

JOURNAL OF ATHLETIC TRAINING

Official Publication of the National Athletic Trainers' Association, Inc Volume 46, Number 3, Supplement, 2011

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Bring this *Supplement* to New Orleans 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 document contains abstracts presented at the 2011 NATA Annual Meeting & Clinical Symposia as part of the National Athletic Trainers' Association Research & Education Foundation's Free Communications Program.

The Free Communications Program provides certified athletic trainers, students and other health care 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 and clinical case reports. These presentations span a wide spectrum of topics. In addition, the Clinical Case Reports sessions allow you to test your clinical assessment skills.

For your convenience, research abstracts are printed in order of presentation at the NATA Annual Meeting in New Orleans. We encourage you to attend these sessions.

The NATA Foundation funds research, a variety of educational programs and annual scholarships to undergraduate and graduate athletic training students. Support from NATA members, corporations and other affiliated groups make this supplement and all of our other programs possible.

Please note projects funded by the NATA Foundation are identified in this *Supplement*. To make an investment in the future of the profession, please contact the NATA Foundation today at 972-532-8837.

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

Sincerely,



Mark A. Hoffman, PhD, ATC
President,
NATA Research & Education Foundation



Marjorie J. Albohm, MS, ATC
President, NATA

Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Committee, we would like to thank the authors who submitted abstracts to the NATA Foundation's Free Communications Program. More than 360 submissions in the Peer Reviewed and Student Exchange tracks were received for the 2011 program.

This year's Free Communications Program contains an exciting mix of both high-caliber research reports and clinical case study reports. Please keep in mind that we consider oral and poster presentations to be equal in terms of stature and we encourage clinicians and researchers to attend both oral and posters sessions.

We would like to take this opportunity to extend a special thanks to the NATA Foundation staff and especially Patsy Brown, 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: Joseph Hart, PhD, ATC; Lisa Jutte, PhD, ATC, LAC; Thomas Kaminski, PhD, ATC, FNATA; Melanie McGrath, PhD, ATC; Darin Padua, PhD, ATC; Kimberly Peer, EdD, ATC, LAT; William Pitney, EdD, ATC; Brian Ragan, PhD, ATC; Steven Straub, ATC; Charles Thigpen, PhD, ATC, PT; Kavin Tsang, PhD, ATC; and Susan Yeargin, PhD, ATC for their many hours of abstract reviews and preparation for our 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 will 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 readers expect from the *Journal of Athletic Training*. We appreciate the feedback we have received from authors. Suggestions are always welcomed and discussed in committee meetings to further improve the process.

We look forward to seeing you in New Orleans and hope you will 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,

A handwritten signature in black ink, appearing to read "Tom Dompier". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Tom Dompier, PhD, ATC
Free Communications Committee Chair

JOURNAL OF ATHLETIC TRAINING

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The Medal for Distinguished Athletic Training Research Presented in Honor of Joe Torg, MD

**Jay Hertel, PhD, ATC, FNATA, FACSM
University of Virginia**

For Jay Hertel, PhD, ATC, FACSM, FNATA, recipient of the 2011 Medal for Distinguished Athletic Training Research, athletic training was a profession he became interested in at an early age. Although he did not have much exposure to athletic training in high school, his father's high school football coach was Dominic Gentile, the first full-time athletic trainer for the Green Bay Packers. After his father put him in touch with Dominic, Hertel knew that athletic training was the career for him.

Over the years, Hertel's research has focused on the challenges of ankle sprains and chronic ankle instability. Ankle sprains are one of the most common injuries in organized sports and one that some athletes tend to disregard; however, ankle instability resulting from sprains can cause long-term disability in athletes, a problem that Hertel hopes his research will aid in reducing.

Today, Hertel is working to better understand the physiology and pathomechanics associated with chronic ankle instability in order to optimize treatment strategies such as manual therapies and balance training to treat the condition and prevent those long-term consequences. Although many sports medicine practitioners use similar treatment approaches for all patients with a specific condition, Hertel believes that "if we can identify which particular treatment approaches work best in patients who present with specific patterns of signs and symptoms, we can really make a difference in improving the outcomes of patients with ankle sprains and chronic ankle instability."

This view on research and clinical care has developed from a career dedicated to asking informed questions and finding both expected and unexpected answers. Hertel says that he now looks at his research agenda much differently than when he started. Even though he feels as if he has made substantial advances in the recognition and treatment of ankle instability, he also realizes that there are countless research questions that still need to be answered.

With hundreds of published articles, abstracts, and presentations, Hertel has had a significant influence on the world of athletic training and sports medicine. Hertel is an associate professor of Kinesiology and Physical Medicine & Rehabilitation at the University of Virginia, an associate editor for 2 journals (including the *Journal of Athletic Training*), and the cofounder, with Thomas W. Kaminski, PhD, ATC, FNATA, of the International Ankle Consortium, an international community of scholars interested in ankle instability.

Two points of view that he hopes to pass on to future athletic training scholars are being open to reading original research in areas outside of sport medicine and being willing to "push the envelope of accepted theories." "Too often," Hertel says, "we come up with a research question, and feel that if we do a study and answer the question in an unanticipated way, it is viewed as a failed study." Instead of viewing such studies as mistakes, Hertel emphasizes using those unexpected results to advance the overall understanding of the topic at hand.

Over the years, Hertel's influences have included Craig R. Denegar, PhD, ATC, PT; Kevin M. Guskiewicz, PhD, ATC, FNATA, FACSM; and David H. Perrin, PhD, ATC, FACSM, who have all provided examples as excellent mentors, scholars, and educators. He is grateful for the service opportunities he has had with the NATA, which have helped to shape his view of translational and clinical research. Hertel also thanks his parents, Jim and Kay Hertel; his wife, Tammy Jandrey Hertel; his children, Reese and Sonia; and all of his former and current students and colleagues, without whom he wouldn't have accomplished what he has.



Joe Torg, MD

Joe Torg, MD, has long been a leader in sports medicine. Widely recognized for his work with spinal cord injuries, Dr. Torg is also responsible for perfecting medical techniques and spurring participation guidelines in sports.

A graduate of Haverford College and the Temple University School of Medicine, Dr. Torg is the founding director of the Temple University Center for Sports Medicine, the first affiliated with a university, which provided care for the athletes of Philadelphia. His research on the effect of the shoe–playing surface interface and its relationship to football knee injuries was directly responsible for both the National Federation of State High School Associations and the National Collegiate Athletic Association mandating that cleats be no longer than one-half inch. His published description of the Lachman Test for anterior cruciate ligament instability, which he named for his professor, John Lachman, MD, is widely regarded as a classic work. Dr. Torg was also instrumental in opening Little League baseball to girls.

Dr. Torg's most well-known contribution has been his research identifying catastrophic cervical spine and cord injuries that result from the previously unrecognized axial loading mechanism of the spine from spearing and head-down contact. After analyzing data from the National Football Head and Neck Injury Registry, Dr. Torg recommended rule changes that resulted in a marked decrease in cervical cord injuries resulting in quadriplegia at both the high school and college levels. He also described cervical cord neurapraxia resulting in transient quadriplegia as a distinct, benign clinical entity. Dr. Torg has published criteria for return to play following cervical spine injury.

In 1978, Dr. Torg was appointed Professor of Orthopedic Surgery and Director of the University of Pennsylvania Sports Medicine Program, where he initiated one of the first Sports Medicine Fellowships. He has since trained 36 fellows.

Dr. Torg has co-authored three textbooks and well over 100 articles published in prestigious peer-reviewed journals. He served on President Reagan's Council on Physical Fitness and Sports.

Dr. Torg received the Ninth Annual Eastern Orthopedic Association award for spinal research, the Nicholas Andre Award, the North American Spine Association annual award, the NATA President's Challenge award and the 2004 Elizabeth Winston Lanier Kappa Delta award. He is also an AOSSM Hall of Fame member.



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

**Steven P. Broglio, PhD, ATC
University of Michigan**

Although athletic training has not always been his first choice, Steven P. Broglio, PhD, ATC, the recipient of the 2011 New Investigator Award, “fell into” the profession with grace. Broglio began his college years as a molecular genetics major at The Ohio State University (OSU), but after deciding that genetics was not his true calling, he began to search for a new major. A close friend, who had been the manager of the OSU football team, suggested that he contact OSU athletic trainer Bill Davis, and a newfound passion was born.

At the University of North Carolina at Chapel Hill, where he transferred after deciding to pursue a career in athletic training, Broglio also began to cultivate an interest in head injuries, beginning with an honors project recommended by mentor Kevin M. Guskiewicz, PhD, ATC, FNATA, FACSM. Today, 10 years after his initial project, Broglio has become a top researcher in concussions, with numerous funded grants resulting in published articles that influence the treatment of concussions around the world.

Currently, Broglio is studying the biomechanics of concussion in high school athletes in “real time” and the long-term effects of concussion on the athlete, attempting to both identify the causes of concussions and develop ways to assist retired athletes with the physical and mental consequences of years of neural trauma. As the former director of the Neurotrauma Research Laboratory and the undergraduate and graduate athletic training education programs at the University of Illinois at Urbana-Champaign, Broglio has made substantial contributions to neurotrauma prevention, diagnosis, and rehabilitation and to athletic training education. This fall, he will bring his expertise and research to the University of Michigan as an assistant professor in the school of Kinesiology and director of the Neurotrauma Laboratory.

Along with his countless publications in a variety of journals, Broglio is also on the editorial boards of the *Journal of Athletic Training*, the *British Journal of Sports Medicine*, and *Athletic Training & Sports Health Care*, and he is a reviewer for 18 journals.

As for future athletic trainers who hope to one day follow in his footsteps? Broglio says that the keys are “getting lucky” and working hard – “don’t be afraid to ask questions, even if you don’t understand; just because something has always been done a certain way, [it] doesn’t mean it’s the right or the best way.”

Broglio credits much of his success to his time with Kevin Guskiewicz, who set him on the investigative path to concussions, and Michael S. Ferrara, PhD, ATC, FNATA, who was instrumental in helping him to “polish” his work and see the bigger picture in all of his research.

He also thanks his parents, Joyce and Dennis Broglio, for encouraging him to earn his doctorate and reach to achieve his goals; his wife, Jane, who has provided unwavering support; his daughter, Lillian; and the NATA Research & Education Foundation and the *Journal of Athletic Training*, which have allowed him to “give back” to athletic training and share his enthusiasm for his work with students and colleagues.



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 University of Pittsburgh Medical Center.

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 Center for Sports Medicine – has grown into the region's largest, most comprehensive sports medicine center, regarded among the best in the country.

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

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

Dr. Fu is the editor of 26 major orthopedic textbooks and author of 75 book chapters on managing sports injuries. He has authored or co-authored 180 peer-reviewed articles and has given more than 600 national and international presentations.

Former president of the Pennsylvania Orthopaedic Society, he is a member of 40 other professional and academic medical organizations including the prestigious Herodicus Society. Currently he serves as Second Vice President of the International Society of Arthroscopy, Knee Surgery and Orthopedic Sports Medicine and will assume the presidency of ISAKOS in 2009. He is also on the Board of the American Orthopaedic Society for Sports Medicine and the Orthopaedic Research and Education Foundation. Dr. Fu has served as chairman of the board and executive medical director of the UPMC/City of Pittsburgh Marathon, company physician and board member for the Pittsburgh Ballet Theatre, and team physician for Mt. Lebanon High School.



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

**Jason P. Mihalik, PhD, ATC
University of North Carolina at Chapel Hill**

As an avid athlete throughout his high school years, Jason P. Mihalik, PhD, CAT(C), ATC, was injured multiple times, but because of the capable care he received from an athletic therapist, he went on to enjoy his active lifestyle. Through this athletic therapist, Mihalik, recipient of the 2011 Doctoral Dissertation Award, discovered a way to merge sports with clinical practice – athletic therapy. A few years later, an undergraduate project caused him to read an athletic training journal on concussions, sparking a number of unanswered questions and sending him on an unexpected journey from Canada to his current home at The University of North Carolina at Chapel Hill.

