief complaint of left-sided low back pain(LBP) after landing awkwardly from a ski jump during practice. The patient failed 1 week of conservative treatment consisting of stretching, ice, and nonsteroidal anti-inflammatory drugs prior to evaluation. **Differential Diagnosis:** muscle spasm, muscle strain, annular wall tear with or without herniation, facet joint injury, pars fractures(spondylolysis), spondylolisthesis, sacroiliac(SI) joint injury, vertebral body fracture, ankylosing spondylitis. **Treatment:** A thorough physical examination of the lumbar spine revealed tenderness to palpation around the left L4-L5 facet region and pain with extension. Radiographs illustrated a sacralized L5-S1 and did not demonstrate pars fractures. MRI illustrated annular disc tears and stress reaction on the left L4 pedicle and pars interarticularis. CT scan illustrated an incomplete fracture of the left L4 pars. The patient was treated with a lumbosacral brace for 3 months followed by physical therapy(PT), emphasizing core stabilization. Four months after initial injury, the patient was deemed healed by CT scan and returned to full sport participation. The patient had 1 episode of LBP after participating in a ski competition 3 weeks after returning to sport; however, no further injury was incurred which was confirmed by radiographic examination. After full participation in sports for 6 months while asymptomatic, the patient had an onset of right superior SI region pain associated with a leg press exercise. After persistent right LBP for 1 week, the patient returned for evaluation. Physical exam revealed tenderness to palpation around the right SI region and pain with SI provocation. Again, radiographs were negative for pars fractures. The patient completed SI joint and muscle trigger point injections, both non-diagnostic and non-therapeutic. MRI illustrated substantial pars stress reaction on the right side at L4-L5. CT scan confirmed diagnosis of a new right-sided pars fracture. Treatment options included lumbosacral brace, surgical repair of the pars, or surgical fusion of the L4-L5 vertebrae. The patient and his parents opted for pars repair. The bilateral pars were surgically repaired using a unilateral pars screw with bilateral bone graft reinforcement. Following surgery, the patient wore a lumbosacral brace and avoided bending, lifting, and twisting for 4 months. A 4 month postoperative CT scan revealed bone healing and hypertrophy on both sides, indicating a successful surge. **Uniqueness:** Conservative treatment for the left pars fracture was successful; however, the second fracture (right side) placed the patient at a higher risk for developing a spondylolisthesis, or an anterior slippage of the L4 vertebrae on L5. Most incidences of pars fractures are treated conservatively with a lumbosacral brace and rest. However, a spondylolisthesis may require a surgical fusion, which would have left this patient with only three lumbar motion segments, ultimately limiting motion and placing more stress on the L3-L4 level. By surgically repairing the pars, bony healing of the bilateral fracture sites was accomplished which may aid in the prevention of a spondylolisthesis. This patient opted for a pars repair given he experienced a second fracture on the contralateral side coupled with his desire to continue to participate in high-level sports. **Conclusions:** Clinicians should have a high index of suspicion for pars fractures when adolescent athletes have unilateral or bilateral LBP, especially when associated with extension. It is critical to understand that often, plain radiographs may not identify a fracture when one truly does exist. Advanced studies, including MRIs and CT scans, are required for this diagnosis that is commonly missed.

## Acute Osteomyelitis in a Division I Collegiate Cross Country Runner: A Case Report

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**Background:** An 18-year-old female NCAA Division I cross country runner presented to the athletic trainer with unilateral lower back pain and right anterior hip pain during the fall semester. The patient had a history of bilateral injury and re-injury to the hip flexor muscle groups. The patients' symptoms were initially at a low intensity and were exacerbated over a two-week period of time. The patient was originally diagnosed with a hip flexor strain and adductor strain; however, despite one month of conservative treatment, the patient continued to have incidence of hip flexor tightness and increased pain. The patient was reevaluated and admitted to a local emergency room after complaining of severe intractable pain in the right hip, an inability to bear weight on both legs, and disruption in sleeping due to pain. Upon hospitalization, radiographic imaging revealed inflammation and separation of the pubic symphysis raising concern for osteitis pubis of the right pubic symphysis. Although a preliminary diagnosis of osteitis pubis was established, the patient developed a fever, which generated a need for more imaging. Secondary imaging revealed acute bilateral pubic body osteomyelitis, a right sacral ala stress fracture, an isointense lesion within the musculature of the right obturator externus, pyomyositis of the right obturator externus (with a pelvic abscess), and septic arthritis of the pubis symphysis. **Differential Diagnosis:** Osteitis pubis, hip flexor strain, adductor strain, sacral stress fracture, isointense obturator lesion, pyomyositis, septic arthritis, and illiopsoas bursitis. **Treatment:** Physicians confirmed the diagnosis of pelvic osteomyelitis via blood cultures, X-ray and MRI imaging. Results from the culture taken allowed the physicians to start the patient on the right course of antibiotics to remove the infections from the osteomyelitis and from the pyomyositis. The patient was also prescribed medication for pain, and prohibited from completing any strenuous activity for eight weeks. The patient was immobilized and non-weight bearing for three weeks, partial weight-bearing with crutches for two weeks, and finally full weight bearing. The patient underwent a rehabilitation program that focused on reducing pain and symptoms, exercises for increasing ROM, hip mobility, core strength, flexibility, hip flexor lengthening, and a jogging program. The athlete was removed from competition for a total of 81 days, after which, she was able to make a full return to activity. **Uniqueness:** Pelvic osteomyelitis is a condition that presents chronically in the long bones of children, vertebrae of adults, and in postsurgical individuals. It most commonly occurs as a result of a hematogenous spread, or is caused by the bacterial pathogen staphylococcus aureus. In the pelvis, osteomyelitis most commonly affects the iliac bone, not the pubic bone as in this patient's case. Though the cause of the osteomyelitis in this patient is common for adults, staphylococcus aureus, this case is unique because of the acute occurrence in the pelvis of a collegiate female athlete; most cases of pelvic osteomyelitis in athletes occur in males at a 2:1 ratio. Pelvic osteomyelitis may also commonly occur with osteitis pubis at a 25% occurrence rate; however, it rarely occurs with a sacral fracture and pyomyositis, as it did with this athlete. **Conclusions:** Early identification of osteomyelitis is challenging yet important for proper treatment of the condition. This injury can lead to a high degree of disability and time away from sport; therefore, consideration of osteitis pubis and osteomyelitis in individuals with hip, pelvic, or groin pain is beneficial when crafting a differential diagnosis.

## A Rare Case of a Ligamentum Teres Avulsion Fracture and Hip Labral Tear in a Baseball Catcher

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**Background:** An 18 year old elite-level baseball catcher reported immediate sharp pain in his left hip accompanied by a popping sensation during a throw. Physical exam findings included difficulty with weight-bearing and extreme pain during the lift-off phase of gait. He was evaluated 5-weeks post-injury by an orthopaedist, where he reported left hip weakness and catching. He reported symptoms prior to his acute injury, including intermittent c-shaped anterior groin pain and a catching sensation in his hip. **Differential Diagnosis:** Iliopsoas tendinitis, anterior inferior iliac spine avulsion fracture, rectus femoris tendinitis, avascular necrosis of the femoral head, microinstability of the hip joint, hip dysplasia, acetabular labral tear, femoroacetabular impingement (FAI). **Treatment:** Physical exam of the left hip revealed pain with anterior and posterior impingement test, Dial test, and positive Ober test. He had decreased ROM in his left hip with flexion, internal and external rotation, and adduction. There was no evidence of hip microinstability. Imaging studies confirmed diagnosis of left hip FAI with an associated labral tear and a ligamentum teres avulsion fracture of the perifoveal region of the femoral head. Arthroscopic evaluation showed an osteochondral defect with complete fibrocartilage healing in the perifovial region of the femoral head, a loose osteochondral fragment, and a labral tear with an associated FAI CAM lesion. While the ligamentum teres avulsion and osteochrondral defect was a result of an acute injury, the labral tear and FAI was likely chronic and progressive. Treatment for his injury included an arthroscopic debridement of the ligamentum teres, labral repair with treatment of FAI, and removal of a loose osteochondral fragment. **Uniqueness:** To our knowledge, there

have been no other cases in the literature that have shown an avulsion fracture of the ligamentum teres in an elite athlete. The patient's mechanism of injury is unique as during the acceleration phase of proper throwing mechanics, the lead-hip strides forward moving into flexion, adduction, and internal rotation, creating a risk for anterior-superior impingement, but the ligamentum teres is not necessarily at peak tension. The ligamentum teres becomes taut during hip flexion, adduction, and external rotation, and is commonly injured in hyperabduction and flexion mechanisms when it acts as a "sling-like" structure, inferiorly supporting the femoral head. The ligamentum teres contributes to axial stability of the hip joint, and when injured can result in microinstability of the hip in some patients. Furthermore, spontaneous healing of an osteochondral defect from a ligamentum teres avulsion has not been described. **Conclusions:** We present a case of an 18 year old baseball catcher who presented with a left hip ligamentum teres avulsion fracture of the femoral head and FAI with an associated labral tear after a throw. Arthroscopy of the left hip revealed a loose osteochondral fragment and an osteochondral defect within the femoral head that had healed with fibrocartilage. Treatment consisted of debridement of the ligamentum teres, removal of the loose fragment, and treatment of his FAI and labral tear. Intra-articular hip injuries are rare in the elite-level athlete, however, it is important for athletic trainers to recognize that the high axial and torsional forces placed on the hip during high-level activities puts the athlete at risk for both chondral and labral injury. It is imperative to recognize uncommon mechanisms of injury and to diagnose these injuries early to prevent irreversible damage to the hip joint. It is also important to note that avulsion injuries are more commonly seen in children and adolescents, whereas older patients have a tendency to rupture ligaments. Early diagnosis and treatment of this injury pattern is critical, as joint arthritis can occur with an intra-articular loose body.

## Knee Pain in an Interscholastic Wrestler

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**Background:** A 16 year-old high school Caucasian wrestler experienced severe left knee pain and locking secondary to forced knee flexion and external rotation during a maneuver at practice. The patient reported to the AT that he had felt the same sensation three days prior during an away wrestling match, but did not seek medical attention because there was no pain and he was able to unlock his knee. On-site AT examination did not reveal any visual or palpable abnormalities. Active ROM testing was WNL; however, passive ROM testing provoked pain with knee flexion and a positive McMurry's test was elicited during combined knee flexion and external rotation. **Differential Diagnosis:** Synovial plica, osteochondritis dissecans, chondral fracture, ligamentous sprain, baker cyst, meniscal tear, discoid meniscus. **Treatment:** After initial evaluation, the patient was conservatively treated and cleared to resume wrestling the next day after re-evaluation and passing a battery of functional testing. The patient was able to successfully finish the remaining nine weeks of the season with no treatment, despite feeling repeated locking sensations during wrestling. Status-post nine weeks, the patient was referred to his PCP who then referred him to an orthopedist. The orthopedist's examination revealed no joint effusion, erythema, or warmth, but elicited lateral joint line tenderness, pain with forced knee extension and terminal knee flexion, and a positive McMurry's test. An MRI was ordered and revealed free-floating chondral debris and an uninjured lateral discoid meniscus. The patient was subsequently definitively diagnosed and status-post 13 weeks, the patient underwent a lateral meniscal saucerization and the free-floating chondral debris was removed. Post-operatively, the patient was placed in a hinged knee immobilizer in full extension, was instructed to ice, elevate, ambulate NWB with crutches, and was prescribed rehabilitation. Status-post 15 weeks, the patient could flex his knee 30°; status-post 17 weeks, the patient could flex his knee 60°; and status-post 19 weeks, the patient could flex his knee 90°. During the early stages of rehabilitation, the program focused on soft tissue mobility, ROM, neuromuscular control, and the patient was slowly progressed from non-weight bearing to touchdown weight bearing, to partial weight bearing. Status-post 21 weeks, the patient was removed from crutches and placed in a neoprene sleeve. Status- post 23 weeks, the knee orthosis was removed and the rehabilitation program aggressively focused on increasing ROM and conservatively progressed to focus on muscular strength and endurance, and postural control and stability. Status-post 26 weeks, the patient demonstrated full ROM, and rehabilitation focused on functional progressions. Status-post 28 weeks, the patient was cleared for unrestricted athletic activities and discharged from care. The patient's return to wrestling did not elicit pain or apprehension. **Uniqueness:** A discoid meniscus is a rare congenital condition with a reported prevalence of approximately .4% in the general population. This case is also unique because a majority of cases occur in people of Asian descent with, 5% only of all cases occurring in Caucasians. **Conclusions:** A discoid meniscus is an unusual congenital anatomical abnormality involving a thicker and/or wider meniscus than normal, and often half-moon or oval shape rather than a normal crescent moon. Although a discoid meniscus is more prone to injury than a normally shaped meniscus, patients can experience symptoms without injury to the meniscus, as in this case. Specifically, the patient's abnormally thick and irregularly oval shaped meniscus and subsequent chondral debris created the locking sensations. The patient's discoid meniscus was treated with saucerization, a procedure in which the meniscus was cut and reshaped into a crescent. With a surgically reshaped meniscus, the patient was able to return to wrestling without increased risk of a future meniscal tear.