Today, Mihalik continues to influence the study of concussions in multiple settings, from high schools and youth sports to the United States military, where he promotes athletic trainers as medical providers for soldiers with traumatic brain injuries. He is exploring the biomechanics and the sex differences behind head impacts sustained by female and male hockey players, as investigators have shown that female players may be at higher risk for concussion, even though body checking is not allowed in women's ice hockey.

Mihalik hopes that research advances in the area of concussions will encourage the NCAA, the NHL, and other leading athletic organizations to update their safety rules as needed. For example, whether to allow body checking at younger ages in ice hockey is in debate. One goal of Mihalik's work is to understand if teaching players how to body check correctly will result in less direct head contact and fewer concussions overall.

Despite all of the research that has been done, Mihalik believes the world of medicine still knows very little about the brain, a subject that he plans to continue studying for many years to come. As an assistant professor at Chapel Hill, a reviewer for more than 8 journals, and an editorial board member of *Athletic Training & Sports Health Care*, Mihalik is steadily contributing to our knowledge of concussions and their long-term effects.

For those who are interested in athletic training, Mihalik offers the following advice: don't back away from research, as "research for athletic trainers tends to be very clinically applicable. My recommendation for those who don't pursue research is to understand [that] there needs to be evidence for what they do in the clinic."

Mihalik thanks Kevin M. Guskiewicz, PhD, ATC, FNATA, FACSM, for being a strong mentor and now a great colleague; Joseph Myers, PhD, ATC, for mentoring him as a graduate student; Stephen W. Marshall, PhD, for his continued support; and Johna Register-Mihalik, PhD, ATC, for being a wonderful wife and colleague and always providing him with love, encouragement, and support.



David H. Perrin, PhD, ATC, FACSMT

David H. Perrin, PhD, ATC, 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. He currently serves on the NATA Foundation Board of Directors.

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.

EBF: Ankle

Monday, June 20, 2011, 8:00AM-9:00AM, Room 217

Free Communications, Oral Presentations: Clinical Ankle Measurements

Monday, June 20, 2011, 9:15AM-10:30AM, Room 217; Moderator: Tricia Hubbard, PhD, ATC

Comparison Of Low And High Frequency Ultrasound Imaging In The Measurement Of Anterior Talofibular Ligament Length

Childress S, Croy T, Hertel J, Saliba S: University of Virginia, Charlottesville, VA

Context: Lateral ankle sprains are common and assessment of ligament injury is challenging. Ultrasound (US) imaging may help identify anterior talofibular ligament (ATFL) injuries by allowing for the quantification of ATFL length changes during ankle stress maneuvers. US devices operating at higher frequencies provide improved tissue resolution, but it is unknown whether clinicians using US devices operating at differing frequencies can produce agreement in ATFL length measurements. **Objective:** To compare ATFL length in neutral and inversion stress positions between two US devices, a low-frequency device (8MHz, 38 mm linear probe) and a high-frequency (15 MHz, 23 mm linear probe) device. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 20 subjects without history of ankle injury (height=171±9.5 cm, mass=73.5±18.3 kg, age=24.7±4.2 years) volunteered. **Intervention(s):** Three US images of the ATFL were taken in a neutral position and at end-range inversion with both the low-frequency and high-frequency devices. **Main Outcome Measures:** Images were analyzed using imaging software and the linear distance between the ATFL's malleolar origin and talar insertion was measured with a digital calipers. Mean ATFL lengths (mm) from low-frequency and high-frequency US images were measured in the neutral and inversion positions. The percent change in ligament length from the neutral to inversion stress positions was also calculated. Interexaminer and intra-

examiner reliability estimates (ICC_{3,1}) for the length measures in the three conditions ranged from .77 to .91 and .93 to .96, respectively (SEM: 0.3 to 0.4 mm). Paired t-tests were conducted to compare measures: 1) from the neutral and stress images within each device, and 2) the percent length changes between devices. Bland-Altman plots were also assessed to evaluate the agreement in length measures between devices. **Results:** ATFL length significantly increased from the neutral to the inversion positions with the low-frequency (neutral=18.7±1.4 mm, inversion=20.1±2.0 mm, p=.001) and high-frequency (neutral=16.9±1.9 mm, inversion=17.6±1.3 mm, p=.03) devices. No significant between-device difference in percent length change was observed (low frequency=6.7±7.9%, high frequency=4.6±8.1%, p=.36). Bland-Altman plots demonstrated consistent mean differences between devices with ATFL length measures with the low-frequency device being a mean of 2.1 mm (95% CI: -1.8 to 6.2 mm) longer than with the high-frequency device. **Conclusions:** Significant increases in ATFL length with inversion stress were shown on images taken with both US devices. While the low frequency device produced consistently longer ATFL length measures in both neutral and inversion stress images, percent change scores were not significantly different between devices. Both devices were able to identify ATFL length changes similarly. Differences in absolute ATFL length measures between devices used in this study may be due to either probe length or frequency.

Comparison Of Arthrometry And Stress Ultrasound Imaging In The Assessment Of Laxity In Healthy Ankles

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Context: Ultrasonography (US) may aid in the assessment of the anterior talofibular ligament (ATFL) injury after lateral ankle sprains by visualizing and measuring the injured ligament length changes during anterior drawer and inversion stress maneuvers. Validation of US against an established and objective method of anterior talocrural and inversion laxity, such as ankle arthrometry (AA), is needed. **Objective:** To evaluate the relationships between the ATFL length measurements taken with US during anterior drawer and inversion stress to the maximum inversion and anterior drawer displacement observed with AA in healthy subjects. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 20 subjects without a history of ankle injury (height: 171±9.5 cm; mass 73.5±18.3 kg; age 24.7±4.2 years) volunteered. **Interventions:** Anterior drawer talocrural laxity was assessed with two methods; US imaging and AA. US imaging of the ATFL (USAD) was performed in sidelying with the ankle under 125N of sustained anterior drawer stress. AA (AAAD) was performed using a 125 N anterior drawer force. Inversion laxity was measured during end-range inversion stress with US (USINV) stress imaging and then again with AA (AAINV) at 4000N*mm of inversion torque in the supine position. Three US images were taken in USAD and USINV positions and mean ATFL lengths calculated. Three trials of AAAD and AAINV were performed and the mean maximum anterior drawer

translation (mm) and inversion ($^{\circ}$) laxity values were calculated. **Main Outcome Measures:** USAD (mm), AAAD (mm), USINV (mm) and AAINV ($^{\circ}$) and normalized ATFL length change scores during anterior drawer (USAD%) and inversion (USINV%). Descriptive statistics and correlations between dependent variables were calculated. **Results:** Group means were: USAD (19.0 ± 0.2 mm), USINV (20.1 ± 0.2 mm), AAAD (5.6 ± 2.8 mm), AAINV ($25.7 \pm 9.1^{\circ}$), USAD% ($1.7 \pm 10.5\%$), and USINV% ($7.6 \pm 9.9\%$). No significant correlations were observed between USAD and AAAD ($r = -.34$, $p = .09$) or USINV and AAINV ($r = -.04$, $p = .85$). The AAAD and AAINV measures were positively correlated ($r = .61$, $p < .0001$) as were USAD and USINV ($r = .762$, $p < .0001$). Likewise, USAD% and USINV% were positively correlated ($r = .764$, $p < .0001$). **Conclusions:** US measures of anterior drawer and inversion laxity were not significantly correlated with AA measures in healthy ankles. Differences between the US and AA devices and procedures that may have affected these results include different rates of joint loading and subject positioning. Change scores demonstrated relatively small levels of lengthening in healthy ankles and results may differ in ATFL-injured ankles where joint laxity is greater.

Development Of A New Motorized Ankle Tester And Its Use In The Measurement Of The Effectiveness Of Bracing

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Context: We introduce a new technique for assessment of the three-dimensional passive support characteristics of ankle braces. Brace effectiveness in combination with a shoe has never been evaluated in vitro. With the use of a mechanical device, ankle flexion and positioning and the

magnitude of force and torque applied can be controlled so that meaningful comparisons can be made. Measurement reliability is critical when new devices or techniques are developed. **Objective:** To design a motorized ankle testing device with a six degrees-of-freedom linkage to accurately and reproducibly measure ankle complex motion. The device was used to make comparisons among no braced (NB), braced and post-exercise braced conditions. **Design:** Measurement reliability was examined using a test-retest design for the non-braced ankle and repeated measures compared ankle complex stability among the no brace and braced conditions. **Setting:** Research laboratory. **Participants:** Six normal fresh-frozen cadaver ankles. **Interventions:** The specimen was mounted to a jig proximally via a tibial rod cemented into the tibial medullary cavity and distally via an athletic shoe fixed to a mounting plate of the testing machine. The specimens were loaded to 2 Nm in internal-external rotation at 0° plantar-flexion (PF), as well as 4 Nm inversion-eversion rotation at 15° PF. Two repeated measurements were performed on each ankle for each test. Exercise consisted of dorsi-plantar flexion (DPF) cycling to ± 1.5 Nm for 10 minutes. **Main Outcome Measurements:** Measurements included total internal-external and inversion-eversion (I-E) ankle complex rotation. Intraclass correlation coefficients (ICC 2,1) assessed reliability. Separate one-way repeated measures ANOVA's examined effects of an ankle de-rotation orthosis on ankle complex rotation. Significance was set a priori at $P < .05$. **Results:** Test-retest data indicate high reliability measurement for internal-external rotation (Measurement 1 = $43.05 \pm 18.4^{\circ}$ and Measurement 2 = $44.19 \pm 18.9^{\circ}$, ICC = .99) and inversion-eversion rotation (Measurement 1 = $62.51 \pm 17.4^{\circ}$ and Measurement 2 = $62.49 \pm 17.2^{\circ}$, ICC = .99). For internal-external loading, rotation decreased 12° between the NB ($43.05 \pm 18.4^{\circ}$) and braced ($31.33 \pm 14.9^{\circ}$, $P = .017$) ankles, and there was a non-significant increase of 2.6° rotation after

exercise for the braced ankle ($33.95 \pm 15.6^{\circ}$, $P = .09$). For inversion-eversion loading, ankle complex rotation decreased 25.2° between the NB ($62.51 \pm 17.4^{\circ}$) and braced ($37.3 \pm 10.0^{\circ}$, $P = .001$) conditions, with a 1.1° rotation increase after exercise for the braced condition ($38.4 \pm 9.9^{\circ}$, $P > .05$). **Conclusions:** Excellent test-retest correlations were observed, and comparison results indicate that the NB and braced ankles varied significantly, but not between the pre-post exercise-braced ankles. We plan to use this device in future studies to offer new evidence as to which method of ankle support is more effective in maintaining ankle complex stability.

Plantar Flexion And Inversion Strength Deficits Revealed In Previously Sprained Ankles

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Context: Ankles are the most frequently injured joint in sport, and it is estimated that up to 40% of people sustaining a significant sprain are left with residual problems (pain, weakness) despite optimal rehabilitation. Although counter-intuitive, deficits in plantar flexion (PF) and inversion (INV) strength have been mentioned as possible risk factors for recurrent ankle sprains and/or instability. **Objective:** To examine differences in isokinetic strength in those with a history of ankle sprain (SP) and those without a history of ankle sprain (NS). **Design:** Cross-sectional study. **Setting:** Athletic Training Research Laboratory. **Patients or Other Participants:** Forty-seven NCAA Division I collegiate athletes (age = 18.1 ± 0.5 years, mass = 69.3 ± 11.8 kg, height = 172.5 ± 10.7 cm) for a total of 94 ankle measurements. **Interventions:** Strength was measured by using a KinCom 125-AP isokinetic dynamometer (Chattanooga Group, Hixson, TN). PF and INV strength was assessed at a velocity of $120^{\circ}/\text{sec}$.

Both concentric (CON) and eccentric (ECC) muscle actions were assessed and then normalized to lean body mass derived and SP groups. **Main Outcome Measures:** History of ankle sprain served as the independent variable, while the dependent variables were the normalized average (AT) and peak (PT) torque values (Nm/kg) from concentric and eccentric PF and INV isokinetic strength. **Results:** Isokinetic strength in the SP group was significantly weaker than the NS group across all variables including: CON-PF-AT (NS: 1.08 ± 0.30 vs. SP: 0.91 ± 0.26 , $p=0.006$), CON-PF-PT (NS: 1.44 ± 0.36 vs. SP: 1.27 ± 0.26 , $p=0.012$), ECC-PF-AT (NS: 0.53 ± 0.07 vs. SP: 0.50 ± 0.08 , $p=0.023$), ECC-PF-PT (NS: 3.48 ± 0.96 vs. SP: 2.95 ± 0.86 , $p=0.007$), CON-INV-AT (NS: 0.18 ± 0.05 vs. SP: 0.15 ± 0.04 , $p=0.003$), CON-INV-PT (NS: 0.25 ± 0.05 vs. SP: 0.22 ± 0.05 , $p=0.011$), ECC-INV-AT (NS: 0.28 ± 0.08 vs. SP: 0.24 ± 0.06 , $p=0.005$), ECC-INV-PT (NS: 0.41 ± 0.11 vs. SP: 0.36 ± 0.11 , $p=0.021$). **Conclusions:** Traditionally, clinicians have focused on eversion and dorsiflexion strength in the rehabilitation of a lateral ankle sprain. Although strength deficits in PF and INV appear to be novel, there is support in the literature for these findings. Strength deficits found in PF and INV could be a result of persistent reflex neuromuscular inhibition of the periarticular ankle muscles stemming from a previous ankle sprain. Inhibition of joint musculature after distention and/or damage to a joint has been previously described in the literature. The results of this study suggest a role for restoring both PF and INV strength in the rehabilitation of a lateral ankle sprain.

Ankle Copers Demonstrate Increased Anterior Stiffness Compared To Healthy And Unstable Ankles

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Context: Ankle sprains are the most common injuries in athletics, with approximately 50% of patients complaining of repeated bouts of “giving way.” (functional instability, FAI). While extensive research has explored the mechanical and sensorimotor implications behind FAI, the fifty percent of subjects that do not develop instability are lost to follow-up. Understanding this group of “potential copers” can provide insight into relevant interventions to prevent instability. Research has been inconclusive in demonstrating changes in ankle stiffness in patients with ankle instability; however, comparisons have not been seen in a group of “potential copers”. **Objective:** To determine changes in passive ankle stiffness that exist in “potential ankle copers” when compared to healthy and functionally unstable ankles. **Design:** Post-test only with comparison group. **Setting:** Human Performance Laboratory. **Patients or Other Participants:** 39 subjects (23.0 ± 2.9 yrs, 171.5 ± 10.3 cm, 69.7 ± 13.2 kg) provided 78 ankles for this study. Ankles were stratified into three groups using the Cumberland Ankle Instability Tool (CAIT): healthy (HA, $n=37$), functionally unstable (AI, $n=22$), and potential copers (PC, $n=19$). **Interventions:** Ankle laxity and stiffness was assessed using an instrumented ankle arthrometer (Blue Bay Research, Milton, FL). Three anterior translations to a force of 125N and three inversion rotations to a torque of 4200Nmm were applied to the ankle joint. **Main Outcome Measures:** Peak anterior displacement (mm) and inversion rotation ($^{\circ}$) was assessed for between-group differences using univariate ANOVA's. Passive ankle stiffness was assessed at 25N intervals from 0 to

125N of anterior force, and 1Nm intervals from 0 to 4Nm of inversion torque. A 2-way repeated-measures ANOVA was used to determine differences within each force level, and between groups. The alpha level was set *a priori* at 0.05. **Results:** Group was observed to have a significant effect on anterior stiffness values ($F_{2,56}=5.9$, $p=.005$), and post-hoc tests revealed that the PC group exhibited significantly greater stiffness than HA at 0-25N ($p=.002$), and greater stiffness than AI ankles at each interval up to 100N ($p<.05$). The AI group demonstrated increased anterior displacement compared to HA and PC groups (HA= 7.9 ± 2.0 mm; AI= 9.8 ± 2.5 mm; PC= 7.8 ± 2.3 mm, $p=.005$). No group differences were observed for inversion rotation (HA= $32.3 \pm 4.6^{\circ}$; AI= 34.7 ± 8.7 , PC= $31.2 \pm 9.0^{\circ}$, $p=.29$) or for inversion stiffness ($F_{6,204}=1.085$, $p=.37$). **Conclusions:** The PC group observed to have an increased resistance to anterior displacement of the ankle, despite seeing no changes in peak laxity. Previous investigations on the neuromechanical contributors to joint stability have emphasized the importance of achieving optimal joint stiffness. Our data suggests that these “potential copers” exhibit a mechanical adaptation that may assist in preventing additional episodes of giving way in the ankle joint. This adaptation is markedly greater during the short range stiffness, where previous research has suggested the sensation of an impending roll-over incident is most important.

EBF: Concussion

Monday, June 20, 2011, 10:45AM-11:45AM, Room 217

Free Communications, Oral Presentations: Concussion Issues

Monday, June 20, 2011, 12:00PM-1:00PM, Room 217; Moderator: Ryan Tierney, PhD, ATC

Prevalence Of Injurious Impacts In Interscholastic Football

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Context: Sport concussion has received significant media attention as of late. Despite growing awareness and research in this area, little is known about injury biomechanics. **Objective:** The purpose of this investigation was to describe and compare the highest magnitude impacts occurring in interscholastic football across athlete positions. **Design and setting:** Observational field study completed during the 2007, 2008, and 2009 football seasons. **Participants:** Interscholastic football athletes (N=78, 16.8±.8yrs, 181.6±5.6cm, 89.4±13.9kg) volunteered to participate in this investigation. **Interventions:** Each athlete was equipped with the Head Impact Telemetry System (HITS) to monitor and record all impacts occurring during games and practices. Biomechanical data recorded by the HITS mimics that of Hybrid III dummies for linear and rotational accelerations ($r=.98$) and impact location (± 4.1 cm). **Main Outcome Measures:** Data from each impact included linear acceleration (g), rotational acceleration (rad/s/s), and HIT severity profile (HITsp). Data were ranked based on rotational acceleration and categorized based on player position. Group differences in linear acceleration, rotational acceleration and HITsp for the top 0.5% of impacts were evaluated using multiple Analyses of Variance (ANOVAs). We further investigated what percentage of impacts a newly proposed concussion

threshold represented (ie impacts in excess of 5580.0rad/s/s; 96.0g; and impacts to the helmet front, back, or top). **Results:** A total of 76621 impacts were recorded throughout the data collection period and 16 concussions were captured. The top 0.5% most significant impacts included 383 hits spread across the Offensive Line (52 impacts; 4.0 impacts/player), Offensive Skill (128 impacts; 6.4 impacts/player), Defensive Line (163 impacts; 6.3 impacts/player) and Defensive Skill (40 impacts; 4.4 impacts/player) players. ANVOA results indicated no difference ($p>0.05$) between groups for linear acceleration (Offensive Line: 91.6±16.2g; Offensive Skill: 98.4±20.1g; Defensive Line: 95.5±17.5g, Defensive Skill: 94.9±19.5), rotational acceleration (Offensive Line: 8041.7±1285.5rad/s/s; Offensive Skill: 8121.83±1477.4rad/s/s; Defensive Line: 8109.0±1190.6rad/s/s, Defensive Skill: 8101.2±1193.7rad/s/s), or HITsp (Offensive Line: 61.2±21.6; Offensive Skill: 58.7±24.2; Defensive Line: 59.9±20.0, Defensive Skill: 59.8±15.8). Additionally, 74 impacts (0.1% of all impacts) exceeded the newly proposed concussion threshold and included 7 of 16 recorded concussions (43.8%). **Conclusions:** The highest magnitude impacts occurring in interscholastic football are equally distributed among player positions. The most severe impacts do not uniformly result in concussions, suggesting an inconsistent injury threshold between individuals. As such, the variables analyzed here do not provide an appropriate level of information for concussion diagnostics. Future work is needed to determine additional measures that will improve diagnostic criteria and/or define more sensitive tolerance levels.

Influence Of Concussion Knowledge On Reporting Of Concussion In Games And Practices Among A Sample Of High School Athletes

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Purpose: Reporting of concussive injuries is one of the first steps in identification and management. It is estimated that over 50% of these injuries may go unreported. Understanding the influence of concussion knowledge on reporting among high school athletes may help direct education and awareness efforts in this population. **Objective:** To examine the influence of concussion knowledge on concussion reporting prevalence across games and practices among a sample of high school athletes. **Design:** A cross-sectional survey design. **Setting:** The pre-validated survey instrument was completed at the athletes' home. **Patients or Other Participants:** A convenience sample of 167 high school athletes (age=15.7±1.4) completed the questionnaire. **Interventions:** Athletes attended a school-based meeting and received a packet containing the questionnaire and consent documents to take home, complete, and return via mail. The criterion variable was knowledge score, which was calculated as the sum of the correct responses from 35 knowledge questions. The questionnaire was pilot tested and Kappa Agreement across test sessions was 0.6-0.9 for questions (all yes/no) included in the knowledge score. **Main Outcome Measures:** The definition of *concussion reporting* was indicating a recalled concussion or "bell ringer" event as reported to a coach or

medical professional. Concussion reporting measures included: 1) proportion of concussions and “bell ringers” reported during practices, 2) proportion of concussions and “bell ringers” reported during games, 3) overall proportion of reported concussions as defined by the athlete, and 4) overall proportion of reported “bell ringers” as defined by the athlete. Binomial regression models [Prevalence Ratios (PR) and 95% Confidence Intervals (CI)] were used to analyze the influence of a 10-point increase in knowledge score on concussion reporting measures. **Results:** Increased knowledge score was significantly associated with higher reporting prevalence of concussions/“bell ringers” during practices (PR=18.67; 95% CI:5.38-64.76; $P<.001$), and a higher reporting prevalence of “bell ringer” events overall (PR=9.40; 95% CI:3.16-27.98; $P<.001$). No association was observed between knowledge score and reporting prevalence during games (PR=1.46; 95% CI:0.51-4.21; $P=.475$) or concussion events overall (PR=0.98; 95% CI:0.35-2.76; $P=.982$). In games, there were a total of 320 recalled concussions/“bell ringers” with only 73 (23%) of these events reported to a coach or medical professional. In practices, there were a total of 348 recalled concussions/“bell ringers” with only 40 (12%) of these events reported to a coach or medical professional. **Conclusions:** Increased knowledge about concussion may result in increased reporting of events athletes consider to be “bell ringers” and potential concussive events occurring during practices. This study highlights that concussion education may promote reporting of concussive events among high school athletes. In conclusion, this study illustrates the importance of context (game vs. practice) on reporting behaviors.

Impaired Gait Performance Following A Concussion

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Context: Impaired postural control is a hallmark of concussion presentation; however the mechanisms related to these impairments are still largely unknown. During gait, the rhythmic muscle activation patterns are likely controlled by central pattern generators in the thoracic and lumbar spinal cord, however functional MRI studies have suggested overriding supraspinal control of gait, likely residing in the primary motor cortex. It is likely that concussions do not adversely affect central pattern generators, but may impair supraspinal control mechanisms.

Objective: To identify impairments in spatiotemporal parameters of gait following a concussion. **Design:** Cross Sectional. **Setting:** Laboratory.