## Non-Contact Fibular Fracture With Syndesmotic Widening in a Male Adolescent Track Athlete

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**Background:** A 15 year old male (185.42 cm, 116.12 kg) adolescent track athlete fell while participating in discus throwing practice and was unable to get up. His right leg was planted and he described feeling his right ankle "turn in the wrong way" while he was rotating in preparation to throw. The patient described hearing and feeling a pop in his ankle. The patient was sitting with extended knees and ankles in slight plantar flexion when the athletic trainer responded. Moderate swelling was present around the ankle joint. The patient rated his pain as 9/10; and was unable to actively dorsiflex, plantar flex, invert, or evert his right ankle. Posterior tibial and dorsal pedial pulses were within normal limits. The patient was extremely tender to palpation over his medial and lateral malleoli and described the pain as "sharp and shooting up my leg." Ligamentous tests were not performed as a fracture was suspected. Patient denied any previous history of ankle or lower extremity injury **Differential Diagnosis:** Fibular fracture, tibial fracture, lateral ankle sprain, syndesmosis sprain. **Treatment:** The patient's ankle was immobilized and he was transported to the emergency room by his father. X-rays showed a spiral fracture of the right fibula with syndesmotic widening. His ankle fracture was reduced and the ankle placed in a splint. He followed-up with an orthopedic surgeon one week later, where the decision was made to perform an open reduction internal fixation (ORIF) surgery. Surgery was performed three days later with no complications. The patient was non-weight bearing for two weeks following surgery. After two weeks he was given a walking boot and was permitted to weight bear as tolerated with crutches. Six weeks following surgery he was permitted to weight bear in his boot and began range of motion (ROM) exercises. As school was not in session at this time, the patient's rehabilitation was performed at a physical therapy clinic. Approximately 10 weeks after surgery, football conditioning began, the patient did not participate in conditioning activities but completed rehabilitation with the athletic trainer; consisting of ankle strengthening and passive and active ROM. Three months following his surgery, the patient demonstrated pain-free and strong dorsiflexion, plantarflexion, inversion, and eversion. The surgeon released him for full athletic activity but instructed the patient to use pain as a guide. The patient was able to return to non-contact activities with the football team. The patient still experienced pain and stiffness in his ankle after running. The athletic trainer began performing myofascial release of his calves three times weekly, resulting in decreased pain. The patient also performed neuromuscular control exercises such as the Star Excursion balance test and cone pick-up drills for two weeks before he was returned to full contact activities. The patient has continued his stretching exercises and now receives myofascial release as needed.**Uniqueness:** A review of the literature shows that non-contact fibular spiral fractures are uncommon in athletes without a prior history of stress fracture. In this case, the patient had no personal or family history that would suggest risk for a fibular fracture, particularly one caused by a non-contact mechanism. **Conclusions:** Non-contact fibular fractures are rare, but clinicians should be aware of this possibility, using adequate evaluation skills and tools, such as the Ottawa Ankle Rules, as a guide. In this case, the syndesmotic widening was the surgeon's greatest concern. Timely recognition and referral to an orthopedic specialist is crucial when treating this injury.

## ACL Avulsion Fracture in a Youth Tackle Football Athlete

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**Background:** A ten year-old Caucasian male, football athlete sustained a left knee injury during an August pre-season Saturday scrimmage on a dry field. The athlete was immediately evaluated by the youth football league's athletic trainer. The player reported an internal rotation mechanism with a planted foot while tackling another player. The distressed patient indicated he was unable to extend his knee. He denied an audible pop or sensation. While passive range of motion (ROM) increased, full extension was unattainable due to pain. There was no obvious deformity or effusion and no prior history. The patient complained of intense medial patella pain with palpation. Posterior tibialis pulse was intact and he denied neurological symptoms. The patient's age and emotional state hindered further ligamentous stress tests. Unable to weight bear, the patient was carried off the field. **Differential Diagnosis:** Differential diagnosis included patella dislocation/subluxation, fracture, meniscal tear, or anterior cruciate ligament (ACL) tear. **Treatment:** Ice was applied and the patient was taken home. Initially, the patient was non-weight bearing on crutches with a knee sleeve, used anti-inflammatory drugs, and iced three times a day. During Monday's evaluation, the knee had become significantly swollen, but a bony end feel presented during passive extension (-15º). Pain prevented special test evaluation. Conservative treatment was continued, as parents refused a referral appointment. Thursday, he presented partially weight-bearing with an obvious swelling decrease. Valgus stress test was negative for laxity, but increased pain compared bilaterally. Due to muscle guarding and effusion, a false negative Lachman's and Anterior Drawer was found. Nine days post initial injury, the patient presented ambulating without crutches in a brace, but

with a visible limp. On day twelve, the patient ran at P.E. due to no pain, however, the patient's knee still could not fully extend with active or passive ROM. After almost two weeks, an orthopedic appointment was scheduled after multiple parent referral refusals, despite strong suggestion by the athletic trainer. X-rays revealed a left tibial eminence avulsion fracture. A follow-up MRI revealed a thickened ACL, intact discoid lateral meniscus, hemarthrosis, Grade II MCL sprain, and PCL cyst. The patient underwent surgery three weeks post initial injury for the avulsion fracture fixation. Surgical diagnosis identified an intact ACL, with an avulsion fracture physically blocking the knee from fully extending. The bone fragment was reduced and two compression screws secured the fragment. Following surgery, the patient was casted in 60 degrees of knee flexion for five weeks, non-weight bearing. At the five-week post-operative appointment, three views of the knee showed interval callus formation and intact fixation, advancing the patient from cast to knee immobilizer. At eight weeks, the patient was switched to a playmaker brace, continued physical and aquatic therapy, and **Uniqueness:** While ACL avulsion fractures may present clinically as a mid-substance ACL tear, MRI and CT scan may show an intact ACL with a tibial eminence fragment. This bony injury will heal much quicker than a ligament tear. Avulsion fractures can occur at any attachment site, but are predominately seen in the pediatric hip and pelvis. Another possible predisposing factor was the low vitamin D level (normal 40-70 ng/mL) in a skeletally immature individual. **Conclusions:** A common mechanism of injury was responsible for an ACL avulsion fracture in a pediatric football player. Clinical presentation mimicked an adult non-contact ACL injury, of a flexed, internally rotated knee. Conservative treatment did not resolve symptoms. Surgical intervention was required and successful. Beginning to mid stages of rehabilitation have been successfully initiated after ten weeks post-surgery.

## Bilateral ACL Ruptures in Collegiate Female Lacrosse Athlete

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**Background:** In fall 2014, a 22 year-old female collegiate (167cm, 66kg) lacrosse goalie planted on her right leg, felt her knee buckle, and fell to the ground. Once initial pain wore off, the patient continued to play for the next two days without seeking help. The next week, the patient reported to the Athletic Training Facility with noticeable swelling and pain on the medial aspect of her knee. She stated she did not hear a pop when the incident occurred, but described it as a feeling of her knee "shifting". Upon evaluation by the attending Athletic Trainer and Team Physician all ligamentous tests were negative. MRI revealed an ACL rupture in the right knee with a grade III chondral wear of the lateral and medial Femoral condyles. Then, in spring 2015, during a game, the patient stepped out of the box planting on her left leg and was hit from both sides by opponents, she reported feeling her knee shift and hearing a pop. The attending Athletic Trainer noticed some laxity while performing the Anterior Drawer and Lachman's procedures, but stated she was unsure because of the lack of stability when comparing with the contralateral knee's ACL tear. The MRI indicated a left torn ACL tear with a grade III chondral wear of the lateral condyle and a chondral fissuring of the medial Femoral condyle. **Differential Diagnosis:** The physician expected a medial meniscal tear, MCL sprain, or ACL tear. **Treatment:** After the first tear the patient discussed options with two physicians and decided to forgo surgery until the end of her season. She opted to rehab and wear a brace until after her spring season. During late spring, the physician performed surgery on the right ACL in early May; waited 1 month for the right leg to become stable, and then performed surgery on the left ACL in June. The patient progressed quickly through initial phases of rehab, gaining full range of motion with no complications and was cleared to begin running progression in September 2015 with hopes to return for the spring 2016 season as the starting goalie. **Uniqueness:** This case is clinically relevant because of the high percentage of ACL injuries we see in the athletic population and the little information available on performing two ACL operations and playing with a ruptured ACL. Many collegiate athletes suffer season or even career-ending ACL injuries often, so it is important to discuss the risk factors associated with playing without repair and how that affects the likelihood of injury to the other ligaments in the ipsilateral knee and the effects it has on the contralateral knee. **Conclusions:** The patient suffered bilateral ACL injuries over the span of 7 months and received surgery 1 month apart requiring her to rehabilitate both knees simultaneously. This case study illustrates the importance of determining the risks associated with playing without repair of ACL rupture to both the ipsilateral and contralateral knee and the importance of explaining these risk factors to athletes who find themselves in this particular situation.

## Iliopsoas Muscle Tear With Hematoma in an Adolescent Football Athlete

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**Background:** Athlete is a 17 y/o male high school varsity football quarterback. The athlete presented to the Athletic Trainer (AT) in August for a possible grade 1 strain of the tensor fasciae latae muscle. After rest and use of modalities, the athlete was able to play with only minor discomfort until mid-September when he presented after injuring his hip flexor musculature in a non-sport related activity over the weekend. The athlete was non-weight bearing on his right leg, and the leg was contracted in a flexed state at the hip at approximately 30 degrees. The athlete, with parental consent, was immediately referred to the team physician who ordered an MRI, which revealed a grade 3 iliopsoas tear and a 10.5 x 2.5 x 4 cm intramuscular hematoma within the iliopsoas muscle extending proximally within the iliacus muscle. There was also a small right hip join effusion. **Differential Diagnosis:** Avulsion of psoas tendon, Avulsion of iliacus tendon, Muscle strain, Iliopsoas bursitis. **Treatment:** Non-surgical conservative treatment was determined to be the best course of action given the age and healthy status of the athlete. Athlete was then referred to a specialist to attempt to aspirate the hematoma. The attempt to aspirate yielded 2 ml of hemorrhagic thick fluid but other attempts to decompress the hematoma were unsuccessful. The plan of care chosen for treatment was similar to that of a quadriceps contusion in terms of decreasing the likelihood of subsequent hetertropic ossification. The athlete was treated with therapeutic massage to redistribute the pooled blood, light stretching and range of motion movements, and therapeutic ultrasound. The athlete was then placed in an extended position at the hip while applying ice and hi-volt electrical stimulation in order to further assist in moving the hematoma out of the muscle belly. The athlete was advised to place the affected leg in the same position on a regular basis while at home. Once the pain level of the athlete decreased from a 7/10 to a 3/10 on the visual analog scale, the athlete was progressed to therapeutic exercise along with the aforementioned therapeutic modalities and stretch. Upon follow up visit to the team physician 3 weeks post-injury, the athlete was cleared for day to day practice due to minimal pain and the ability to jog, run, and walk with only minor gait lag. The athlete played the majority of the game the following week with no issues. **Uniqueness:** Very little documentation was found through searches of CINAHL, ProQuest, and other healthcare databases regarding injury of the iliopsoas musculature with associated hematoma. In fact, the only related entries found were in regards to hematomae in the iliopsoas as a complication associated with certain surgeries. No literature was found in regards to treatment of such an injury, leading to the conclusion that such an injury is fairly rare in virtually every population. This is a unique opportunity to show a certain treatment protocol can be performed in order to assist in the recovery of an iliopsoas tear. **Conclusions:** This case highlights the treatment and subsequent recovery of an athlete with a fairly rare iliopsoas muscle tear with associated hematoma. The athlete underwent treatment that was completed over a 3 week period using various modalities and techniques that proved to be helpful in a timely recovery. The athlete fully recovered from the original injury and was able to finish the football season with no further complications. This case highlights the importance of conservative treatment options for a unique injury based on location.