Patients or Other Participants: A total of 18 subjects were divided into two groups, 9 subjects (5 Male, 1.73 ± 0.09m ht, 80.8 ± 20.4kg, 1.0 ± 1.4 previous concussions) who suffered Grade II (Cantu Evidence Based grading system) concussions were matched to 9 healthy control subjects (5 Male, 1.71 ± 0.08m ht, 77.8 ± 17.9kg) who had no history of concussion. **Intervention:** All subjects completed 10 trials of self-selected paced gait on a 4.9m Gaitrite instrumented walkway, a reliable (ICC: 0.80 – 0.98) and valid (ICC: 0.92 – 0.99) instrument. Concussion subjects completed their trials within 24 hours post-injury and control data was collected during preseason pre-participation physical examination.

Main Outcome Measures: Spatiotemporal measures of gait performance including stride length, stride velocity, and gait cadence were compared between groups using a One-way ANOVA with Bonferroni corrections thus setting the alpha level at 0.017. A paired sample T-Test compared the gait cycle percentage in stance phase between groups. **Results:** The concussion subjects walked with

a significantly reduced gait velocity ($1.15 \pm 0.14\text{m/s}$ and $1.42 \pm 0.11\text{m/s}$ respectively, $P<0.001$), cadence (107.9 ± 9.1 steps/minute and 119.7 ± 8.3 steps/minute respectively, $P=0.011$), and spent more time in stance ($62.6 \pm 1.6\%$ and $60.6 \pm 1.2\%$ of the gait cycle respectively, $P=0.03$) than the healthy subjects. After Bonferroni correction, there was a non-significant 28% reduction in stride length in the concussion subjects compared to the healthy control subjects ($1.11 \pm 0.45\text{m}$ and $1.42 \pm 0.09\text{m}$ respectively, $P=0.04$). **Conclusions:** The results of this study suggest that concussion acutely impairs spatiotemporal parameters of gait performance. The concussion subjects in this study demonstrated a posturally conservative gait pattern whereby they reduced their gait velocity and cadence as well as increased the amount of time spent in stance. Further, these results support the recent findings suggesting overriding supraspinal control of gait; however, further investigation is required to more precisely identify brain structures and networks associated with the impaired postural control. Finally, the Gaitrite portable gait analysis system appears effective in identifying altered gait patterns following a sports-related concussion.

Subconcussive Head Impacts Do Not Result In Short-Term Clinical Impairments In Youth Ice Hockey Players

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Context: The long-term clinical impairments that have been identified in retired athletes have largely been attributed to repeated subconcussive head impact exposures during their earlier playing days. It is yet unknown whether repeated head impacts in a young and vulnerable population may result in short-term clinical impairments observed following a season of regular participation in collision sports.

Objective: To study how the frequency, severity, location, and cumulative magnitude of sub-concussive head impacts affects neurocognitive function, balance performance, and symptomatology in youth ice hockey players. We hypothesized any changes in clinical measures of concussion would be explained by measures of head impact exposure. **Design:** Quasi-experimental prospective repeated measures cohort. **Setting:** Clinical research center and field settings. **Patients or Other Participants:** A convenience sample of 83 male ice hockey players (age=14.5±1.1 years; height=171.2±8.8 cm; mass= 64.0± 11.4 kg; experience=3.7±3.7 years). **Interventions:** Preseason and postseason testing consisted of the following common clinical measures of concussion: Immediate Post-concussion Assessment and Cognitive Test (ImPACT), Balance Error Scoring System (BESS), and 22-item Postconcussion Symptom Scale (PCSS). Head impact exposure, including impact magnitude and location, were collected for all players over the course of the playing season by using helmets customized to accommodate the Head Impact Technology System (HITS) instrumentation. Separate multiple linear regressions were employed for each outcome measure while including the following criterion variables: ≥10g, frequency of severe head impacts, ≥80g, frequency of top-of-head impacts, and cumulative sum of linear acceleration of all head impacts. **Main Outcome Measures:** Change scores (Δ =postseason - preseason) were computed for the ImPACT composite indices (verbal memory, visual memory, visuomotor processing speed, and reaction time), the BESS total error score, and PCSS total symptom severity score. **Results:** Our analyses regressed change in clinical outcome against the frequency ≥10g of head (median=270 impacts), frequency of severe ≥80g head (median=2 impacts;

range=0 to 28 impacts), frequency of top-of-head impacts (median=35 impacts), and cumulative sum of linear acceleration of head impacts (mean=5894.9g; sd=3300.8g) observed for each player. The multiple linear regressions for change scores in verbal memory ($F_{4,78}=0.56$; $P=0.696$; $R^2=0.028$), visual memory ($F_{4,78}=1.14$; $P=0.343$; $R^2=0.055$), visuomotor processing speed ($F_{4,78}=0.44$; $P=0.779$; $R^2=0.022$), reaction time ($F_{4,78}=0.38$; $P=0.823$; $R^2=0.019$), BESS ($F_{4,78}=0.84$; $P=0.503$; $R^2=0.044$), and PCSS ($F_{4,78}=2.01$; $P=0.102$; $R^2=0.093$) did not suggest that our independent variables of interest contributed in any way to the changes we observed in our clinical measures of concussion. **Conclusions:** It does not appear that any short-term changes in clinical measures of concussions observed over the course of a single playing season can be explained by the measures of head impact exposure we included in our analyses. Future work should prospectively study the potential long-term effects of head impact exposure on clinical impairments in young athletes.

Strapping Techniques May Influence Immobilization When Shifting A Patient To Clear The Airway

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Context: When caring for the spine-injured athlete, it is necessary to restrict movement of the spinal column to avoid exacerbating or creating neurological injuries secondary to initial trauma, especially during the prehospital stages of patient care. The strapping technique applied must prevent excessive slipping motion in the event the immobilized patient must be rolled to clear the airway. **Objective:** To assess the effectiveness of current strapping techniques and two head immobilizers in minimizing spinal motions. **Design:** Repeated measures. **Setting:** Cadaver laboratory. **Patients or Other Participations:** Five lightly-embalmed cadavers (3 males, 2 females; mass: 135 kg \pm 31.2) with intact cervical spines. **Interventions:** A global instability at C5-C6 was created by a spine surgeon. The cadavers were positioned supine on the spine board. The head was stabilized using two different devices: Ferno Universal Head Immobilizer and Laerdal Speed Block. Three strapping techniques were tested with each of the head immobilizers. The 3-Strap technique involved the placement of straps across the chest, hips, and thighs. The SPIDER strapping technique has preset strap locations determined by the manufacturer. The 7-Strap utilizes straps placed in an X pattern at the chest and across the shoulders, a third strap across the chest, an X pattern across

the pelvis, a strap across the mid-thigh region, and a strap across lower leg. Once the cadaver was properly immobilized, the spine board was rolled to 90° by two researchers. A third researcher monitored an inclinometer attached to the spine board. For all trials, an electromagnetic tracking device registered motion at the C5-C6 level and the digital inclinometer recorded spine board angle. All procedures were completed three times on each cadaver. **Main Outcome Measures:** The primary measurements assessed were angular (flexion/extension, lateral flexion, axial rotation) and linear (anteroposterior translation, medial-lateral translation, and axial translation) motions occurring at the C5-C6 level as the cadaver was rolled 90° while immobilized to the spine board. **Results:** No significant differences were noted between the head holder devices. The 3-Strap technique produced significantly more motion for: flexion-extension [3-Strap: 1.67° \pm 0.34° and SPIDER: 0.97° \pm 0.25°, (p=0.001)]; lateral bending [3-Strap: 2.18° \pm 0.29° and SPIDER: 1.18° \pm 0.22°, (p=0.049)]; axial rotation [3-Strap: 2.03° \pm 0.30° and 7-Strap: 1.40° \pm 0.25°, (p=0.009)]; and medial-lateral [3-Strap: 2.86 mm \pm 0.39mm and SPIDER: 1.71 mm \pm 0.48mm (p=0.041)]. **Conclusions:** Although the data shows the 3-Strap technique is significantly inferior in four of the six outcome measures, the measured difference is small. While not significantly different, the SPIDER technique resulted in less motion than the 7-Strap. Our study shows that the SPIDER technique results in less slipping motion in the event the immobilized patient must be rolled to clear the airway.

Radiographic Evidence Demonstrates That Occipital Padding Maintains Cervical Alignment After Football Helmet Removal

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Context: Minimizing head and neck motion is a key principle in on-field management of cervical-spine injuries. Therefore, recommendations for managing football athletes with such injuries favor facemask removal to allow airway access. Maintaining cervical-spine alignment is another key principle; therefore, if helmet removal becomes necessary, recommendations call for simultaneous shoulder pad removal (all-or-none principle). However, simultaneous removal of shoulder pads and helmet may cause considerable movement especially if adequate trained rescuers are not available. **Objective:** To determine if occipital padding is an effective intervention to maintain cervical spine alignment after helmet-only removal. **Design:** Quasi-experimental, repeated measures. **Setting:** X-ray suite of orthopedic clinic. **Participants:** Convenience sample of 20 males (age = 23.6 \pm 2.7 years, height = 181.1 \pm 8.7cm, weight = 85.5 \pm 12.4kg). **Interventions:** IRB approval was granted for use of x-rays. Participants provided informed consent and were fitted with football helmet and shoulder pads. Helmets and shoulder pads were altered to improve radiographic visibility of the cervical spine (helmets: metal rivets and chinstrap removed; shoulder pads: deltoid protection and metal rivets removed). After appropriate shielding with lead apron and lead throat protection, four lateral radiographs were taken. Participants were first imaged wearing shoulder pads and helmet. Investigators (certified athletic

trainers) then removed the helmet following recommended protocol. Calipers were used to measure the occipital thickness of the helmet; towels matching this thickness were slid under the subject's head after helmet removal. Participants were imaged immediately with occipital padding, again 20 minutes later, and finally without occipital padding. An orthopedic spine surgeon blinded to the study's purpose, determined cervical alignment via Cobb angle measurements of the posterior cervical cortices of C2-C6 vertebrae using angle measurement tools in the digital x-ray software (Stryker Office PACS, Version 4.1.35.2 Stryker Imaging, Kalamazoo, MI). Intraobserver reliability was determined a priori using intraclass coefficient analysis. Measurements were analyzed using a 1x4 RMANOVA and post-hoc pairwise-comparisons with Bonferroni correction. **Main Outcome Measure:** Cervical alignment (C2-C6 Cobb angle). **Results:** Intraobserver analysis showed excellent reliability (ICC=1.0, 95% CI: .999-1.0). RMANOVA detected significant differences ($F=13.34_{3,17}$, $P<0.001$). Pairwise comparisons revealed no differences in cervical alignment (all measurements reported reflect lordosis) when comparing the baseline helmeted condition ($10.1^{\circ}\pm 8.7$; 95% CI: 6.0-14.1) to the padded conditions. Measurements taken after removal of occipital padding ($14.4^{\circ}\pm 8.1$; 95% CI: 10.6-18.2) demonstrated a significant increase in cervical lordosis compared to the immediate padded measurement ($9.5^{\circ}\pm 6.9$; 95% CI: 6.3-12.7; $P=0.011$) and the 20-minute padded measurement ($6.5^{\circ}\pm 6.8$; 95% CI: 3.4-9.7; $P<0.001$). **Conclusions:** These data provide quantitative evidence that the use of occipital padding after helmet-only removal provides a safe alternative to the all-or-none principle of managing football equipment during emergencies. If it becomes necessary to remove the football helmet in the field, occipital padding may be used to maintain cervical alignment until shoulder pads can be safely removed.

The Effects Of Wet And Dry Conditions On The Time For Face Mask Removal Using A Powered Screwdriver And Face Mask Extractor

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Context: There is no published literature examining the effectiveness of face mask removal tools in inclement weather conditions. Therefore, it is difficult to determine which removal method would be best, given current weather conditions. **Objective:** To determine how wet and dry weather conditions affect face mask removal using a cordless powered screwdriver (SD) and a Face Mask Extractor (FME). Analysis of speed and tool effectiveness will help to determine an appropriate face mask removal method given the environmental condition. **Design:** Repeated measures design. **Setting:** Controlled grass field. **Participants:** A convenience sample of nine (3 male, 6 female) licensed athletic trainers participated in this study. The participants had an average age of 32.11 ± 6.72 years and an average of 8.39 ± 7.42 years of experience as a licensed athletic trainer with an average of 4.39 ± 2.93 years of football experience. **Interventions:** All subjects were provided with rain suits for wet and dry trials. Following a familiarization period, each participant completed three trials with each removal tool (SD, FME) under each weather condition (wet, dry). The order of weather condition and tool was counterbalanced to prevent order from affecting results. All trials were completed on a grass field. Wet conditions were simulated by pre-soaking the ground and the participant for eight minutes via a sprinkler system. One investigator, wearing a Schutt Air helmet and shoulder pads simulated the injured athlete. Another investigator provided in-line manual stabilization of the athlete's cervical spine for the duration of each trial. **Main Outcome Measures:** Two researchers independently timed each trial with a stop

watch. The average time of each trial was recorded to the nearest one-hundredth of a second. The average time of the three trials with each tool and under each weather condition was used for the analysis. A 2X2 repeated measures Analysis of Variance was used to examine the effects of weather condition and tool on the time to remove the face mask. **Results:** Means and standard deviations for the removal using the FME in wet and dry conditions were $82.46s\pm 32.19s$ and $81.53s\pm 36.58s$ respectively. Means and standard deviations for the removal using the SD in wet and dry conditions were $42.57s\pm 14.89s$ and $35.41s\pm 15.14s$ respectively. There was no significant interaction between tool and condition ($p=0.684$) and no significant main effect of condition ($p=0.290$). There was a significant main effect of tool ($p<0.0005$) on face mask removal time. The participants removed the face mask faster when using the SD. **Conclusions:** This study supports the NATA position statement of a screwdriver being an athletic trainer's primary means of face mask removal, with a cutting tool available as a backup. Our results suggest that regardless of weather condition, face mask removal can be completed more quickly using a SD.

The Effect Of Lacrosse Helmet Use On Face Mask Removal With A Cordless Screwdriver

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Context: Timely and successful face mask removal (FMR) is essential when catastrophic injuries occur in helmeted athletes. Previous work on FMR of football helmets has shown that cordless screwdrivers can be rendered useless on helmets that have been worn for a single season. Research on lacrosse helmets is lacking; however catastrophic injury has occurred 13 times over the last 26 years. **Objective:** To determine the frequency of FMR failure for lacrosse helmets worn for at least one full season using a cordless

screwdriver. **Design:** Cross-sectional. **Setting:** Athletic training laboratory. **Patients or Other Participants:** Helmets were obtained from two colleges (N = 55) and one high school (N = 20) in the mid-Atlantic region. The mean seasons, games, and weeks of practices the helmets were worn were 2.25 ± 1.50 , 35.25 ± 22.91 , and 30.75 ± 19.36 , respectively. None of the helmets had ever been refurbished. **Interventions:** A trial consisted of using a cordless screwdriver to remove all screws that secured the face mask to the helmet shell using standardized procedures. FMR required unscrewing either three (n = 30) or five (n = 45) screws depending on the helmet style. A model was positioned supine on the ground with each helmet fitted properly by an athletic trainer with 6 years of experience fitting lacrosse helmets. An athletic trainer trained in FMR techniques knelt down and put the helmet between their knees while attempting to remove all screws that secured the face mask to the helmet. Removal was attempted on a total of 75 helmets and 310 screws. **Main Outcome Measures:** The frequency of FMR failure was the dependent variable. Proportions of FMR failures for the helmets and individual screws with 95% confidence intervals (CI) were calculated. A removal attempt was considered a failure if the screw could not be removed with the cordless screwdriver because of t-nut spinning, the screw being stuck, the screw being stripped, or another reason. **Results:** FMR failure occurred on 12 of the 75 helmets (16.0%, 95% CI: 7.7%, 24.3%) while removal of 16 of the 310 individual screws failed (5.2%, 95% CI: 2.7%, 7.6%). Eleven of the 16 (68.8%, 95% CI: 28.1%, 100%) failed screws were unsuccessful because of t-nut spinning with the remaining being stuck in the t-nut (31.2%, 95% CI: 3.9%, 58.6%). **Conclusions:** Similar to the results reported on football helmets, we found the cordless screwdriver to be unreliable for FMR of used lacrosse helmets due to the 16% failure rate observed. Based on these results, we

recommend that athletic trainers covering men's lacrosse have a secondary cutting tool immediately available in the event the cordless screwdriver fails. We also recommend routine maintenance checks of helmet hardware throughout the season.

EBF: Heat or Hydration

Tuesday, June 21, 2011, 9:15AM-10:15AM, Room 217

Free Communications, Oral Presentations: Heat Illness Prevention

Tuesday, June 21, 2011, 10:30AM-11:30AM, Room 217; Moderator: Lindsay Eberman, PhD, ATC

Examination Of Two Environmental Symptoms Questionnaire During 10-Days Of Exercise-Heat Acclimation

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Context: The Environmental Symptoms Questionnaire (ESQ), while originally created for altitude-induced stress, has been utilized in hot environments and has been used in both its full (56-ESQ) and a modified 14-question form (14-ESQ) however neither were validated for heat stress or correlated with physiological data. **Objective:** The purpose of this study was 1) Validate the 56-ESQ specifically for heat stress and heat acclimation 2) to compare a modified version of the ESQ (14-ESQ) to the 56-ESQ over the course of a 10-day exercise heat acclimation protocol 3) Correlate all scales with physiological data. **Design:** 10-Day exercise heat acclimation protocol. **Setting:** College University. **Patients or Other Participants:** Eleven, non-trained, non-heat-acclimatized males (age 20±1y; height 183.7±8.4cm; weight 81.7±12.2kg; percent body fat 10.1±2.9%). **Interventions:** Subjects followed 10 consecutive days of heat acclimation (walking at 5.6 km·h⁻¹, 5% grade for 90 min duration; 33°C, 30-50% relative humidity). ESQ forms were completed on days 1,4,7 and 10 pre- and post-exercise. During exercise, rectal temperature (T_r) Heart rate (HR) and Rating of Perceived Exertion (RPE) were recorded. **Main Outcome Measures:** Correlations were performed with HR, T_r, and RPE. A one-way ANOVA assessed mean differences across days 1-10 while a Pearson's Bivariate Correlation was performed for correlations between ESQ scores and physiological data. An *a priori* alpha level of 0.05 was set. **Results:** Verification of heat acclimation was

based on T_r and HR, which were significantly greater on day 1 vs day 4 (P=0.004, P=0.002) and all-subsequent days. 56-ESQ and 14-ESQ were significantly lower beginning on day four compared to day one (P=0.004 and P=0.013 respectively) supporting evidence of heat acclimation. Pre-exercise ESQ scores across days 1-10 revealed no significant differences for 56-ESQ (P=0.998). Pre- and post-exercise 56-ESQ scores were significantly correlated with T_r, (P<0.001, R=0.378) HR (P<0.001, R=0.453), RPE (P<0.001, R=0.382). Post-exercise 14-ESQ was significantly correlated with T_r (P<0.001, R=0.529), HR (P<0.001, R=0.591), RPE (P<0.001, R=0.570). **Conclusions:** The 14-ESQ was significantly correlated with 56-ESQ during exercise heat acclimation. All ESQs were significantly correlated with physiological variables and signs and symptoms of heat stress. Both ESQ forms may be used during exercise heat acclimation as an efficient method to indicate environmental heat stress and symptoms.

Effect Of Fluid Administration On Ad Libitum Fluid Consumption And Hydration Status

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Context: The use of an external fluid administrator (EFA) to deliver fluids is a recent phenomenon in athletics. However, this has yet to be compared to the traditional method of self administration (SA). **Objective:** To examine the influence fluid

administration methods have on fluid consumption, hydration status, and perceptual variables (PV). **Design:** Randomized crossover design. **Setting:** Outdoor field study in warm conditions (22.2±3.5pC). **Participants:** Nineteen physically fit (>4x/wk) individuals (14M, 5F, 30±10y, 176±8cm, 72.5±10kg) were recruited from the university and local running clubs. **Interventions:** The independent variable was fluid administration (EFA and SA). EFA refers to when someone else squirts water into the participant's mouth, whereas SA, the participant squirts water into their own mouth. The water bottle (WB) was kept equal distance from the mouth for both conditions. Participants weight (t-shirt and/or shorts only) and urine samples were collected prior to exercise. Participants then completed a 10-min warm-up. Participants had a 2-min fluid break (FB) before the exercise protocol (EP), which included a series of five 15-minute stations. Exercises provided aerobic and anaerobic demands, including hill jogging, push-ups, jumping jacks, ladder drills, and intermittent rest. After completing each station, participants received a 5-min FB where they drank *ad libitum*. Fluid variables and PV were collected during every FB. Following the final FB, participants provided a post-exercise weight and urine sample. The order of conditions and exercise stations were randomly assigned. **Main Outcome Measures:** Hydration status was assessed via urine specific gravity (Usg) and body mass loss (BML). Fluid variables were total volume consumed (TVC), total number of squirts (TSq), and volume-per-squirt (VSq). PV for thirst and fullness were also recorded. Repeated-measures ANOVA was used for Usg and perceptual measures to analyze groups across time. All other variables were

analyzed by group with a paired t-test. $P < 0.05$ *a priori* **Results:** With no difference between conditions ($p = 0.49$), participants arrived hydrated (Usg SA = 1.016 ± 0.009 ; EFA = 1.019 ± 0.008) and remained (Usg SA = 1.019 ± 0.008 ; EFA = 1.020 ± 0.007) hydrated throughout. There was no statistically significant difference between SA (26 ± 9 mL) and EFA (20 ± 10 mL). A significant interaction ($F_{1,5} = 2.037, p = 0.05$) of condition and time for thirst was demonstrated; EFA indicated more thirst at FB 3 and 6 as compared to SA. A significant interaction ($F_{1,5} = 4.783, p = 0.001$) for fullness indicated SA felt more full during the last three FB. **Conclusions:** SA promoted more TVC likely due to greater VSq. Both conditions remained euhydrated, but EFA consumed less fluids and felt thirstier. Euhydration may have been maintained because of regularly spaced FB and when regular FBs are unavailable, EFA may result in more BML and hypohydration.