## Acute Knee Injury of a Division I Collegiate Football Player: A Case Report

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**Background:** While performing a multiple rep max test on a back squat, a 22 year old, 5th year senior, male, football fullback dropped to the ground as his right knee buckled into a valgus position. On the descent of his second squat he felt 3 "pops" on the lateral aspect of his knee causing his collapse. He was unable to ambulate by himself and was assisted to the athletic training room for evaluation. He reported pain over the anterolateral thigh and quadriceps tendon just proximal to the patella. Upon evaluation, a palpable deformity was noted in the area of pain in addition to moderate swelling. Ligamentous tests were inconclusive. Prior to this incident, the athlete had no significant injuries. **Differential Diagnosis:** Rupture of the vastus lateralis, rupture of the quadriceps tendon, ACL sprain, MCL sprain, LCL sprain, femoral stress fracture, patellar fracture. **Treatment:** After an initial evaluation by the athletic training staff he was immobilized in a straight leg splint and taken immediately to the team orthopedist for further evaluation. An MRI of the knee and thigh revealed an avulsion of the lateral 20-25% of the quadriceps tendon attachment from the superior patella with a retraction of 1.5-2cm without injury to the knee joint. Three days post injury; he underwent an open surgical repair of his vastus lateralis. Three days post operation he started NMES daily on his quadriceps. During the first two weeks of rehabilitation, the athlete was locked at 0° of extension in a straight leg splint. Beginning the third week post-surgery, the brace was opened to 30° and progressed as tolerated. Strengthening exercises continued to progress from quad sets to straight leg raises in the first three weeks. Four weeks following surgery he was cleared to begin walking in the pool. He continued with basic strengthening exercises, and six weeks

post-surgery he progressed to leg press, body weight squats and other closed kinetic chain activities to increase strength. He was cleared to return to full activity ten weeks post-surgery and is currently participating fully. **Uniqueness:** This case is extremely unusual due to the uncommon incidence of this injury. Partial and complete quadriceps tendon rupture is a relatively unusual injury with an incidence of 1.37 out of 100,000 patients per year, affecting primarily males over women with a ratio of 4.2 to 1. The average age this injury occurs is 51.1 years. In searching literature there are only two other cases that involve an isolated avulsion of the vastus lateralis. In this case, he returned ten weeks post-surgery while another case study showed a return to full activity after one year. Since it was the athletes 5th year and his last year of eligibility, he opted for the accelerated return. Each case detailing patient care, thus far, is drastically different likely due to the rarity of the injury and population involved. **Conclusions:** Surgery and rehabilitation was successful and allowed him to participate in all activity without setbacks; the athlete played in a collegiate football game ten weeks after injury. Immediately recognizing that there was a deformity and immobilizing the athlete was critical to proper care. This potentially debilitating condition may be overlooked as the vast majority of the quadriceps tendon is still intact. During a knee evaluation, with suspected rupture in the quadriceps tendon, it is important to test extension of the knee against gravity because patients with this injury often cannot fully extend. More research needs to be done on isolated avulsions of the vastus lateralis, as not much is known about the timeline to full recovery.

## Low Leg Pain in College Softball Athlete

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**Background:** The athlete is a 19-year-old female college softball player. The athlete's prior medical history includes generalized lower back pain, sciatica, and multiple lateral ankle sprains. The athlete came in complaining of a dull and achy pain in her lower leg for the past 8 months that increases with activity. The athlete denied any specific mechanism of injury. Upon observation there was nothing remarkable. There was no point tenderness noted upon palpation. ROM and MMT were equal bilaterally with knee flexion, knee extension, internal rotation, external rotation, ankle dorsiflexion, ankle plantar flexion, ankle inversion, and ankle eversion. Negative squeeze test, negative bump test, negative tap test, negative calf raise test, and negative x-ray. **Differential Diagnosis:** peripheral neuropathy or chronic exertional compartment syndrome. **Treatment:** The following day the athlete took an intercompartment pressure measurement test; which showed the athlete had increased pressure in all four of her compartments. The athlete was referred for surgery for a four compartment fasciotomy release. Following the surgery the athlete was instructed to go through a graduated rehabilitation program with their athletic trainer back at their college and to call if there are any other signs or symptoms in the area. **Uniqueness:** The athlete did not present any weakness with dorsiflexion, plantar flexion, and inversion as seen with other cases of chronic exertional compartment syndrome. The athlete didn't present with the traditional mechanism of injury. This case is unique because athlete was diagnosed with compartment syndrome in all four compartments and is unilateral which is uncommon compared to the normal bilateral appearance. The results of the intercompartmental testing were before test: (mm/Hg) Anterior: 16, Lateral: 15, Posterior Superficial: 12, and Posterior Deep: 8, after test: (mm/Hg) Anterior: 21, Lateral: 31, Posterior Superficial: 24, and Posterior Deep: 28, and 5 minutes after: (mm/Hg) Anterior:17, Lateral:32, Posterior Superficial:19, and Posterior Deep:29. The results are unique because the athlete is positive for compartment syndrome in at least 1 compartment in all three stages of testing. After a four compartment fasciotomy, the athlete is having immediate relief post-surgery in all four compartments which is uncommon. Studies report more post-op relief in the anterior and lateral compartments than the deep posterior compartment. **Conclusions:** This case further shows that conservative treatments for chronic exertional compartment syndrome such as rehabilitative exercises before surgery have little to no effect of pain relief when compared to surgical options such as a fasciotomy. This case study further accentuates the difficulty of diagnosing athletes with chronic exertional compartment syndrome, the different conservative treatments and invasive treatments, and the theories of why athletes can have chronic exertional compartment syndrome.

## Acute and Chronic/Exertional Compartment Syndrome of the Thigh: A Case Series

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**Background:** Patient 1 (P1; 21 yoa, male, football athlete, 84kg, 172cm) developed compartment syndrome in his right anterolateral compartment after it was believed he was struck in the thigh by a helmet during practice. The next morning P1 reported pain, headache, and tightness in his thigh, and within 3 hours was unable to bear weight and was transported to the hospital where intra-compartmental pressures (ICP) were assessed, revealing a right thigh lateral and anterolateral compartment pressure readings of 28 mmHg and 120 mmHg, respectively. Patient 2 (P2; 19-yoa, male, basketball athlete, 91kg, 191cm) developed acute compartment syndrome of the left thigh after similarly being struck during basketball practice, but in contrast P2 was able to compete with no limitations until a week later when he experienced tightness and unbearable pain in the thigh while walking. P2 was taken to the hospital where X-Ray and ultrasound were found to be negative for DVT. The next day, one week after initially being struck, P2 had the inability to flex the knee, extreme tightness, and a fever. P2 underwent multiple ICP readings in the anterior compartment with initial findings of 36 mmHg. After an hour and no decrease of pain, ICP readings were retaken and found to be 41 mmHg in the anterolateral compartment and P2 was diagnosed with acute thigh compartment syndrome. Both underwent emergency fasciotomy. While P1 and P2, upon clinical examination, commonly presented with quadriceps tightness, pain bearing weight, and obvious swelling around the knee, the timeline for treatment was quite different. **Treatment:** During morning treatment time with the athletic training staff P1 received electrical stimulation and ice along with a compression wrap, believing the injury was a quadriceps contusion. After one hour wearing the ace compression wrap, symptoms increased until P1 fell walking. P1 was then referred to the hospital with the differential of compartment syndrome or DVT. Once admitted compartment syndrome was diagnosed and an emergency fasciotomy was performed. P2 was treated for a week with similar therapeutic techniques believing the injury was a quadriceps contusion. After being referred to the hospital P2 was initially dismissed and prescribed rest and ice and to cease activity until symptoms resolved. The next day upon inspection by the athletic trainer, P2 was referred to the hospital again with the indication of acute compartment syndrome, ICP was measured, and an emergency fasciotomy was performed. **Results:** Both P1 and P2 had emergency fasciotomy and had full return to play. The physician determined that P1 may have had exertional compartment syndrome as well after a transverse cut had to be made in the fascia lata to relieve pressure on the vastus lateralis anteriorly. P2 had an incision length 5x longer than P1 (10cm v. 50cm). Return to play guidelines for P1 were unique in that he had no restrictions after the incision was healed but developed an infection, which likely occurred while participating in his football game with thirteen staples. P2 in contrast experienced no complications and was not allowed to return to play until four months post-surgery. This difference may be due to the difference in length of incision. **Uniqueness:** Compartment syndrome found in the thigh rather than the lower leg. **Conclusions:** Compartment syndrome is not just in the lower leg and can be challenging to diagnose and yet requires urgent treatment in order to avoid disastrous complications to the health of the muscle. ATs must discern the different signs and symptoms associated with compartment syndrome to reduce the risk of limb threatening consequences that can result if symptoms are not identified in a timely manner.

## Fractured Sesamoid in Female Collegiate Distance Runner

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**Background:** Our subject is a 24 year-old female collegiate distance runner (cross-country, indoor and outdoor track). In September 2013, she began experiencing increased tenderness and sharp, radiating pain on the plantar aspect of her right 1st metatarsophalangeal joint following short interval workouts. Because of the gradual onset of the condition, the athletic training staff suspected sesamoiditis. For 10 days, she replaced running with cross training and was treated with ultrasound and cryotherapy. During this time, there was no improvement in her symptoms. She was then referred to a podiatrist for further evaluation and x-rays. **Differential Diagnosis:** Sesamoiditis, flexor hallucis brevis tendinitis, distal 1st metatarsal stress fracture, sesamoid fracture, hallux rigidus, plantar digital nerve compression. **Treatment:** The x-rays revealed the lateral (fibular) sesamoid fractured into three fragments. The podiatrist's first treatment option involved corticosteroid injections every three months as needed to control pain, modified training plan including cross training, and orthotics to off-load the fractured sesamoid. The second option involved surgical removal with a three-month recovery timeline. The non-surgical, conservative course of treatment was chosen and followed for 13 months including five corticosteroid injections (10/2013, 12/2013, 3/2014. 6/2014, 9/2014). This plan allowed her to successfully train and compete until September 2014, when her pain became unmanageable with corticosteroids. Follow up x-rays revealed the fractured pieces were moving slightly; however, surgery at this point would have jeopardized her final year of eligibility. Complete immobilization in a walking boot and non-weight-bearing cross training were implemented to decrease pain and inflammation until training could be resumed (three weeks). This protocol was

followed for flare-ups until the completion of her collegiate career. On May 27, 2015, she had a sesamoidectomy, in hope to resume normal training in pursuit of a post-collegiate running career. A 4-cm. incision was made and the three pieces of her fibular sesamoid were excised. At three weeks post-op, a follow-up x-ray confirmed the health of the remaining tibial sesamoid. At seven weeks post-op, she began her gradual return to running protocol and by three months progressed to 7-8 km/day x 6 days/week. **Uniqueness:** The podiatrist believed her sesamoid was fractured before she began to exhibit any symptoms. The lack of swelling and gradual onset of pain indicated that it was not an acute fracture, but may have occurred as far back as four years previous, when she experienced similar sensitivity. A bipartite sesamoid was suspected as a predisposing factor. Although bilateral bipartite fibular sesamoids are recorded in 50-85% of cases, our subject never had an x-ray to confirm the presence. In the absence of bipartite sesamoid, involvement of fibular sesamoid is unique. Tibial sesamoids are more likely to fracture because they normally receive most of the weight transmitted by the first metatarsal. **Conclusions:** Our subject did have a successful collegiate running career in spite of this injury. It was imperative that our subject exhaust conservative treatment options before opting for surgery, which could not guarantee better pain management and long-term results. Although the conservative treatment regimen resulted in flare-ups and necessitated suboptimal running volume, she was still able to compete successfully for 20 months. Currently at five months post-op, our subject's foot biomechanics have not yet returned to normal causing foot cramping and pain limiting her ability to run, likely caused from compensatory motion and/or reduced flexor hallucis strength. Despite the minor set backs following surgery, lack of pain in the surgical area and a successful initial return to activity indicates that our subject will likely be able to transition back into full, unrestricted running.

### Catastrophic Knee Injury in a Collegiate Football Player

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**Background:** A male division III collegiate football player suffered a non-contact knee injury resulting from a hyperextension and varus force mechanism. Following an on-field evaluation, it was determined that there was severe knee instability and obvious deformity to the tibia but no neural or vascular deficits. The patient was placed in a vacuum splint and transported to emergency facilities for imaging. **Differential Diagnosis:** ACL rupture, PCL rupture, tibial plateau fracture. **Treatment:** X-rays revealed a medial tibial plateau compression fracture. The patient was then referred for MRI and 3D CT bone scan. Imaging revealed an avulsion fracture of the proximal PCL and distal ACL, as well as rupture of the arcuate complex, posterolateral capsule, and LCL. The patient underwent open knee surgery one week post-injury. This surgery revealed that there was also an avulsion of the biceps femoris tendon from the fibular head. The ACL, PCL, and biceps femoris tendon were all reattached to their respective origin and insertion points. The LCL, arcuate ligament complex, and posterolateral capsule were also surgically repaired. The patient has been placed in a locked hinge brace at 60 degrees of knee flexion for two weeks post-surgery. The patient has been receiving ice and electric stimulation for pain, and will be beginning rehabilitation at the two week mark within the Athletic Training Clinic. The rehabilitation protocol will begin with partial weight bearing activities progressing to full weight bearing. The estimated return to play for this injury is suggested to be one year post surgery. **Uniqueness:** An avulsion of the biceps femoris insertion is a rare pathology in itself, however the combination of this and avulsion fractures of the ACL and PCL, ruptures of the arcuate complex, posterolateral capsule, and LCL resulting from a non-contact mechanism make this case unique. Injuries of this magnitude are more common in high velocity contact trauma. Knee dislocations in sports occur in .02-.2% of all orthopedic injuries, and most of these cases are due to a contact mechanism. **Conclusions:** An obvious deformity led the Athletic Training staff and students to believe there was a tibial plateau fracture in addition to severe ligamentous injury. Imaging revealed extensive ligamentous, tendinous and bony damage to the knee. Not many cases have been reported on such complex tissue damage in the knee, however the literature does state that distal hamstring ruptures occur in conjunction with multi-ligamentous damage. Studies have shown that 45% of knee dislocations are accompanied by neurovascular damage.

## Os Trigonum in a High School Soccer Player

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**Background:** A 16 year old female soccer player was evaluated in the athletic training clinic following a preseason practice. The chief complaint was pain along the medial aspect of the right ankle. The athlete collided with another player resulting in the foot being forced into eversion. A medical history indicated that there was a previous fracture to the talus of the involved limb. Initial pain was described as a four out of ten with a one out of ten rating with activities of daily living, and a one out of ten rating while at rest. The patient's gait appeared normal at the time of the initial evaluation. There was mild edema and swelling over the deltoid ligament and the medial malleolus. All fracture tests suggested there was no acute fracture to the tibia, fibula or other foot structures. All range-of-motion assessments were within normal limits, however, pain was elicited during active, passive, and resistive eversion, as well as resistive inversion and ankle plantarflexion. Manual muscle testing revealed weakness and pain of the tibialis posterior and peroneus tertius. Talar tilt and kleiger's test were both positive for pain when moving the foot into eversion. There were no circulation or neurological deficits present. The initial diagnosis was believed to be a grade I eversion ankle sprain, however, following 2 weeks of unsuccessful rehabilitation, the patient was referred for an x-ray, which revealed the presence of bilateral Os Trigonum syndrome. **Differential Diagnosis:** Os trigonum can go unnoticed due to the location of pain and its association with achilles tendon strain or rupture. Talar fractures can be indicated if the mechanism of injury involved forced plantarflexion of the tibio-talar joint. In this case, an eversion ankle sprain was the initial impression. **Treatment:** Conservative treatment has taken place while maintaining patient comfort. Rehabilitation has included stretching exercises, range-of-motion exercises, isometrics, and neuromuscular control activities, followed by resistance exercises. All rehabilitation activities were done while avoiding terminal plantarflexion of the ankle joint to avoid irritation following the discovery of the os trigonum. **Uniqueness:** The patient had previously suffered a fracture to the talus. Although an x-ray was used previously to diagnose the fracture, the os trigonum was not identified at that time. Knowledge of this injury was not available until the present injury occurred. **Conclusions:** Although the patient presented initially with an eversion ankle sprain, concern began to arise when the patient was not recovering in a timely fashion. The presence of os trigonum in both ankles may be a contributing factor to the delay in recovery for this patient. This may be due to the fact that while participating in practices and games, there was constant irritation to the posterior aspect of the talus. Os trigonum is often found accidentally during the time of a radiograph and is present in approximately 10% of the population. It is difficult for physicians to differentiate between a true os trigonum and a fracture to the lateral tubercle of the talus. Often observation of the fragment is helpful in identifying whether os trigonum is present. Os trigonum will appear smooth and rounded while a fragment due to a fracture will present as jagged. Past literature has suggested conservative treatment initially for this pathology, including RICE therapy. NSAID's can be utilized when pain is present. Stretching exercises and ankle rehabilitation programs should be initiated and performed as tolerated. Surgery is considered four to six months following unsuccessful conservative treatment.

## Rectus Femoris Tear in a Division I Collegiate Football Placekicker

Williams J, Christie S, Knight J: Campbell University, Buies Creek, NC

**Background:** A 20 year old male division I collegiate football placekicker reported right quadriceps pain. The previous year, he had a grade one right groin strain that was still symptomatic. The subject conveyed to the Athletic Trainer that he had no pain with walking or jogging, but had minimal pain when he sprinted. He elicited that the pain he experienced in his groin had migrated to his quadriceps. Upon examination there was no discoloration, swelling or other physical finding, but he did have some minimal point tenderness over the proximal aspect of the rectus femoris. He was clinically diagnosed with a grade one rectus femoris strain. He progressed through therapy, responded well, and was functionally cleared to begin kicking. The first two field goal attempts were pain free however the last three attempts were unsuccessful and resulted in a reoccurrence of pain in the rectus femoris. The patient was referred to the team's physician. A diagnostic ultrasound test was ordered. **Differential Diagnosis:** Rectus femoris strain, rectus femoris rupture, rectus femoris avulsion **Treatment:** The diagnostic ultrasound concluded that he suffered a 4 by 2 cm strain to his right rectus femoris. He immediately received treatment of percutaneous electrical nerve stimulation (PENS) at the physician's office. This therapy was followed by treatment of additional therapeutic modalities and therapeutic exercise. The therapeutic modalities consisted of cryotherapy and electrical stimulation. Therapeutic exercises comprised range of motion and strengthening exercises. He successfully progressed to jogging, running and agility training. He then began a kicking progression that was implemented in five phases. The first phase was ten no-step kicks at 50%, and ten no-step kicks at 100%. The second

phase included five no-step kicks at 50%, five no-step kicks at 100%, five one-step kicks at 50%, and five one-step kicks at 100%. The third phase included five no-step kicks at 50%, five no-step kicks at 100%, ten one-step kicks at 50%, and ten one-step kicks at 100%. The fourth phase included five no-step kicks at 50%, five no-step kicks at 100%, five one-step kicks at 50%, five one-step kicks at 100%, ten two-step kicks at 50%, and ten two-step kicks at 100% .The last phase included five no-step kicks at 50%, five no-step kicks at 100%, five one-step kicks at 50%, five one-step kicks at 100%, fifteen two-step kicks at 50%, and fifteen two-step kicks at 100%. The subject was pain free and transitioned into practice and was ultimately cleared for full participation. **Uniqueness:** Generally with a quadriceps strain there is evidence of swelling at the site of the tear. In this case the subject had no inflammation or physical findings of insult to the rectus femoris other than point tenderness. Recovery time from a quadriceps strain is commonly three months. The subject fully recovered and was functionally cleared for participation within two months and was able to participate as the starting place kicker for field goals. Considering the size of the tear the patient responded well to treatment. **Conclusions:** Athletic Trainers should consider that placekickers are at risk for developing quadriceps strains. Therefore, it is necessary for the placekickers to maintain their physical strength in their lower extremity. Muscle strains should not be ignored, with proper care it is possible to return to participation within a reasonable amount of time, thus allowing the patient to return sooner than expected.



## Knee Dislocation in a Collegiate Division I Football Defensive Back

Dolphin K, Christie S, Taylor R, Knight J: Campbell University, Buies Creek, NC

**Background:** 23 year-old male Division I football athlete presented with gross swelling to the left knee. He was in extreme pain and reported to the Athletic Trainer that he believed that his leg was broken; no obvious deformity was present. Subject had never sustained a traumatic injury and had no previous or current medical conditions. Subject was removed from the field and further evaluated by the Athletic Trainer. Mechanism of injury was unknown and due to the severity of pain the subject was transported to the visiting team's athletic training facility where radiographs were conducted. **Differential Diagnosis:** Tibia Fracture; Fibula Fracture; Knee Dislocation; ACL/PCL Sprain. **Treatment:** Radiographs were negative. Subject was immobilized and placed on crutches. Upon returning to campus the orthopedic physician evaluated the subject and suspected ligamentous damage and a possible posterolateral corner injury. Subject was referred for a Magnetic Resonance Imaging (MRI). MRI confirmed a complete tear of the Lateral Collateral Ligament (LCL), Anterior Cruciate Ligament (ACL) and a partial tear of the Posterior Cruciate Ligament (PCL). In addition, findings revealed a posterolateral corner injury. Orthopedic physician suggested two surgical procedures. The goal of the first procedure was to reconstruct the LCL via posterior tibial tendon allograph and repair any meniscal trauma. During the procedure there was no noted meniscal damage, however, the LCL was completely detached and impeding the popliteus muscle. Subject is currently undergoing LCL reconstruction rehabilitation protocol and furthermore increasing quadriceps strength prior to second surgical procedure. The second surgical procedure will be performed approximately eight weeks after the previous procedure to reconstruct the ACL and possibly the PCL. **Uniqueness:** Upon review of the game film, it was apparent the subject's left knee was dislocated and self-reduced on the field. A knee dislocation is rare due to the ligamentous support structure and strong musculature surrounding the joint. Trauma to the LCL can be extensive but in this case it is believed that the entrapment of the LCL in the popliteus resulted from the self-reduction of the knee. The MRI indicated a substantial posterolateral corner injury, which is atypical because posterolateral damage is often unnoticed via MRI. The repair graft of the LCL was unique in that a cadaver posterior tibial tendon was chosen over a hamstring tendon or autograph. **Conclusions:** Overall the case presented atypical of a knee dislocation. Due to situational factors a knee dislocation may not present with gross deformity. Therefore, it is crucial that an Athletic Trainer thoroughly evaluate the injured joint and consider all possible pathologies for a clinical diagnosis. Precautions should be taken to ensure thorough assessment of the condition as to not overlook any critical or compromising threats to the limb or overall health of the patient.

## Knee Injury and Dislocation in A Division I Collegiate Running Back

Pacheco R, Christie S, Taylor R, Brannon C: Campbell University, Buies Creek, NC

**Background:** 20-year-old male collegiate athlete with no prior injuries to his lower extremities presented with extreme pain in his right knee. The mechanism of injury involved the subject being forcefully pulled down from behind causing his trunk to twist while his right foot remained planted. On field evaluation by the athletic trainer through use of a Lachman's test showed gross laxity of the right knee. Due to the amount of laxity felt during the on field examination and subject's pain level no further testing was conducted. The subject was assisted off the field, once on the sideline the athletic trainer applied cryotherapy and compression to his right knee. The subject was placed in a straight leg knee immobilizer and non-weight bearing on crutches, and administered pain medication by the opposing team physician for the plane ride home. **Differential Diagnosis:** Anterior Cruciate Ligament (ACL) sprain, Medial Collateral Ligament (MCL) sprain, Meniscal injury. **Treatment:** Upon returning to campus the team orthopedic physician evaluated the subject and suspected ligamentous damage and a possible fracture. The subject was referred for radiographs and Magnetic Resonance Imaging (MRI). Radiographs were negative. The MRI found eight notable impressions: 1 - rupture of the ACL, 2 - tear of the femoral insertion of the posterior collateral ligament (PCL), 3 - tear of the posterior root of the lateral meniscus, 4 - severe contusions of the posterior tibial plateau, lateral femoral condyle and to a lesser extent the medial femoral condyle. 5 - nondisplaced fracture of fibular head, 6 - subchondral impaction fracture of the lateral femoral condyle, 7 - large joint effusion with sequelae of prior hemarthrosis, 8 - partial tear distal insertion of the MCL. The orthopedic physician ordered rehabilitation prior to surgery to allow for swelling to decrease and to strengthen the surrounding knee structures. The subject completed twelve therapy sessions over four weeks prior to surgery. Subject underwent surgery to repair his ACL using a Hamstring Tendon Graft. The subject initially completed two months of post-operative rehabilitation protocol before he returned home for the summer. During the summer he failed to maintain his rehabilitation schedule which impeded his recovery. The subject returned to college and was more compliant with his rehabilitation schedule which allowed him to progress to sports specific activities. **Uniqueness:** Review of game film depicted that the subject dislocated his right knee during the game. The knee spontaneously reduced before it was examined by the athletic trainer. Knee dislocations are uncommon and are a very serious injury that can pose a threat to the injured limb. **Conclusions:** Health care providers need to be aware of the complexities of a knee dislocation and understand that it may spontaneously reduce which may make it difficult to initially recognize. It is important for the examiner to be aware of this potential injury and rule out any neurovascular damage during the initial evaluation. In addition, as with any post-operative procedure, compliance throughout the rehabilitation process needs to be explained to the patient in order for optimal results.

## Undetected ACL Tear in Collegiate Football Player

Fiorito ME, Stoller GL, Eversole P, Brooks EK, Dailey SW, Hess R: Miami University, Oxford, OH

**Background:** During summer training camp, a male, 19year-old football offensive lineman sustained an injury to his left knee during one-on-one drills. The mechanism was a non-contact injury to the knee, suffering excessive valgus and internal rotation with a dorsiflexed foot. He has no prior injury to either knee, but did suffer a hamstring strain the previous year to the left leg. The patient reported feeling a pop at the time of the injury along with pain, but did not hear any audible sounds at the time of injury. On visual inspection, there was obvious edema on the medial border of the Patella near the medial Patellofemoral ligament. The patient was point tender over the medial Patella with no point tenderness over any other structural ligaments. Anterior Drawer, Lachmans, Varus and Valgus tests were all negative and the patient finished practice after the on-field assessment **Differential Diagnosis:** At the time of injury, it was believed the patient suffered Patella subluxation with a medial Patellofemoral ligament sprain. After initial evaluation, the patient could have also suffered a meniscal tear on the medial side or a Medial Collateral Ligament sprain. **Treatment:** The patient received an MRI to rule out medial meniscal tear. The MRI revealed a clear Anterior Cruciate Ligament tear. After reading the MRI, the Lellli's test was performed, producing a positive outcome. This ligamentous test was performed both by staff athletic trainers as well as the team physician. Lelli's test was the only ACL special test that produced a positive finding. After discussion, the patient, team doctors, and the sports medicine staff decided that he was able to continue to participate in football, wearing a functional knee brace at all times. Fifteen days later, after slow progression back into participation, it was decided that the patient

would receive reparative ACL surgery due to instability in the joint and lack of range of motion. At the end of the month, the patient underwent arthroscopic ACL reconstruction utilizing the Quadriceps tendon on the involved side. The patient has since been progressing well through rehabilitation and physical therapy with little to no setbacks. **Uniqueness:** In this case, every common Anterior Cruciate Ligament ligamentous test was performed on the patient and demonstrated a negative finding. This led to the preseumption there was no ACL tear. Upon a positive findings on the MRI for a grade three ACL tear, the Lelli's Test was performed and demonstrated a positive finding. Not only was this patient able to participate in a highly intensive contact sport on the torn ACL, the ACL tear was only present in Lelli's Test is a rare occasion. **Conclusions:** A football player suffered an injury during summer training camp which was believed to be a Patella subluxation due to negative findings on all ACL testing. After an MRI confirmed that there was an ACL tear, the Lelli's test, which was not done originally, was performed indicating positive finding. This case proves the need for the development of stronger research on the Lelli's ACL test. At the moment, it is a new test with relatively no data backing its accuracy. In the case of this football player, it is evident that it is a reliable test that can provide an accurate diagnosis. By increasing the accuracy of this special test, Athletic Trainers in many clinical settings will be able to use it during evaluation and come to a conclusion faster to provide the best possible care for their athletes.