Thermoregulatory And Cardiovascular Responses To Intermittent, Superficial Cooling During Exercise In The Heat

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Context: Decreasing core body temperature during exercise in a hot, humid environment may improve exercise tolerance, facilitate acclimatization, and prevent exertional heat illness (EHI) from developing during intense summer training. In order to effectively cool athletes during exercise, the cooling method must be practical and easily worn during training or competition. **Objective:** Evaluate the effect of intermittent, superficial “phase change cooling” on thermoregulatory and cardiovascular responses during exercise in a hot-

humid environment. **Design:** A randomized, counterbalanced, repeated measures investigation with two conditions (Control, Cooling) during exercise and recovery. **Setting:** Outdoors on artificial turf in a hot, humid tropical climate in the sun ($WBG T_o = 27.0 \pm 0.8$ °C, range = 25.8-28.1 °C) and in the shade ($WBG T_o = 25.4 \pm 0.9$ °C, range = 24.3-26.8 °C). **Participants:** Purposefully sampled 16 participants from a pool of volunteers meeting inclusionary criteria and 10 were included in data analysis (age = 22.6 ± 1.6 y; height = 176.0 ± 6.9 cm; mass = 76.5 ± 7.8 kg; body fat = 15.6 ± 5.4 %). **Interventions:** Participants wore one of the following: shorts and t-shirt (Control) or cooling vest (Cooling) during 5-min rest breaks every 20 min during 60 min of intense, exercise in the heat. Participants were monitored every 5 min during 30 min of recovery in the shade. Exercise sessions consisted of typical American football training and conditioning exercises at an average heart rate of 85-95% of heart rate maximum. Participants consumed cold water *ad libitum*. Meals, snacks, and pre-exercise hydration status were controlled. **Main Outcome Measures:** We assessed gastrointestinal (T_{gi}) and skin (T_{sk}) temperature, and heart rate (HR) during intermittent rest breaks during exercise and recovery. A 2-way repeated-measures (condition x time) analysis of variance (ANOVA) was used and data are reported as mean \pm SD. **Results:** During rest breaks, T_{gi} was significantly ($p = 0.046$) decreased in Cooling (38.2 ± 0.2 °C) compared to Control (38.5 ± 0.1 °C). The difference in T_{gi} (ΔT_{gi}) between pre- and post-cooling breaks was significantly less ($p = 0.033$) in Cooling (-0.1 ± 0.1 °C) than Control (-0.4 ± 0.2 °C). During recovery, T_{gi} was not significantly different ($p = 0.450$, partial eta squared = .028, power = .074) between Cooling (37.8 ± 0.1 °C) and Control (37.8 ± 0.1 °C). During rest breaks, T_{sk} was significantly ($p < 0.001$) decreased in Cooling (31.8 ± 0.4 °C) compared to Control (34.4 ± 0.5 °C). During recovery, T_{sk} was significantly ($p = 0.001$) lower in Cooling (32.2 ± 0.5 °C) compared to Control (32.8 ± 0.4 °C). During rest breaks, HR

was not significantly different ($p = 0.307$, partial eta squared = 0.115, power = 0.163) between Cooling (147.6 ± 2.6 bpm) and Control (150.1 ± 3.5 bpm). During recovery, HR was significantly ($p = 0.005$) lower for Cooling (95.3 ± 2.6 bpm) than Control (102.4 ± 4.1 bpm). **Conclusions:** Phase change cooling was effective in reducing skin temperature but core body temperature and cardiovascular strain were not sufficiently attenuated during exercise. Superficial cooling may be useful in decreasing skin temperature during exercise and facilitating recovery after exercise in the heat; however, it should not replace ice water immersion in the treatment of EHI.

Effect Of Water Bottle Fluid Delivery On Ad Libitum Fluid Consumption And Hydration Status

Yeargin SW, Finn ME, Eberman LE, McDermott BP, Gage MJ, Niemann AJ: Department of Applied Medicine and Rehabilitation, Indiana State University, Terre Haute, IN, and Department of Health and Human Performance, University of Tennessee at Chattanooga, Chattanooga, TN

Context: Athletic Trainers commonly provide fluids during team athletic events with water bottles (WB). When a minimal number of WB exist, the team must share and avoid mouth-to-bottle contact, whereas individual bottles eliminate this issue. **Objective:** To determine if fluid delivery, by allowing mouth-to-bottle contact or not, influences fluid consumption and hydration status. **Design:** Randomized crossover design. **Setting:** Outdoor field study in warm conditions (22.2 ± 3.5 °C). **Patients or Other Participants:** Nineteen physically fit (> 4 x/wk) individuals (14M, 5F, independent variable was fluid delivery with two levels; drinking with mouth-to-bottle contact (MOn) or drinking with the mouth 1-2in away from the WB top (MOff). Participants arrived at a local park, weighed in wearing only t-

shirt and/or shorts, and provided a urine sample. They warmed-up for 10min and then exercised for 75min. Each station involved aerobic and anaerobic exercise such as hill jogging, ladder drills, and jumping jacks with intermittent rest; each lasting 15min. After the warm up, a 2min fluid break(FB) was given, and after every station, a 5min FB was given. Participants drank *ad libitum*, had their own 1L squeeze pop-top WB, and were provided a filled WB at each FB. All dependent variables were measured at each FB. After the last FB, participants weighed and provided a urine sample again. The order of conditions and the order of exercise stations were randomly assigned.

Main Outcome Measures:

Hydration status via urine specific gravity(Usg) and body mass loss was recorded. Fluid variables measured were total volume consumed(TVC), total number of squirts(TSq), and volume per squirt(VSq). Perceptual variables for thirst and fullness were also recorded. Repeated-measures ANOVA was used for Usg and perceptual measures to analyze groups across time. All other variables were analyzed by group with a paired t-test. $P < 0.05$ *a priori*. **Results:** Participants arrived (Usg 1.017 ± 0.009) and remained (Usg 1.019 ± 0.008) hydrated, with no difference between conditions ($p = 0.49$). MOff lost (0.989 ± 0.454 kg) significantly more ($p = 0.05$) body mass than MOn (0.778 ± 0.567 kg). MOn drank significantly ($p = 0.05$) more TVC (1.060 ± 0.526 L) than MOff (0.867 ± 0.312 L). MOn and MOff significantly ($p = 0.009$) differed in TSq; 30 ± 14 and 35 ± 16 respectively. MOn drank significantly ($p = 0.035$) more VSq (37 ± 24 mL) than MOff (26 ± 9 mL). There was no interaction between condition and time for thirst ($F_{1,5} = 2.117, p = 0.207$). An interaction ($F_{1,5} = 3.013, p = 0.014$) for fullness demonstrated MOn felt more full during the second FB than MOff.

Conclusions: MOn condition increased *ad libitum* TVC with fewer TSq needed and maintained euhydration. This may help athletes

with good hydration in a less amount of time during an event. MOff also maintained euhydration but needed more TSq and drank less TVC. When possible, athletic trainers should employ personal WB for athletes and provide regularly spaced FB to encourage good hydration behaviors.

Free Communications, Oral Presentations: Shoulder Girdle Adaptations In Overhead Athletes

Wednesday, June 22, 2011, 8:00AM-8:45AM, 9:00AM-9:45AM, Room 217; Moderator: TBD

Changes In Glenohumeral Rotational Range Of Motion In Collegiate Baseball Players: Predictive Factors

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Context: Understanding which factors predispose overhead-throwers to changes in glenohumeral range of motion (ROM) may help clinicians identify those susceptible to the pathologies associated with glenohumeral internal rotation deficit.

Objective: To observe overhead-throwers' range of internal and external rotation (IR, ER) over the course of an athletic season and to identify predictors of ROM changes.

Design: Observational repeated-measures design.

Setting: Collegiate Athletic Training Clinics.

Participants: Twenty-nine healthy NCAA Division-I (n=12) or Division-II (n=17) baseball athletes (13 pitchers, 16 fielders, 19.9±1.5y, 179±14cm, 87.7±11.1kg).

Interventions: Investigators (PD and PT) measured ROM (inter-rater reliability ICC range=0.79-0.96) for Division-I and-II athletes in their respective athletic training clinics prior to the fall and after the spring baseball season.

Main Outcome Measures: We measured bilateral passive glenohumeral IR and ER using a mechanical inclinometer (Sears, Roebuck & Co, Chicago IL). Maximum ROM was achieved at a firm capsular end-feel or just prior to scapular motion. Using SAS 9.2 (SAS, Cary, NC), investigators conducted multiple regression analyses using independent variables: pre-season IR and ER, years of baseball experience, NCAA division, position (pitcher, non-pitcher) with the dependent variable of change in total arc (IR+ER) of motion between pre-fall and post-spring measures ($p<0.05$ a priori). **Results:**

Athletes reported 13.4±3.1 years experience and exhibited 43.3±13.0° of IR and 96.2±14.7° of ER during pre-fall measurements. Athletes gained 11.3±19.2° of total arc over the course of the season. Using the full regression model: change in total arc = position + pre-season IR + pre-season ER + experience + division, investigators accounted for 78% of the variance in change in total arc ($F_{5,28}=16.01$, $p<0.001$, $R^2=0.78$). Statistically, position ($t_{28}=-0.00$, $p=0.99$), experience ($t_{28}=1.63$, $p=0.12$), and pre-fall IR ($t=0.53$, $p=0.60$) were not significant contributors to changes in total arc and were dropped from the model. The refined regression model: total arc change = division + pre-fall ER accounted for 74% of the variance in total arc changes ($F_{2,28}=37.6$, $p<0.001$, $R^2=0.74$). Division was a significant contributor to changes in total arc ($t_{28}=8.67$, $p<0.001$) as was pre-season ER ($t_{28}=3.89$, $p=0.002$). Division-I athletes gained 7° IR and 21° ER and Division-II athletes lost 3° IR and gained 3° ER. Pre-season ER was 104° for Division-I athletes and 90° for Division-II athletes. **Conclusions:** Division-I and Division-II athletes displayed similar pre-season total arc (137 and 140°, respectively). Division-I players increased their total arc of motion over the season, while Division-II players did not. Monitoring these changes throughout the season should identify those athletes developing the conditions associated with injury including any loss of IR that is not met with an equal gain of ER. Clinicians should consider the effect pre-season ER and level of competition may have on the total arc when monitoring ROM throughout the season.

Dynamic Acromiohumeral Interval Changes In Trained And Untrained Females With Differences In External Rotation Strength

Thompson MD, Landin D, Page P: Louisiana State University, Baton Rouge, LA

Context: Previous research has demonstrated narrowing of the acromiohumeral interval (AHI) during arm elevation. Weakness and fatigue of the external rotators may result in further narrowing. Previous static AHI comparisons between trained and untrained individuals are contradictory and no research has directly compared dynamic AHI differences between these groups.

Objective: To determine if dynamic AHI differences exist between trained females with strong external rotators (ER) and untrained females with relatively weaker ER during loaded and unloaded scaption.

Design: Descriptive cohort study design.

Setting: Athletic training facility.

Participants: Fifteen, female, collegiate softball and volleyball players (age = 19.5±0.6 years, mass = 69.9±10.1 kg, height = 1.70±.06 m, ER strength = 13.4±1.6 kg) with no history of surgery or current injury involving their dominant arm. Fifteen, collegiate females with no history of regular overhead sport participation (age = 20.5±1.8 years, mass = 63.6±13.3 kg, and height = 1.65±.09 m, ER strength = 7.9±1.7 kg).

Interventions: Participants performed three trials each of an unloaded and loaded scaption exercise from 0°-90° while seated. Amount of load during the weighted scaption exercise was normalized based on anthropometric data for each participant. True anterior-posterior fluoroscopic images of the glenohumeral joint were captured in real time video during the last two trials of each condition. Video was captured at 30 frames per second with a

1000x1000 pixel resolution, transferred via a digital video recording device to a computer and analyzed using OsiriX software. A repeated measures ANOVA was used to detect dynamic AHI differences based on load (loaded, unloaded), position (0°, 30°, 60°, 90°), and group (athlete, untrained). Post hoc *t* tests were performed as necessary. **Main Outcome Measures:** ER strength was calculated as the average of three seated, maximal voluntary isometric contractions against a handheld dynamometer stabilized by the wall. AHI was measured as the smallest vertical distance between the inferior acromion and superior humeral head. AHI values were recorded at 4 humeral-thoracic elevation positions (0°, 30°, 60°, 90°). One investigator (MT) performed all measurements. **Results:** Athletes had significantly greater ER strength ($P<.001$) and a significantly larger overall AHI than the untrained females ($P=.003$). On average athletes had an AHI that was $2.05\pm.49$ mm wider between 0°-30° during unloaded scaption and $1.73\pm.64$ mm wider between 0°-60° during loaded scaption. Regardless of group, loaded scaption (4.7 ± 1.6 mm) resulted in significantly greater ($P<.001$) AHI narrowing compared to unloaded scaption (5.5 ± 1.6 mm). **Conclusions:** Healthy female athletes with strong ER had a significantly wider AHI between 0°-60°. Regardless of differences in strength, both groups experienced an 11%-14% narrowing of the AHI with the application of an external load during scaption. Future research should attempt to determine if external rotation strengthening protocols could improve dynamic AHI.