## Salter Harris Type II Fracture of the Medial Malleolus in a High School Athlete

Moon T, Christie S, Gaddy E : Campbell University, Buies Creek, NC, and Orange High School, Hillsborough, NC

**Background:** 15 year old male high school football player sustained an injury to right medial malleolus during pre-season conditioning. The subject sprinted up an incline when suddenly felt a "pop" in ankle. There was no torsion or rolling of ankle when this occurred. Subject had no prior history of injury to his right ankle. The Athletic Trainer completed the initial evaluation which revealed pain and point tenderness over the right medical malleolus. The Athletic Trainer spoke to parents of the subject and advised them to see a physician. **Differential Diagnosis:** Tibial fracture; Eversion ankle sprain; Syndesmotic ankle sprain. **Treatment:** The subject was evaluated by a Physician Assistant at an urgent facility and diagnosed with a Salter-Harris Type II Fracture of the medial malleolus. The subject was told surgery was his best option, however neither subject nor the parents agreed with option. The parents of the subject sought additional opinions from three different orthopedic surgeons. The orthopedic surgeons agreed the subject had obtained a Salter-Harris Type II Fracture of the medial malleolus; however, there were three different rehabilitative diagnoses. The first and second orthopedic surgeons stated the subject would not return to play during the current season. The third orthopedic surgeon would allow the subject to return to play twelve weeks post surgery. The parents and the subject agreed with the third surgeon so subject would be able to return to play within the current season. The surgeon performed an open reduction internal fixation (ORIF) and the subject was placed into a hard cast for six weeks. Following the cast, the subject was placed in a walking boot for four weeks. While in the immobilized the subject continued to maintain his upper body strength and overall cardiovascular fitness. While in the walking boot athletic trainer and physical therapist began rehabilitation focused on increasing range of motion and strengthening of the lower extremity. The subject was released for non-contact practice and eventually cleared for full participation. He was able to return to play within the current season. **Uniqueness:** The mechanism of injury was running straight up a hill. The subject could not recall any motions such as supination or external rotation of the ankle that would lead the examiner to believe that the patient suffered from a Salter-Harris Type II Fracture. Usually, Salter-Harris Type II Fractures are non-operative in which they are treated by closed reduction and cast immobilization. In the case, an operative route was chosen which is more common for Salter Harris Type III and IV Fractures. **Conclusions:** An athletic trainer who provides care for youth athletes must be mindful of youth related injuries and classification systems such as Salter-Harris fractures. When providing care for minors the parents or guardians are always informed and included in the treatment process. In this case, the patient was a minor and the parents felt the need for several opinions before choosing a specific treatment. The health care community and the family members must work together and communicate so there is continuity of care.

## Mid-Shaft Fracture of the 5th Metatarsal in a Collegiate Football Player

Berry KR, Eversole P, Brooks EK, Dailey SW: Miami University, Oxford, OH

**Background:** A 21 y/o male football player (188 cm, 102 kg) reported acute lateral foot pain during spring football practice. The patient reported that the lateral side of his left foot had been stepped on during a live play. While he initially reported the injury during practice, he was able to continue playing. During evaluation of the injury, there was obvious swelling over the base of the fifth metatarsal. There were no observable or palpable bony deformities and/or dislocations. Swelling was absent in the toes, ankle or on the medial side of the left foot. There was also a great amount of point tenderness over the base of the fifth metatarsal along with pain with palpation. The patient has a previous history of a lateral ankle sprain on his right foot but there is no previous history for the left foot. **Differential Diagnosis:** Bone Contusion, Metatarsal Fracture, and Navicular Fracture. **Treatment:** The patient was sent to the local hospital for further evaluation. Radiographs revealed that there was nondisplaced transverse fracture of the proximal 5th metatarsal in the left foot. Initially the athlete was placed in a walking boot for immobilization and stabilization. He was given crutches to limit as much weight bearing activity as possible. He was removed from any further sport participation. Because of the poor blood supply in the proximal fifth metatarsal in the metaphyseal-diaphyseal junction, surgery was the chosen method of treatment. Surgery was also chosen for treatment of this injury because of the shorter associated recovery times compared to conservative nonsurgical treatments. The patient underwent surgery about one week after the initial injury. The orthopedic surgeon placed a 66mm screw into the fifth metatarsal to assist in healing the bone back together in the correct position. **Uniqueness:** With an initial description of this injury one can assume Jones Fracture. A Jones Fracture is a really specific injury of the fifth metatarsal. It is specifically located where the base of the fifth meets the shaft of the metatarsal bone. A Jones Fracture is typically located about ¾ away from the base of the fifth metatarsal. This particular fracture can be considered to be a stress fracture because of the location of the fracture. In relation to the base of the fifth metatarsal, the fracture is located more distally. **Conclusions:** Fractures of the fifth metatarsal can be a very detrimental injury to an athletic career. The injury has been previously treated with conservative rehab and rest, but the risks for re-fracture and also prolonged healing times are greatly increased. Fifth metatarsal fractures have been on the rise in occurrence especially in athletes. Although they can be easily treated with surgery and often have relatively short recovery times, the decision for which treatment method, conservative or surgical, is ultimately up to the patient. Understanding the overall goals for the patient is critical in making this decision. Do they wish to have a speedy recovery? Do they want to undergo surgery? Are they willing to take the risk of re-fracturing the metatarsal if they do not choose surgical treatment? These are just a few things that we as clinicians should think about when we are developing the appropriate treatment protocol for this specific injury.

## Chronic Ankle Pain in a Collegiate Football Player

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**Background:** A 23 year-old male collegiate football player presented to the AT during a game with moderate sharp anteriomedial right ankle pain secondary to everting and dorsiflexing his planted foot while cutting a block. On-site examination revealed an antalgic gait, mild anterior distal tibiofibular joint effusion, diffuse tenderness with no deformities, minimal ankle ROM limitations, 4/5 MMT, hyperlaxity with stress testing and intact neurovascular function. The patient's previous medical history is significant for chronic ankle pain without acute trauma. **Differential Diagnosis:** Syndesmosis sprain, lateral ankle sprain, medial ankle sprain, talus fracture, osteochondral lesion, osteochondritis dissecans, tarsal coalition, tibiofibular synostosis, capsulitis, and calcium deposit. **Treatment:** The patient successfully completed functional testing, was taped, and cleared to return to the game. Post-game, the patient was iced, provided compression, and instructed to follow up with the AT. Status-post one day, the patient reported increased pain with running and standing for long periods. He was treated conservatively for three weeks and subsequently referred to the team physician. Status-post three weeks, the patient reported a gradual increase in pain without disability. Physician examination revealed mild ankle edema, full active ROM and strength, hyperlaxity, and intact neurovascular function. The physician differentially diagnosed the patient with a chronic syndesmotic injury versus an OCD lesion, and prescribed NSAIDs, an ankle orthosis, and rehabilitation. The physician ordered radiographs and an MRI, cleared the patient for activity, and instructed the patient to follow up pending diagnostic imaging. Status-post six weeks, physician re-evaluation identified full active ROM and strength without any significant swelling. Diagnostic imaging revealed calcifications within the syndesmosis with an intact mortise and definitively diagnosed

the patient with syndesmotic calcium deposits. The patient was cleared for activity and prescribed continued NSAIDs, an ankle orthosis, and rehabilitation with emphasis on preventing excessive stresses on the syndemosis and restoring optimal kinetic chain functioning. The treatment plan was altered to focus on creative activity modification during athletic activity and the rehabilitation program consisted of cryotherapy, electrotherapy, manual therapy, PNF, and low impact whole body therapeutic exercises. Status-post three months, the patient continued to report pain with high intensity activity, but completed the season without missing a game. Status-post six months, the patient completed rehabilitation with a complete resolution of symptoms. He was discharged and instructed to follow up if he became symptomatic. **Uniqueness:** The deposition of calcium in various tissues in the body such as arteries, cartilage, muscles, and tendons in locations such as the shoulder, elbow, and spine are common; however, evidence of calcium deposits in other tissues and areas of the body such as in ankle ligaments is uncommon and lacking in the literature. **Conclusions:** Calcium is transported in the blood and as such, calcium deposits can occur anywhere in the body. Many factors can lead to calcium deposits. It is considered a normal and harmless part of aging; however, calcium deposits can disrupt normal tissue function. In this case, the underlying cause of the calcium deposits was associated with repetitive microtrauma compromising normal joint and anatomic function. Specifically, the calcium was laid down as a result of the body's response to stress over time. Despite some calcium deposits being benign, these calcium deposits further contributed to a malfunctioning kinetic chain resulting in compensatory overload, inflammation, chronic joint pain, dysfunction, and decreased performance. The identification of adaptive and compensatory actions and correction of the pathomechanics assisted in facilitating an optimal healing environment. It was critical to address the muscle imbalances, myofascial adhesions, altered arthrokinematics, and improve neuromuscular control during the rehabilitation process to allow the body to readapt to the stresses of activity and restore optimal kinetic chain functioning.

# Free Communications, Poster Presentations: Validity and Reliability Techniques and Devices

Baltimore Convention Center, Swing Hall; Thursday, June 23, 10:00AM-5:00PM; Friday, June 24, 10:00AM-5:00PM; Saturday, June 25, 10:00AM-1:00PM

Authors present June 23: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

### The Reliability of Detecting Quadriceps Motor Points

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**Context:** Neuromuscular electrical stimulation (NMES) is a common intervention that clinicians use to address muscle weakness and inhibition following injury or surgery. Current evidence suggests that NMES treatments conducted with electrodes placed over individually identified motor points produces improved force production with decreased patient discomfort compared to traditional electrodes placement. The utilization of a point stimulator to identify quadriceps motor points prior to NMES application is a novel technique, the reliability of which has yet to be established between clinicians. **Objective:** To determine the inter- and intra-rater reliability of using a TENS unit with a point stimulator to identify motor points of the quadriceps muscle group. **Design:** Inter-tester and intra-tester reliability study. **Setting:** Laboratory. **Patients or Other Participants:** 22 certified athletic trainers (Mean age: 25.9 ± 4.3; mean years certified experience: 4.8 ± 4.6) **Interventions:** Participants completed the motor point identification process of the seven quadriceps motor points of one male model on two occasions, separated by one week. The seven motor points identified were two in the vastus medalis oblique (VMOprox and VMOdis), two in the rectus femoris (RFprox and RFdis), and three in the vastus lateralis (VLprox, VLinter, VLdis). Locations of the motor points where marked and measured in centimeters (cm) by (X,Y) coordinates from pre-established reference lines between anatomical landmarks of the lower extremity. One expert in motor point location also assessed the seven motor points of the quadriceps. **Main Outcome Measures:** Intra- and inter-rater reliability of the motor point identification process and standard error of measurement were assessed by the difference between clinicians motor point location and the expert's motor point location in centimeters. Intra-rater reliability was calculated with ICC (3,k) between all participants and inter-rater reliability was calculated between session 1 and session 2 with ICC (1,1). Standard error of measurement was calculated as distance in cm. **Results:** Fair intra-rater reliability was observed for the VMOprox: 0.49, p = .05, RFprox: 0.56, p = .007, RFdis: 0.45, p = 0.09, and VLinter: 0.54, p = .046. Poor intra-rater reliability was observed in VMOdis: 0.21, p = .27, VLprox: 0.31, p = .16, , and VLdis: 0.23, p = .271. Fair inter-rater reliability was observed in the VMOprox: 0.48, p = .07, RFprox: 0.48, p = .07, RFdis: 0.45, p = 0.08, and VLinter: 0.55, p = .036, while poor reliability was seen in the VMOdis:0.15, p = .36, VLprox: 0.23, p = .28, and VLdis:0.19, p = .30. Standard error of measurement were: VMOprox: 0.66cm, VMOdis: 0.65cm, RFprox: 0.88cm, RFdis: 2.25cm, VLprox: 1.39cm, VLinter: 1.47cm, and VLdis: 0.77cm. **Conclusions:** A TENS unit with point stimulator method of motor point identification demonstrated fair to poor reliability for identifying quadriceps motor points in healthy individuals. However, standard error of measurement ranged between 0.65-2.25cm, suggesting that electrode placement based off this clinical assessment would likely place an electrode over the motor point. Future research should examine additional methods of motor point identification to improve NMES applications.