Association Between A History Of Upper Extremity Injury And Maximum Upper Torso-Pelvis Separation Angle During Throwing In Collegiate Softball Position Players

Oyama S, Aragon VJ, Oliaro SM, Padua DA, Myers JB: University of North Carolina at Chapel Hill, Chapel Hill, NC, and Duke University, Durham, NC

Context: Throwing-related upper extremity injuries are common among competitive softball players. During throwing, coiling/re-coiling of the trunk is necessary to store and transfer energy to the upper extremity. Therefore, excessive or insufficient coiling (separation between the upper torso and the pelvis) may place the anterior trunk and shoulder musculature in suboptimal lengths during the re-coil, and thereby lead to development of upper extremity injuries. However, whether the absolute amount of maximum upper torso-pelvis separation (max-separation) and the max-separation relative to the available trunk rotation range of motion (ROM) (normalized max-separation) are linked to the upper extremity injuries has not been investigated. **Objective:** To investigate an association between the throwing-related upper extremity injury history and the maximum upper torso-pelvis separation angle during throwing in softball position players. **Design:** Cross-sectional design. **Setting:** University softball fields. **Patients or Other Participants:** Sixty-five collegiate softball position players (age = 19.5 ± 1.2 years, height = 165.4 ± 7.0 cm, mass = 69.1 kg). **Interventions:** Each participant completed a questionnaire to provide a recent (past 2 years) upper extremity injury history, and performed five maximum-effort throws (distance= 25.9 m), during which the mechanics were captured using two video cameras. For each trial, the video footages were manually digitized, synchronized, and processed using a direct linear transformation to calculate the max-separation. Additionally, a half-

kneeling rotation test was performed to measure the trunk rotation ROM towards the side of the throwing arm to calculate the normalized max-separation (=max-separation/trunk rotation flexibility*100), which represents how much of the available ROM a person uses when throwing. **Main Outcome Measures:** Mean of the variables from the three highest self-rated trials were used for analyses. Independent samples *t*-tests were used to compare the max-separation angle and the normalized max-separation between groups with and without an injury history. Logistic regression was used to calculate the odds ratio of having an injury history between the participants categorized (using tertiles) to demonstrate high and low normalized max-separation. **Results:** While the max-separation was not significantly different between groups (mean difference= $3.4\pm7.6\%$, $t_{1,63}=1.65$, $p=0.10$), normalized max-separation was significantly greater in the group with an injury history compared to the group without (mean difference= $12.7\pm17.5\%$, $t_{1,63}=2.66$, $p=0.01$). Participants with high (>68.1%) normalized max-separation were 5.5 times (CI:1.3-23.7) more likely to have an injury history compared to those with low (<50.6%) normalized max-separation ($X^2=6.6$, $p=0.04$). **Conclusions:** The results indicate that individuals who use a greater percentage of their available ROM are at greater risk for injury. Coiling/re-coiling of the trunk is necessary for effective energy transfer to the upper extremity during throwing. Therefore, improvement of the available trunk rotation ROM through combination of stretching and neuromuscular training may allow greater max-separation to occur within the optimal range of the trunk rotation ROM, and thereby help prevent the development of the upper extremity injuries.

Humeral Retrotorsion Is Associated With Decreased Shoulder Internal Rotation And Horizontal Adduction Range Of Motion In The Professional Pitchers But Not Elite Quarterbacks

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Context: Humeral torsion(HT) is thought to contribute to alterations in shoulder external(ER), internal(IR), and horizontal adduction(HA) range of motion(ROM) in the throwing(T) shoulder. Biomechanical differences are documented between the pitcher's and quarterback's(QB) throwing motion but it is unknown if these influence their respective osseous adaptations or shoulder ROM. **Objective:** The purpose of this study was to compare HT and shoulder ROM between a group of professional pitchers and QBs participating at the 2010 NFL Combine. **Design:** Cross Sectional **Setting:** Field Laboratory **Patients:** 50 (36 right; 14 left) professional pitchers (mean age=23; height=190cm; weight=88kg) and 17(15 right; 2 left) elite QBs(mean age=22; height=189cm; weight=94kg) were currently asymptomatic and participating without restriction in spring training or the NFL Combine respectively. **Interventions:** A digital inclinometer was used to measure bilateral ER, IR, HA ROM and HT in supine with the scapula stabilized at 90° of abduction. HT was measured via an indirect ultrasonographic technique. All measures displayed acceptable reliability ($ICC_{(2,1)}=0.88-0.92$) and 2 trials were averaged for analysis. **Main Outcome Measures:** A mixed-model ANOVA(sideXsport) was used to compare the T and NT shoulder for ER, IR, HA and HT between sports. Pearson correlation coefficients and a stepwise linear regression were then evaluated to assess to what degree ER, IR, and HA was influenced by HT for each sport($\alpha = 0.05$). Only effects involv-

ing sport were interpreted. **Results:** There was a significant main effect for sport indicating that pitcher's ER ROM (Pitchers = $130^\circ \pm 9.5^\circ$; QBs = $117.3 \pm 11^\circ$) was greater compared to QBs. There were no significant interactions effects indicating that sport did not influence side to side differences in HT, IR, or HA ($p>.05$). There were significant correlations between HT and IR($r=-.67$; $p<0.01$), HA($r=-.50$; $p<0.01$), ER($r=-.27$; $p=0.01$) for the T shoulder of pitchers. There were no significant correlations between T arm HT and IR($r=-0.33$; $p=0.11$), HA($r=-.34$; $p=0.09$), ER($r=-.24$; $p=0.17$) showing that HT was not associated with ER, IR, or HA in QBs. Regression analyses revealed that both IR($R^2=.45$, $P<.05$) and HA($R^2=.25$, $P<.05$) were significant predictors of HT in pitchers but not QBs. The final regression model indicated IR and HA together predicted HT($R^2=.52$, $P<.05$) independent of gains in ER($R^2=.12$, $P=.14$) for pitchers. **Conclusions:** Our results show the T shoulder of pitchers displays greater overall ER but similar alterations in HT, IR and HA to QBs. Interestingly, HT influences clinical measures of shoulder IR and HA ROM in pitchers independent of gains in ER. However, in this small sample HT did not influence clinical measures of shoulder ROM or account for the observed differences in shoulder ROM in elite QBs. Therefore, changes in QB ROM are likely the result of soft tissue adaptations. Clinicians should carefully interpret ROM measures in QBs and pitchers and in particular IR and HA ROM of the pitching shoulder. Future studies should examine a larger sample to confirm these results.

Predictors Of Dominant Limb Humeral Retrotorsion In High School Baseball Players

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Context: Baseball players' dominant limbs demonstrate greater humeral retrotorsion compared to their non-dominant limb and the limbs of the non-overhead athletes. This increased dominant limb humeral retrotorsion (DLHR) in baseball players is believed to be a result of a combination of a congenital contribution and the retrotorsion acquired due to the torsional stress applied to the humerus from throwing. It is considered that the greater the magnitude and cumulative frequency of the stress applied to the humerus, greater the retrotorsion acquired. Therefore, the amount of DLHT may be predicted from the congenital contribution, physical characteristics, and participation factors that may affect the torsional stress applied to the bone. **Objective:** To determine whether the congenital contribution, physical characteristics, and participation factors are predictive of the amount of humeral retrotorsion in the dominant limb of high school baseball players. **Design:** Cross sectional design. **Setting:** High school sports medicine and/or baseball facilities. **Participants:** 312 varsity high school baseball players (age = 16.5 ± 1.0 years, mass = 77.5 ± 12.6 kg, height = 180.1 ± 6.8 cm). **Interventions:** Subject demographic, height, and mass were obtained. Bilateral humeral retrotorsion was measured using ultrasonography and a digital inclinometer ($ICC=.96-.98$, $SEM=2.0-2.3^\circ$). Shoulder rotation strength was measured with a handheld dynamometer ($ICC=.90-.92$, $SEM=.73-.74\%$). Additionally, participants completed a survey regarding their baseball participation history. **Main Outcome Measures:** Univariate linear regressions were used to determine if

the congenital, physical characteristics, and baseball participation factors are predictive of DLHR in high school baseball players. The amount of non-dominant limb humeral retrotorsion (NLHR) is representative of the congenital contribution affecting DLHT. The physical characteristic predictor variables included age, height, mass, humeral internal rotation (IR) and external rotation (ER) strength normalized to body mass, and ER:IR strength ratio (ER:IR). Baseball participation predictor variables were years of baseball participation (YBP), seasons played in the past 3 years (S3), years of pitching experience (YPE), and seasons pitched in the past three years (SP3). **Results:** NLHR significantly predicted DLHR ($n=312, r^2=.347, p<.0001$). Age ($n=311, r^2=.004, p=.27$), height ($n=308, r^2=.003, p=.37$), mass ($n=312, r^2=.009, p=.11$), IR strength ($n=292, r^2=.004, p=.25$), ER strength ($n=291, r^2=.005, p=.23$), and ER:IR ($n=291, r^2=.002, p=.50$) were not predictors. YPE was a statistically significant predictor of DLHR ($n=250, r^2=.031, p=.01$), yet only explained 3.1% of the variance in DLHT. YBP ($n=311, r^2=.000, p=.85$), S3 ($n=312, r^2=.010, p=.07$), YPE ($n=250, r^2=.031, p=.01$), and SP3 ($n=242, r^2=.000, p=.03$) were not significant predictors. **Conclusions:** The results indicate that 35% of the variance in DLHR can be explained by NLHR, which represents the congenital contributor influencing the DLHR. None of the physical characteristics or the participation variables individually explained more than 3% of the variance in DLHT. Factors not accounted for in the current study that need to be examined in future studies include throwing mechanics, skeletal maturity, and more detailed participation factors (exposure, competitive level, and participation/pitching volume variables). Further research using prospective designs are needed given the limitations of cross-sectional studies.

Humeral Retroversion And Its Association With Posterior Capsule Thickness In Collegiate Baseball Players

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Context: Baseball players commonly present with decreases in internal rotation (IR) and concurrent increases in external rotation (ER) motion. Several glenohumeral adaptations have been theorized to cause these changes in motion including humeral retroversion and posterior capsule thickness (PCT). However, limited data exists examining the interrelationship between humeral retroversion and posterior capsule thickness. **Objective:** To measure humeral retroversion, glenohumeral (GH) IR and ER rotation, and posterior capsule thickness. **Design:** A single group post test only. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** Twenty four division one collegiate baseball players (age = 19.6 ± 1.3 years, mass = 89.2 ± 5.8 kg, height = 186.3 ± 4.9 cm) with no current injury or surgery in the past eight months. **Interventions:** Independent variables were arm (dominant and non-dominant). Humeral retroversion and posterior capsule thickness was measured with an ultrasound system (Sonosite Titan, Sonosite Inc., Bothell, WA) and GH internal and external rotation (IR) was

measured with a Saunders Digital Inclinometer (The Saunders Group Inc. Chaska, MN). A paired sampled t-test was performed to compare humeral retroversion bilaterally. Separate Pearson correlations were performed for humeral retroversion, IR, ER, and PCT. **Main Outcome Measures:** Humeral retroversion was measured supine with the arm abducted to 90° and elbow flexed to 90° . GH IR and ER were measured supine with the scapula stabilized. PCT was measured seated with the arm at the side in neutral rotation. **Results:** The dominant arm had significantly more retroversion ($15.6^\circ, p=.0001$) than the non-dominant arm. A significant negative relationship was found between humeral retroversion and GH IR ($-0.472, p=0.001$) and a significant positive relationship between humeral retroversion and GH ER ($0.295, p=0.042$). A significant positive correlation was also found between humeral retroversion and PCT ($0.427, p=0.003$). **Conclusions:** This was the first study to identify a relationship between humeral retroversion and PCT in addition to GH IR & ER. The identification of these multiple correlations appears to suggest that the loss of IR caused from humeral retroversion may be placing additional stress on the posterior capsule during the deceleration phase of the throw thereby causing a fibroblastic healing response. Humeral retroversion has previously been identified as a positive adaptation due to the increase in external rotation without anterior capsule attenuation. However, the current study suggests that humeral retroversion may be contributing to the negative adaptation of posterior capsule thickness. Additional research should prospectively evaluate baseball players to identify the sequential development of these adaptations and how they contribute to injury.