### The Rotational Dynamic Leap and Balance Test (RDLBT): A Test-Retest Reliability Study

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**Context:** New clinical assessment tools are needed for quantifying dynamic balance during functional movements like walking and running. We previously conducted a study on a new dynamic balance assessment tool, the Dynamic Leap and Balance Test (DLBT) that involved leaping movements towards five directions laid out on a floor. Participants faced straight-ahead while keeping their hips vertical during these movements. **Objective:** To extend the functionality of the DLBT we added a rotational component to the test. Another reliability study was needed to assess transverse plane motion at the lower extremity to mimic activities like back peddling, pivoting and running tasks often seen in defensive backs, basketball players, and gymnasts. **Design:** A test-retest intra-rater reliability study. **Setting:** Testing was conducted in a university athletic training and sports medicine research laboratory. **Patients or Other Participants:** Fifteen healthy subjects (9 males and 6 females), from the university community (age 25.00 ± 3.76 years, height 170.28 ± 7.58 cm, weight 69.71 ± 9.00 kg ) volunteered to participate in this study. **Interventions:** During the DLBT, subjects performed leaping movements at 100% and 150% from reference SEBT distances normalized for limb length. A pattern of targets on the floor was laid out similar to half of the SEBT matrix. Subjects leapt from two peripheral targets to one central target alternating weight bearing from one leg to the other. Stabilization for two seconds was required when landing on the dominant limb in the central target. Stability was assessed using qualitative

measures similar to Balance Error Scoring System (BESS). However, in rotational DLBT the only difference was that participants were instructed to rotate their body to land in the direction of the peripheral targets and then return to their original starting position. Three trials were performed on each of two days with a separation of at least six days. **Main Outcome Measures:** Time required by the participants to complete the leaping task is the dependent variable. Intraclass Correlation Coefficient (ICC 3, 1) was used to establish between session intra-rater reliability of the RDLBT trial averages. Significance was set a priori at $p < 0.05$. **Results:** The ICC was 0.934 with a 95% confidence interval from 0.816 to 0.977 and $p < 0.05$ that shows an excellent intra-rater test-retest reliability. **Conclusions:** Balance evaluation is an important clinical procedure that helps in determining the degree of impairment and level of recovery during rehabilitation. The RDLBT is a reliable and clinically relevant testing procedure that requires minimal space and no special instrumentation for quantifying balance. The task requires successive leaps with alternating limbs in five different directions and stabilizing the body over a new base of support after each leap. These patterns of movement imitates functional movements including running, cutting, and pivoting.

## Reliability of Video-Based Observation of Head Impacts Compared to a Standardized Instrument in Male Collegiate Lacrosse Players

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**Context:** Mild traumatic brain injuries (mTBI), commonly referred to as concussions, have increasingly raised concerns over immediate and long-term health consequences. Despite advances in concussion prevention, assessment, and management, the prevalence of concussive injuries persist. In 2013, the NFL implemented the use of an additional "eye in the sky" athletic trainer positioned in the stadium replay booth to visually monitor players who have sustained head impacts that may warrant further assessment by the sideline medical staff. A number of NCAA football programs have followed suit and the NHL has incorporated this policy as of the 2015 season. To date, there is no research supporting the efficacy of these additional personnel in identifying concussion occurrence missed by the sideline medical staff. **Objective:** The purpose of this study was to compare video-based observation of head impacts to the actual number of head impacts and magnitude recorded by Brain Sentry® impact sensors. **Design:** Observational Cohort. **Setting:** Lacrosse practice and games. **Patients or Other Participants:** 45 members of an NCAA Division III men's lacrosse team during the spring 2015 season. **Interventions:** Head impact data derived from Brain Sentry® impact counters was collected from the practices and games of 45 members of a Division III men's lacrosse team during the spring 2015 season. In addition, three observers reviewed high definition videotape of eight games for operationally defined observable head impacts. Results were compared to actual hit frequency data provided by the head impact sensors for those same eight games. **Main Outcome Measures:** The frequency of observed head impacts and frequency and magnitude (g-forces) of sensor impacts were recorded. Interclass Correlation Coefficients (ICC) were calculated with the a-priori $\alpha = 0.05$. **Results:** An average of 12.7 head impacts per game were identified by the observers for the eight games studied. Games in which both sensor and videotape data were collected revealed that visual observation detected 12% of the total number of head impacts $\geq$ 80g. Reliability of detected impacts derived from the three observers over eight games was poor (ICC = 0.71, CI = -.252 - .600). There was 0.4% agreement between the three observers in identifying identical head impact occurrences. **Conclusions:** The total number of observed head impacts was considerably lower than the frequency of impacts registered by the impact sensors. The poor reliability, combined with the low frequency of visual observation compared to sensor data, raises the question as to whether the "eye in the sky" approach to monitoring head impacts is an appropriate method of detecting potential cases of mTBI.

## Do Traditional Measures of Plantarflexion Induce Systematic Error?

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**Context:** Studies of assessment techniques for talocrural joint motion have focused on measures of dorsiflexion (DF), with limited attention to plantarflexion (PF). Several of the PF investigations utilized non-standardized techniques, demonstrating poor to moderate reliability. Recommended closed-chain DF measures, while reliable, are not appropriate for PF assessment. Further, all of the techniques incorporate adjacent joint motion, overestimating talocrural motion. **Objective:** To compare two techniques for measuring PF motion and assess intra- and inter-rater reliability. **Design:** Reliability study **Setting:** Research laboratory. **Patients or Other Participants:** A convenience sample of 34 currently healthy volunteers (age: 22.65 ± 2.28; 26 female). Ten (29.4%) reported an ankle injury in the previous 4 years. **Interventions:** After two practice sessions, two clinicians performed PF measurements in a randomly assigned order using a standard goniometer. Passive talocrural PF range was measured, unilaterally, using a modified version of the approach described by Norkin & White. Test limb was: a) the previously injured limb; b) a control-matched limb, or c) assigned for equal distribution between right and left. A standard warm up preceded data collection. The participant was prone with the knee flexed 90°. The shaft of the 5th metatarsal (MET) and the distal border of the calcaneus (CAL) were marked, serving as visual guides for the movement arm. The stationary arm was parallel with the fibula and the axis of rotation was in-line with the movement arm. Three measures were obtained in each condition; the highest value was recorded. All marks were removed before the second examiner repeated the process. Procedures were repeated 72-96 hours later. **Main Outcome Measures:** Paired samples t-tests were performed to compare passive PF range in MET and CAL techniques. A 2-way mixed model intraclass correlation coefficient (ICC3,1) was calculated for intra-rater reliability; a 2-way random model (ICC2,2) was used for inter-rater reliability. Standard error of measurement (SEM) and minimal detectible change (MCD) were also determined. **Results:** PF for MET = 62.6°¬+¬9.67° and CAL = 45.1° + 7.52° (Mean difference = 17.55° + 6.35°; 95% CI 16.47 to 18.5; $t(135) = 33.25$; $p < .001$). Intra-rater reliability for MET was good (ICC3,1 = 0.82-0.89, SEM = 3.02-4.29; MDC = 8.37-11.89) and moderate to good for CAL (ICC3,1 = 0.74-.81, SEM = 3.17-3.79; MDC = 8.80-10.50). Inter-rater reliability for MET and CAL was good (ICC2,2 = 0.87, SEM = 3.49; MDC = 9.66; ICC2,2 = 0.76 SEM = 3.68; MDC = 10.21, respectively). **Conclusions:** Both techniques reliably measure PF, though MET is significantly greater than CAL. The MET landmarks allow motion through the calcaneocuboid and tarsometatarsal joints in the sagittal plane. CAL landmarks allow a more accurate measure of motion at the talocrural joint. Comparisons of these two measures may allow the clinician to assess sources of hyper- and hypo-mobility in patients with foot and ankle dysfunction.

## Validation of Center of Pressure Balance Measurements Using the MatScan® Pressure-Mat

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**Context:** Center of pressure (COP) balance measurements are commonly performed to evaluate changes in postural control associated with medical conditions. Pressure-mat devices, such as the MatScan® are portable alternatives to force plates. It is unknown whether the data from the 2 devices agree. It is essential to establish agreement between devices to inform medical professionals of the validity of a new instrument that may impact clinical practice. **Objective:** The purposes of this study were to correlate 1) eyes-open and eyes-closed COP measures during single-leg balance and 2) the ability to detect changes in COP measures with the loss of visual input (eyes-open to eyes-closed) between the MatScan® pressure-mat and laboratory grade force-plate. **Design:** Descriptive laboratory study **Setting:** Laboratory **Patients or Other Participants:** Thirty healthy, recreationally active young adults (sex: 19 F,11 M, age: 22.7 ± 3.4 years, mass: 70.3 ± 14.5 kg, height: 1.71 ± 0.09 m) with no history of vestibular/balance disorder, lower extremity neuropathy or pain, or concussion in the previous 3-months. **Interventions:** Participants completed 3 eyes-open and 3 eyes-closed unipedal balance trials. **Main Outcome Measures:** COP excursions were simultaneously measured using pressure-mat and force-plate devices. The mean of the 3 trials was used to calculate peak COP excursions in the medial-lateral (ML) and anterior-posterior (AP) directions, total COP distance, and COP area, with eyes-open and eyes-closed. Percent-change were calculated between eyes-open to closed conditions for each variable and for both devices. Pearson's r correlation coefficients were calculated and Bland-Altman8 plots with mean differences and 95% limits of agreement were constructed

to compare the eyes-open, eyes-closed, and %-change for each COP variable between the pressure-mat and force-plate. **Results:** All COP variables were highly correlated between devices for eyes-open (ML: r = 0.93, P < 0.001, AP: r = 0.99, P < 0.001, distance: r = 0.99, P < 0.001, area: r = 0.92, P < 0.001) and eyes-closed conditions(ML: r = 0.97, P < 0.001, AP: r = 0.97, P < 0.001, distance: r = 0.99, P < 0.001, area: r = 0.92, P < 0.001). Percent-change in COP variables were high correlated between devices (ML: r = 0.95, P < 0.001, AP: r = 0.94, P < 0.001, distance: r = 0.98, P < 0.001, area: r = 0.85, P < 0.001). Bland-Altman plots (not included with submission) showed bias towards smaller COP measurements by the pressure-mat compared to force-plate, and greater differences in COP measures between devices were observed as the magnitude of the COP variable increased. **Conclusions:** COP measures and change scores were highly correlated between devices. This suggests the 2 devices are measuring are measuring similar aspects of postural control.

## The Reliability of Instrumented Knee and Ankle Orthopedic Special Tests Performed With a LigMaster™ Multijoint Arthrometer

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**Context:** Knee and ankle joint arthrometers are designed to increase the precision and objectivity of clinical measures of joint laxity and mechanical stiffness. The LigMaster™ multijoint arthrometer can be used to perform instrumented orthopedic special tests at the knee, ankle, shoulder and elbow. To date, few lower extremity studies have been conducted with this device. **Objective:** To establish the intrarater test-retest reliability of measuring the mechanical properties of knee and ankle ligaments with a multijoint arthrometer. **Design:** Cross-sectional study. **Setting:** Research laboratory. **Patients or Other Participants:** 40 healthy, physically-active adults (20 women, 20 men; age = 22.7 ± 2.0 yrs; height = 171.1 + 12.1 cm; mass = 71.1 + 13.9 kg). **Interventions:** Six instrumented special tests (4 at the knee, 2 at the ankle) were performed on each participant on two occasions on the same day. We calculated intrarater test-retest reliability using the ICC 3,1 formula, and used the Shrout and Fleiss (1979) criteria to categorize the level of reliability indicated by the ICC values. **Main Outcome Measures:** We obtained joint displacement and slope values at 90N and 130N loads for instrumented Lachman, posterior drawer, valgus and varus stress tests at the knee. We also obtained joint displacement and slope values using 125N and 150N loads for instrumented anterior drawer and inversion talar tilt tests at the ankle. **Results:** The test-retest reliability for one examiner performing instrumented Lachman, posterior drawer, varus and valgus stress tests ranged from "excellent" to "good to fair" (ICC 3,1 = 0.85 to 0.53). Average anterior displacement with the 90N Lachman test was 24.2 + 3.2 mm. The intrarater reliability of the knee slope values for the posterior drawer test, varus and valgus stress tests was also "excellent" to "good to fair" (ICC 3,1 = 0.82 to 0.51). The intrarater reliability of ankle degree for the inversion talar tilt test and ankle displacement for ankle anterior drawer test at 125N and 150N ranged from "excellent" to "good to fair" (ICC 3,1 = 0.79 to 0.62). The intrarater reliability of the ankle slope value for the ankle anterior drawer test was "good to fair" (ICC3,1 = 0.54). **Conclusions:** The instrumented Lachman, valgus, and varus stress tests at the knee and inversion talar tilt test as performed with the LigMaster™ arthrometer on healthy, physically-active adults had moderate reliability, similar to previous studies by Aronson et al (2010) and Docherty et al (2009). The posterior drawer test and the ankle anterior drawer test had markedly lower levels of test-retest reliability. While this device has unique testing capabilities, its software generates joint displacement and stiffness values that are proprietary and thus unique. These non-standard values do not correspond with output from other commercially-available arthrometers, making direct comparisons with other studies difficult, if not impossible.

## Between-Day Reliability of Lower Extremity Movement Quality During Double and Single Leg Squatting Tasks

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**Context:** Movement quality screening is utilized in clinical and athletic settings to identify movement errors and injury risk factors, and also guide the design of injury prevention and performance enhancement programs. Establishing the between-day reliability (intra-rater) of screening tools is important when examining an individual's movement quality over time and when performing large-scale movement screens. Squatting is commonly used during movement quality screens, but the reliability of specific movement quality errors has not been investigated. **Objective:** To determine the between-day (intra-rater) reliability of specific movement quality errors during three different squatting tasks. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Eleven healthy, physically active individuals (8 female, 3 male; age 22.64 ± 1.96 yrs; height 170.3 ± 12.53cm; mass 63.79 ± 12.72kg) participated in this study. **Interventions:** Participants reported to the laboratory on separate days for two testing sessions (48-72 hours apart). Movement quality of the right leg was assessed during double-limb squats (DLS), double-limb squats with heel lift (DLS-HL), and single-limb squats (SLS). The same investigator conducted all movement quality assessments. Movement errors were identified using Fusionetics© definitions for each task. Errors were dichotomously recorded by the investigator (0 = no error, 1 = error). **Main Outcome Measures:** Between-day (intra-rater) reliability was assessed for each movement error by calculating kappa (κ) and adjusted kappa (PABAK) values. Composite test error sum reliability was assessed using the ICC(2,1) procedure for each squat assessment. **Results:** The following variables demonstrated moderate (κ = 0.41-0.6) to substantial (κ = 0.61-0.80) agreement: toe-out DLS (κ = 0.74) and weight-shift DLS-HL (κ = 0.62). The majority of variables displayed a high prevalence index (>0.50), which has been shown to suppress κ values. Adjusting for the prevalence index resulted in moderate (κ = 0.41-0.6) to almost perfect (κ = 0.81-1.0) PABAK values during the DLS (toe-out = 0.82 heel-lift = 1.00, back-round = 0.82, knee-out = 1.00, knee-in = 0.64, forward-lean = 0.64, weight-shift = 0.64, feet-flat = 0.45, arm-forward = 0.45), DLS-HL (toe-out = 1.00, knee-in = 1.00, knee-out = 1.00, forward-lean = 1.00, back-round = 0.82, weight-shift = 0.82, feet-flat = 0.64), and SLS (knee-out = 1.00, knee-in = 0.63, feet-flat = 0.45). Composite test error sum scores demonstrated moderate intra-rater reliability: DLS (ICC(2,1) = 0.655, SEM = 1.56), DLS-HL (ICC(2,1) = 0.43, SEM = 0.94), SLS (ICC(2,1) = 0.52. SEM = 2.6). **Conclusions:** Our results indicate that there is moderate to almost perfect between-day (intra-rater) agreement for the majority of squatting errors identified using the Fusionetics© definitions for movement quality. Our findings suggest that the DLS, DLS-HL, and SLS are functional tasks that can be utilized to reliably identify movement compensations at the ankle, knee, hip, and trunk. This study was limited by a small sample size. Future research should employ a larger sample size and utilize the same assessment on varying clinical populations. However, the PABAK values reported in this study suggest that squatting tasks employing the Fusionetics© definitions can be utilized reliably when conducting serial assessments of patients across multiple sessions. Therefore, clinicians can utilize this assessment to track patient improvement or regression over time, improving patient-centered intervention delivery. Research supported by Fusionetics©.

Learning Objectives:

At the conclusion of the session, participants will be able to:

1. Describe the parameters of the lower extremity movement screen that have the highest intra-rater reliability. 2. Explain how a movement screen that is shown to have high intra-rater reliability in detecting movement compensations can be used clinically to evaluate patients.

References:

1. Padua DA, Bell DR, Clark MA. Neuromuscular characteristics of individuals displaying excessive medial knee displacement. Journal of Athletic Training. 2012; 47(5): 525-536.
2. Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Physical Therapy. 2005; 85: 257-268.

## Inter-Rater Reliability of a Lower Extremity Movement Efficiency Screening Tool

Frank BS, Stanley LE, Padua DA: University of North Carolina, Chapel Hill, NC

**Context:** Lower extremity movement quality screening can be leveraged by sports medicine clinicians to identify individuals that may benefit from corrective exercise programming to lower an athlete's injury risk and enhance performance during sport participation. Before clinical education and mass deployment of a movement quality assessment it is important to establish the inter-rater reliability of the assessment tool. Double and single-leg squatting (DLS & SLS) motions are common movement quality evaluation tasks, yet the reliability of identifying specific aberrant movements between an expert and novice rater has yet to be investigated. **Objective:** To determine the inter-rater reliability between a novice and expert rater for identifying aberrant movement patterns (errors) during three different squatting tasks. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** 25 healthy, female NCAA Division I athletes (n = 4 soccer, n = 2 volleyball, n = 3 field hockey, n = 6 lacrosse, n = 7 tennis, n = 3 basketball; age = 20.6 ± 1 yrs; height = 168.71 ± 4.0cm; mass = 75.8 ± 25.5kg) participated in this study. **Interventions:** The novice rater completed a standardized education curriculum to identify movement errors during a double-leg squat (DLS), double-leg squat with heel lift (DLS-HL), and single-leg squat (SLS). Participants reported to the laboratory for a single assessment session where the novice and expert rater blinded to each others' scoring concurrently evaluated movement quality of the right leg during the DLS, DLS-HL, and SLS. Movement errors were identified using Fusionetics© definitions for each task. Errors were dichotomously recorded by the investigators (0 = no error, 1 = error). **Main Outcome Measures:** Inter-rater reliability was assessed for each movement error by calculating kappa (k) and adjusted kappa (PABAK) values. Composite test error sum reliability was assessed using the ICC(2,1) procedure for each squat assessment. **Results:** The following variables demonstrated moderate (k = 0.40-0.6) to substantial (k = 0.61-0.80) agreement: DLS (arms-forward = 0.8, foot-flat = 0.76, forward-lean = 0.68, back-arch = 0.64, weight-shift = 0.40), DLS-HL (weight-shift = 0.60, arms-forward = 0.50), SLS (foot-flat = 0.61, loss-of-balance = 0.48). Other variables exhibited a high prevalence index (>0.50), known to suppress values. Prevalence index adjustment resulted in moderate (0.40-0.6) to almost perfect (0.81-1.0) PABAK values during the DLS (knee-in = 1.0, back-round = 0.92, toe-out = 0.76, heel-lift = 0.76, knee-out = 0.76), DLS-HL (knee-in = 1.0, foot-flat = 1.0, forward-lean = 1.0, back-arch = 0.92, toe-out = 0.84, back-round = 0.76, knee-out = 0.52), and SLS (knee-out = 0.92, knee-in = 0.76, uncontrolled-trunk = 0.52). Composite test error sum scores demonstrated good to excellent inter-rater reliability DLS (ICC(2,1) = 0.76, SEM = 1.3), DLS-HL (ICC(2,1) = 0.81, SEM = 1.0), and SLS (ICC(2,1) = 0.78, SEM = 0.93). **Conclusions:** The DLS, DLS-HL, and SLS exhibit moderate to high inter-rater reliability. A novice clinician can be educated to accurately identify aberrant movement patterns during the DLS, DLS-HL, and SLS assessments relative to an expert rater. Our findings suggest clinicians can confidently deploy lower extremity squat assessments to effectively and efficiently identify athletes presenting with movement errors associated with an elevated risk of injury and decreased performance during sport participation. Future research should investigate the wide-spread adoption and implementation of these reliable clinical movement assessments promoting safe athletic participation.

## Reliability of Four Physical Fundamental Movement Skills in Assessing Physical Literacy

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**Context:** Increased attention is given to movement in children and their physical literacy (PL) contributing to many claims specific to physical skill, injury prevention, and lifelong activity. Little reliability and validity data exist putting into question the efficacy of these programs. **Objective:** The purpose of this study was to determine the test reliability of four skills often used in PL intervention and testing. **Design:** Repeated measures reliability. **Setting:** Laboratory. **Patients or Other Participants:** A convenience sample of forty-three (F = 29, M = 14) second (n = 13) and fourth (n = 30) year exercise science students volunteered as raters in this study, providing 100% participation rate. Raters underwent a 20-minute training session to recognize performance of each of the cues for each skill. **Interventions:** Four physical skills and four specific cues for each skill were identified by experts in PL and physical education, and based on existing PL programming. Videos of sixteen children aged six to eight performing the four physical skills (static balance, horizontal jump, underhand toss, and skipping) with varying abilities were shown to the raters. **Main Outcome Measures:** Raters completed an online form to record assessment each child's completion of each cue (4) for each skill (4). Dichotomous ratings of each cue (0, 1) were totaled to give overall skill rating (0-4) for each task. Each cue was subjected to interrater reliability (ICC 2,k) analysis before the overall skill performance was analyzed, also using interclass correlation (ICC 2,k) evaluation. **Results:** Chronbach's alpha for cues and skill are listed with 95% confidence interval (CI). Static balance cues were 0.941 (CI .845-.990), 0.898 (CI .733-.983), 0.912 (IC .769-.985), and 0.62 (CI .001-.937). The overall score result was 0.935 (CI .829-.989).

Chronbach's alphas for cues during horizontal jump were 0.968 (CI .915-.995), 0.739 (CI .312-957), 0.949 (CI .867-.992), and 0.989 (CI .971-.998), with the overall skill at 0.987 (CI .967-.998). The underhand toss cues Chronbach's alphas were 0.889 (CI .707-.982), 0.983 (CI .956-.997), 0.343 (CI -0.734-0.891), 0.968 (CI .917-.995) with the overall skill of 0.982 (CI .935-.997). Skipping cues had Chronbach's alphas of 0.976 (CI .936-.996), 0.963 (IC .904-.994), 0.874 (CI .669-.979), and 0.916 (CI .780-.986), with the overall skill of 0.997 (CI .939-.996). **Conclusions:** These results show excellent reliability for most cues for each skill, and excellent reliability for judging the skill itself. Reliable measures of PL are necessary to determine improvements in physical skill capabilities. These results could contribute to intervention studies establishing the merits of PL.

## Handheld Tablets Are Reliable for Analyzing Frontal Plane Motion During Drop Vertical Jumps When Positioned in Slightly Altered Views

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**Context:** Drop vertical jumps(DVJ) are commonly used to evaluate athletes for lower extremity injury(LE) risk. While the use of handheld devices to observe and evaluate movement patterns is increasing, little is known about the measurement error of these tools, particularly when used by varying observers in slightly different positions. **Objective:** To determine the reliability and measurement error of frontal plane projection angle (FPPA) on 2 handheld tablets capturing simultaneous DVJ data in slightly different positions and analyzed by a series of randomly assigned investigators. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 30 healthy volunteers participated (24 females, 6 males; age: 20.0 ± 1.0 yrs; height: 164.9 ± 13.0cm; mass: 69.0 ± 15.4kg). **Interventions:** Participants performed 3 trials of DVJ from a 31.0cm box. Of the 6 investigators, a rotating schedule allowed for two investigators to be randomly assigned to capture a participant's trials. These 2 investigators stood side-by-side at 3.7m in front of the participant. The side to which the investigators stood (left or right) was randomly assigned. Each investigator held a tablet at a self-selected chest height, perpendicular to the ground in portrait view orientation. Each DVJ trial was captured simultaneously on 2 tablets. The same 6 investigators were randomly assigned to measure left limb FPPA using a free video analysis tablet application. **Main Outcome Measures:** For each captured video, the frame selected for analysis was at the instant of maximum downward displacement during the landing phase of the DVJ. FPPA was measured as the acute angle created by the intersection of 2 lines: one line from the anterior superior iliac spine to the midpoint between the femoral condyles, and a second line from the midpoint between the tibial and fibular malleoli to the midpoint of the femoral condyles. No investigator analyzed the same trial on both tablets. In total, 180 trials were analyzed; 90 trials were randomly selected for which intraclass correlation coefficients (ICC2,1) and standard error of measurement (SEM) were calculated between the two tablets. For the other 90 trials, a paired samples t-test was used to determine the difference in FPPA between the tablets. **Results:** Means ± SD are presented for descriptive results. The reliability analysis revealed good agreement between the left (163.5° ± 9.2) and right (160.1° ± 9.4) tablets (ICC2,1 = 0.8; SEM = 2.4°; $p < .001$). For the differences analysis, there was no significant difference between FPPA angles for the left (164.8° ± 9.0) or right (162.9° ± 9.1) tablets, $p = 0.1$. The difference (1.9° ± 10.5) between the two tablets did not exceed the SEM. **Conclusions:** Evaluating FPPA during DVJs can be consistently performed by different observers, even when stationed in slightly different positions when using handheld tablets and standard, freely-available, biomechanical measurement applications. These findings provide evidence supporting the use of tablets in clinical and field settings for evaluating FPPA during DVJs for biomechanical profiles related to LE injury.

References

1. King DL, Belyea BC. Reliability of Using a Handheld Tablet and Application to Measure Lower Extremity Alignment Angles. J Sport Rehabil. 2014; Oct 13. [Epub ahead of print]

2. Belyea BC, Lewis E, Gabor Z, Jackson J, King DL. Validity and Intra-rater Reliability of 2-Dimensional Motion Analysis Using a Hand-held Tablet Compared to Traditional 3-Dimensional Motion Analysis. J Sport Rehabil. 2015; vol: Technical Notes.

Learning objectives:
At the conclusion of the abstract presentation, participants will be able to:
1) discuss potential reasons for good reliability in frontal plane measurement even amongst non-standardized positioning of a handheld tablet.
2) discuss potential factors that may affect reliability of hand-held movement analysis of frontal plane motion.

## Between Day Reliability of Upper and Lower Extremity Isometric Strength Testing Using the BTE Dynamometer

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**Context:** Objective strength testing is a valuable tool in orthopedic assessment and rehabilitation to monitor strength changes over time. The BTE Primus dynamometer (Hanover, MD) is an understudied dynamometer, but may provide for a more reliable way to measure shoulder and hip isometric strength. **Objective:** To determine between day reliability of shoulder and hip isometric strength tests using the BTE Primus dynamometer. **Design:** Repeated measures design. **Setting:** University Musculoskeletal laboratory. **Patients or Other Participants:** A convenient sample of eight healthy individuals with a mean age of 30 ± 9 years of six men and two women. **Interventions:** Each participant's upper arm and thigh length was measured to calculate torque produced. Participants then performed two trials of isometric strength tests for both the upper and lower extremity on two different days a week apart. Strength tests included seated glenohumeral (GH) abduction with arm at side, GH external rotation (ER) with arm at side, side-lying hip abduction and prone hip extension with hip in neutral position. Each participant generated maximal force for 5 seconds with a 30 second rest between trials. **Main Outcome Measures:** Average torque (Nm) was generated from two maximal isometric contractions for each testing position. All data was normalized to bodyweight. Intraclass correlation coefficients (ICC) and minimal detectable change (MDC) values were recorded. **Results:** Intraclass correlation coefficients (ICC) for average percent of body weight generated were found to be highly reliable (0.90-0.95) for all tests. Specifically, for right GH abduction (0.16 ± 0.04, ICC = 0.94, MDC = 0.03) and left GH abduction (0.16 ± 0.05, ICC = 0.94, MDC = 0.03). The right GH ER (0.09 ± 0.03, ICC = 0.94, MDC = 0.02) and left GH ER (0.1 ± 0.04, ICC = 0.90, MDC = 0.03). The right hip abduction (0.42 ± 0.13, ICC = 0.92, MDC = 0.08) and in the left hip abduction (0.42 ± 0.12, ICC = 0.91, MDC = 0.09), the right hip extension (0.3 ± 0.1, ICC = 0.95, MDC = 0.05) and similarly for the left hip extension (0.3 ± 0.1, ICC = 0.95, MDC = 0.05). **Conclusions:** Testing shoulder and hip isometric strength with the BTE Primus dynamometer has high intrarater reliability. The low minimal detectable changes suggest that this assessment methodology would be responsive to intervention techniques measuring strength changes over time.

## Reliability and Validity of the Korean Version of Identification of Functional Ankle Instability and Foot and Ankle Outcome Score

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**Context:** The questionnaires used for the Identification of Functional Ankle Instability (IdFAI) and Foot and Ankle Outcome Score (FAOS) assess functional limitations of the foot and the ankle in patients with CAI. However, the reliability and validity of the Korean version of these questionnaires have not verified yet. **Objective:** To evaluate the reliability and validity of Korean version of IdFAI (K-IdFAI) and FAOS (KFAOS), and to set up the cut-off criteria for CAI. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Fifty-four subjects with CAI (21M, 33F; 27.4 ± 4.6 yrs; 168.0 ± 8.2cm; 63.8 ± 12.8kg) were diagnosed by orthopedic surgeons. The non-CAI group was recruited from two different populations. 29 healthy individuals with no history of lower extremity injuries (26M, 3F; 27.0 ± 5.1 yrs, 174.1 ± 6.8cm, 70.8 ± 8.5kg) and 25 individuals who have a reported history of either lower leg or foot injuries except for ankle joint complex (25M; 26.2 ± 1.9 yr, 175.0 ± 4.0cm, 74.1 ± 3.7kg) were recruited for this study. **Interventions:** The independent variable for this study was the group difference; CAI and non-CAI. **Main Outcome Measures:** Scores of K-IdFAI and KFAOS [symptom, pain, daily living (ADL), sports, and quality of life (QOL)] were the main outcomes of this study. The test-retest reliability (of at least an interval of 48 hours) was assessed using intra-class correlation coefficients (ICC). The receiver operating characteristic (ROC) curves determined the cut-off score for sensitivity (SN), specificity (SP), positive and negative likelihood ratios (+LR and -LR) for both questionnaires. The area under the curve (AUC) was also used for estimating the accuracy of questionnaires. **Results:** There were excellent test-retest reliabilities for K-IdFAI and KFAOS-symptom, KFAOS-pain, KFAOS-ADL, KFAOS-sports, and KFAOS-QOL (ICC: 0.986, 0.866, 0.984, 0.902, 0.959, and 0.992; SEM: 1.15, 6.98, 1.80, 6.96, 4.50, and 2.11). Significant AUC values and cut-off scores were found for these questionnaires. K-IdFAI: cut-off = 14.5, AUC = 99.6% (95% CI: 99.0-100.0), SN = 0.963, SP = 0.963, +LR = 26.000, -LR = 0.038; KFAOS-symptom: cut-off = 76.8%, AUC = 94.6% (95% CI: 90.5-98.6), SN = 0.889, SP = 0.889, +LR = 8.000, -LR = 0.125; KFAOS-pain: cut-off = 88.9%, AUC = 96.8% (95% CI: 93.8-99.9), SN = 0.889, SP = 0.833, +LR = 5.333, -LR = 0.133; KFAOS-ADL: cut-off = 87.5%, AUC = 73.0% (95% CI: 63.5-82.4), SN = 0.593, SP = 0.593, +LR = 1.455, -LR = 0.687; KFAOS-sports: cut-off = 82.5%, AUC = 99.7% (95% CI: 99.0-100.0), SN = 0.981, SP = 0.889, +LR = 8.833, -LR = 0.021; KFAOS-QOL: cut-off = 84.1%, AUC = 99.7% (95% CI: 99.1-100.0), SN = 0.981, SP = 0.852, +LR = 6.625, -LR = 0.022. **Conclusions:** The results of this study showed that the K-IdFAI and KFAOS were reliable and valid tools to identify CAI patients. Clinically, however, it is recommended that the cut-off point of K-IdFAI and KFAOS would be increased than the international Foot and Ankle Consortium's recommendation and identify those with CAI as the following: K-IdFAI > 14.5; KFAOS-symptom < 76.8%; KFAOS-pain < 88.9%, KFAOS-ADL < 87.5%; KFAOS-sports < 82.5%, and KFAOS-QOL < 84.1%.

## Validity of a Novel Upper Extremity Motion Tracking Device

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**Context:** Pitch volume is a risk factor for overuse upper extremity injuries. Pitch volume is only tracked during games and currently there is not a practical way to track overall workload during practice. Therefore, the total throwing volume is being underestimating for the entire season. A body-worn sensor that can be applied during practice to record throwing volume would be beneficial to provide a more complete measure workload in overhead athletes. **Objective:** This study determined the validity of the Shoulder Motion Acquisition, Recognition and Tracking Inertial Measurement Unit (SMART- IMU) and associated algorithm comparing to visually observed counts during baseball and softball practice. **Design:** Single-blind cross-sectional study. **Setting:** Athletic facility. **Patients or Other Participants:** A convenient sample of 6 healthy individuals with previous baseball or softball participation. Four males and two females (Height = 1.7 ± 0.1m, Mass = 77 ± 14kg, Age = 25 ± 7years) without a history of shoulder injury volunteered to participate **Interventions:** 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 and covered by a compression sleeve. Each subject performed between 4-8 repetitions of seven shoulder exercises utilized for warm-up. The subject was then instructed to complete drills during a typical practice including throwing, fielding, batting and conditioning. A single member of the research team recorded all throws and other activities on Excel worksheet. At the completion of these drills the data from the inertial measurement device was given to a blinded member of the research team. The three-dimensional data of

position, direction, and velocity from the SMART-IMU was processed using MATLAB software. A specially designed pattern recognition classifier was applied to the raw data to determine the number of throws that occurred during a simulated practice session. The visually observed counts were compared to the counts generated by the algorithm from the IMU data using a contingency table and Bland-Altman plot. **Main Outcome Measures:** The number of throws recorded visually and the counts identified by the SMART-IMU pattern recognition classifier. The correlation between visually observed throws and throws identified by the SMART-IMU was determined. The average difference between SMART-IMU and visually observe throw was calculated as described by Bland-Altman. **Results:** Each athlete threw 98 ± 24 times during a simulated practice for a total of 586 visually observed throws. The SMART-IMU identified 605 throws, with an average difference between the two of 3 ± 11 throws. The overall correlation was r = .99 with standard error of predicted y = 2.5 throws **Conclusions:** The SMART-IMU and associated algorithm is an accurate tool to count baseball throws count during a simulated practice in overhead athletes. The SMART-IMU tended to overestimate the number of throws but only by approximately 3%.

## Comparing Spine Immobilization With Spinal Motion Restriction During Transport of Suspected Spine-Injured Patients

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**Context:** Many emergency medical service (EMS) agencies have recently changed protocols for care of patients with suspected spine injuries by eliminating the use of long backboards traditionally employed to achieve spinal immobilization (SI). In its place, spinal motion restriction (SMR) employs cervical collars and the EMS stretcher alone to improve patient comfort, enhance respiratory status, and reduce on-scene times. However, no research has evaluated SMR efficacy to limit spine motion compared to SI during transport. **Objective:** To compare spine motion and self-reported pain prevalence in healthy subjects between SI and SMR during ground transport in the pre-hospital setting. **Design:** Counterbalanced crossover. **Setting:** Controlled laboratory and ambulance. **Patients or Other Participants:** Twenty males without previous history of destabilizing cervical spine injury (age = 20.9 ± 2.2 yrs, height = 178.6 ± 7.6 cm, mass = 83.4 ± 12.6 kg). **Interventions:** Participants were first fitted with a cervical collar. Inertial measurement unit sensors (MyoMotion IMS system, Noraxon USA, Inc, Scottsdale, Arizona) were then placed on the center of the forehead at the brow line and on the sternum 2.54 cm inferior to the base of the cervical collar. Trials began with the participant secured to an EMS stretcher inside the laboratory at its maximum height. The participant was then wheeled outside to an ambulance, loaded inside and driven on a standardized route (approximately 9.6 km) for 15 minutes, returning to the laboratory. Upon return, the participant was unloaded from the ambulance, wheeled into the simulated hospital setting and transferred to a hospital bed, concluding the trial. Participants completed one trial of each condition (SI and SMR) in a randomized, counter-balanced, order. Participant self-reported pain was recorded using a standard numeric pain scale at 7 time-points between the beginning and end of the trial. A two-factor repeated measures ANOVA compared spine motion in each plane (P>.05). Prevalence of pain is described. **Main Outcome Measures:** Dependent variables included cumulative integrated motion (CIM) and peak range of motion (ROM) of the cervical spine in the sagittal, frontal, and transverse planes and pain prevalence. The independent variable was condition (SI, SMR). **Results:** Transverse ROM was less ($F_{1,19} = 7.47$, $p = 0.013$) for SI (6.99 ± 3.09°) compared to SMR trials (8.27 ± 3.39°). No other statistically significant differences were observed ($P > 0.05$). During SI trials, 26.4% of participants reported pain while only 13.6% of participants reported pain in SMR trials. **Conclusions:** While SMR resulted in greater transverse ROM during ground transportation compared to SI, the clinical relevance of this approximate 1.25° difference is unknown. The lack of difference between SI and SMR ROM in the other two planes, combined with no difference in CIM in any plane of motion supports elimination of the traditional use of a long backboard for SI. SMR is further supported by the potential for adverse effects, like pain, associated with using SI.

## A Validation Case Study: The Use of Electromyographic Biofeedback for Post ACL Rehabilitation

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**Background:** The patient is a 19 year old male collegiate football player who sustained an anterior cruciate ligament (ACL) rupture early in the football season. He underwent surgical repair of the ACL and has been completing rehabilitation according to the surgeon's protocol. Due to additional pathology and repair (meniscectomy and repair), the patient was restricted from aggressive ROM therapy. Additionally, the patient was lacking strength in the quadriceps. Deficits in quadriceps strength have frequently been reported following ACL reconstruction. The use of electromyographic biofeedback has been suggested to improve both strength and range of motion (ROM). This case confirms previous findings advocating the use of biofeedback as an adjunctive therapy. **Differential Diagnosis:** ACL tear, posterolateral complex injury, meniscal tear. **Treatment:** Electromyographic Biofeedback was implemented during rehabilitation sessions to augment motor unit activation to increase strength of the quadriceps. The target was captured before the first set was completed and recapturing occurred between the last two sets. Visual and auditory feedback was provided to reinforce maximal voluntary isometric contraction (MVIC). Biofeedback was completed for 10 sessions. MVIC strength has increased consistently throughout the treatment sessions. **Uniqueness:** The extent of the pathology associated with this injury contributes to the uniqueness of this case. Additionally the use of biofeedback as a visual and auditory aid to increase MVIC supports what has previously been reported. **Conclusions:** Patients with quadriceps strength deficits and decreased ROM following ACL reconstruction may benefit from the application of biofeedback. **Relevant Evidence:** Draper and Ballard (1990) and Christanell et al., (2012) have reported that biofeedback promotes quadriceps activation and the restoration of active knee extension. Collectively, they suggest biofeedback is a simple adjunct to traditional rehabilitation therapies.

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