Free Communications, Oral Presentations: Knee Injury Prevention StrategiesWednesday, June 22, 2011, 11:15AM-12:45PM, Room 217; Moderator: Grace Golden, PhD, ATC

Variability of Hip and Knee Joint Biomechanics During Running for Patients With Patellofemoral Pain Syndrome

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Context: Most research studies suggest that reduced movement variability (MV; the ability to produce a consistent and controlled movement pattern) may be associated with running injuries, such as patellofemoral pain syndrome (PFPS). To date, researchers have not determined if MV changes may occur following rehabilitation. **Objective:** To determine the effect of a 6-week rehabilitation protocol on knee and hip joint MV for patients with PFPS. At baseline, we hypothesized that PFPS patients would exhibit reduced involved limb MV compared to controls and that MV would increase after rehabilitation compared to baseline values. We expected no change for the control group knee or hip MV following the protocol. **Design:** Cohort intervention, repeated measures design. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Twenty PFPS patients, assessed by an AT and meeting inclusion criteria based on Boling et al. (2006), volunteered to participate (5 males, 15 females: age=32.2±10.1 years; mass=66.3±9.7kg; height=155.3±8.8cm) Twenty age, limb, and mileage-matched controls (5 males, 15 females: age=30.8±9.8 years; mass=70.6±11.3kg; height=153.3±6.2cm)

also participated. All participants ran a minimum of 20km per week. **Interventions:** Baseline measures of three-dimensional (3D) knee and hip kinematics were recorded using a Vicon 8-camera system (200 Hz) for 25 consecutive footfalls for the PFPS involved limb and matched control limb while running at 2.55 m/s on a treadmill. As part of a larger RCT protocol, PFPS and control subjects were randomized into a 6-week hip- or knee-focused rehabilitation protocol. Both groups were tested at baseline and at 6-weeks. **Main Outcome Measures:** 3D frontal and transverse plane knee and hip joint angles (degrees) were derived, relative to the lab coordinate system. MV (mm²) was defined as the total area of joint motion, in both planes, calculated using custom-written a Matlab program for the 25 footfalls. Between- and within-group differences were determined using 2 (group) x 2 (time) repeated measures ANOVAs and a priori post-hoc testing ($P \leq 0.05$). **Results:** At baseline, PFPS exhibited significantly greater ($P=0.02$) involved knee MV (254.91±96.15mm²) compared to controls (190.38±74.98mm²) and significantly greater ($P=0.05$) involved hip MV (357.32±94.84mm²) compared to controls (309.71±92.54mm²). After 6-weeks, PFPS showed significantly reduced knee ($P=0.03$; 214.44±83.26mm²) and hip ($P=0.04$; 305.22±83.27mm²) MV compared to baseline. Controls showed no change in MV after 6 weeks (knee: 195.38±57.66mm², $P=0.73$; hip: 298.73±97.45mm², $P=0.55$). **Conclusions:** Contrary to the hypotheses, baseline MV was higher for the PFPS involved knee and hip joints compared to controls. Also contrary to the hypotheses, regardless of intervention assignment, PFPS demonstrated reduced knee and hip MV following a 6-week intervention. This is the first

study to determine whether PFPS patients exhibit MV changes following rehabilitation. Funded by the NATA Foundation.

A Comparison Of Lower Extremity Muscle Strength Between Individuals With Patellofemoral Pain Syndrome And Individuals At Risk For Future Development Of Patellofemoral Pain Syndrome

Boling MC, Padua DA, Marshall SW, Beutler AI: University of North Florida, Jacksonville, FL; University of North Carolina, Chapel Hill, NC; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Previous research indicates weakness of the lower extremity musculature in individuals with patellofemoral pain syndrome (PFPS); however, it is not known if this weakness is present prior to or following the development of PFPS. **Objective:** To compare baseline measures of lower extremity isometric strength between individuals who currently have PFPS and individuals who later develop PFPS. **Design:** Prospective cohort. **Setting:** US Military Academy. **Patients or Other Participants:** The cohort consisted of 1,525 cadets (606 females, 919 males; height=172.46±8.87cm, mass=71.31±11.54kg) who were freshmen at the time of enrollment in the current investigation. **Interventions:** Each participant underwent a baseline assessment of isometric strength of the hip and thigh musculature. Participants performed two trials for each strength test and all strength data were normalized to body mass. A baseline questionnaire was completed at the time of strength testing to determine if individuals had a history of PFPS that currently limited their

ability to participate in physical activity. Individuals reporting yes to this question were included in the “injured” group. Following baseline data collection, participants who did not report a history of PFPS were followed prospectively for a maximum of 4 years to determine those diagnosed with PFPS. Individuals who developed PFPS during the 4-year follow up period, which was determined by a manual review of medical records by the principal investigator, were included in the “at risk” group. **Main Outcome Measures:** Normalized mean and peak isometric strength of the knee flexors, knee extensors, hip extensors, hip abductors, hip internal rotators, and hip external rotators were averaged across the two trials and included in the data analysis. Independent t-tests were performed to compare isometric strength between the “injured” and “at risk” groups (≤ 0.05). **Results:** Sixty cadets (31 females, 29 males) reported a history of PFPS that currently limited their ability to participate in physical activity (“injured” group). Sixty-three cadets (34 females, 29 males) were diagnosed with PFPS during the follow-up period (“at risk” group). The “at risk” group had significantly weaker average ($0.248 \pm 0.057\% \text{BW}$ vs. $0.273 \pm 0.075\% \text{BW}$; $P=0.03$) and peak ($0.308 \pm 0.072\% \text{BW}$ vs. $0.342 \pm 0.097\% \text{BW}$; $P=0.04$) isometric strength of the hip extensors. While differences in the other lower extremity muscle strength measures were not statistically significant between groups ($P>0.05$), the “at risk” group displayed lower strength values for all muscle groups compared to the “injured” group. **Conclusions:** While lower extremity strength training is common in treating those with PFPS, strengthening of the lower extremity muscle groups (especially the hip extensors) is an important component that should be incorporated in injury prevention programs aimed at reducing the risk of future development of PFPS.

Neuromuscular Factors Influencing External Knee Valgus Moment In Males And Females

Padua DA, Boling MC, Goerger BM, Beutler AI, Marshall SW: Sports Medicine Research Laboratory, University of North Carolina, Chapel Hill, NC; University of North Florida, Jacksonville, FL; Uniformed Services University of the Health Sciences, Bethesda, MD

Context: Preliminary evidence indicates external knee valgus moment (KVM) is a risk factor for ACL injury. External KVM is also greater in females, who are at increased risk of ACL injury, compared to their male counterparts. Thus, it is important to understand mechanisms associated with increased external KVM. Modifiable factors associated with external KVM are likely multifactorial and may be sex-specific. **Objective:** To determine the association between external KVM and lower extremity biomechanics and strength in males and females. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** 2,662 healthy, physically active participants (males=1,640; females=1032; age= 18.6 ± 0.6 yrs, ht= 173.5 ± 9.2 cm, wt= 71.9 ± 12.9 kg). **Interventions:** Three-dimensional knee and hip joint kinematics and kinetics were quantified using an electromagnetic motion analysis system and force plate while participants performed a jump-landing task (3-trials). Strength was measured using a hand-held dynamometer during a 5-second maximal voluntary isometric contraction (2-trials). **Main Outcome Measures:** Joint angles at initial contact (IC), peak (PK), and displacement (DSP) were identified. Peak joint moments and vertical ground reaction force (VGRF) were also determined. Kinematic and kinetic variables were measured during the first 50% of the stance phase. Separate strength values were

obtained for the knee extensors, knee flexors, hip abductors, hip extensors, hip internal rotators, and hip external rotators. Multivariable linear regression (backward elimination) was performed for the criterion variable of external KVM. The predictor variables included hip and knee joint angles (deg) at IC, PK and DSP; peak internal hip and knee joint moments (normalized to body weight x height); peak VGRF (normalized to body weight); and strength values for all muscles (normalized to body weight). Analyses were performed using all participants and stratified by sex. **Results:** The most parsimonious regression model using all participants included internal hip adduction moment ($.12 \pm .06$), internal hip internal rotation moment ($.06 \pm .03$), VGRF ($3.02 \pm .93$), and knee valgus DSP (3.80 ± 4.45) (R^2 adjusted= $.559$, $P<.001$). The same predictor variables were included in the most parsimonious regression models for males (R^2 adjusted= $.583$, $P<.001$) and females (R^2 adjusted= $.523$, $P<.001$), separately. **Conclusions:** There were no sex differences in factors predicting external KVM. Greater external KVM was associated with increased internal hip adduction and internal rotation moments, VGRF, and knee valgus DSP. Internal hip adduction and internal rotation moments were the strongest predictors of external KVM for both males and females. Muscle strength was not included in the regression models and does not appear to be a major factor associated with external KVM. These findings provide insight into mechanisms associated with external KVM, which may have implications on understanding ACL injury risk factors and designing injury prevention programs.

non-effused knees but investigators should evaluate correlations between normalized and raw concentrations to ensure the data are representative of raw concentrations. This technique may be valuable for examining post-traumatic osteoarthritis onset and progression.

Quantification of Knee Load Associated with Increased Risk for Specific Knee Injury Incidence

Myer GD, Ford KR, Hewett TE: Cincinnati Children's Hospital Medical Center, Cincinnati, OH; University of Cincinnati, Cincinnati, OH; Ohio State University Sports Medicine, Columbus, OH

Context: Patellofemoral dysfunction and the resultant pain symptoms (PFP) affects up to 30% of people aged 13-19 years. PFP symptoms lead three-quarters of affected patients to limit recreational activities or to cease physical activity altogether. Injuries to the Anterior Cruciate Ligament (ACL) result in the greatest time lost from sport and recreational participation by young athletes. Interestingly, there is a similar sex disparity in both conditions, as adolescent females and young women are affected with PFP and ACL injury 2-10 times more often than their male counterparts. Altered or reduced motor control during physical activities result in excessive knee abduction joint load in females. This neuromuscular dysfunction appears to increase risk of acute ACL injury and chronic PFP in females. **Objectives:** The purpose of this study was to compare incidence rates and threshold knee abduction load during landing associated with increased risk of PFP and ACL injury. **Design:** Prospective cohort study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Middle and high school female athletes (n=145) were evaluated by a physician for PFP and for landing biomechanics prior to their basketball season and monitored by certified athletic trainers for PFP

during their competitive seasons. Likewise, 205 high school female volleyball, soccer and basketball athletes were evaluated for landing biomechanics prior to their competitive season and monitored for ACL injury during their competitive seasons. **Interventions:** Logistic regression analyses determined threshold knee abduction moment cut-scores that provided the maximal sensitivity and specificity for prediction of PFP and ACL injury risk. Incidence rates were expressed per 100 athlete competitive seasons. **Main Outcome Measure:** Positive PFP and ACL injury status. **Results:** The cumulative incidence rate for new PFP incidence was increased 2.2 (95% CI 1.11 to 4.34) relative to ACL injury when normalized per 100 athlete seasons (PFP 9.7 vs ACL 4.4). Regression analysis indicated that PFP risk increased in athletes who demonstrated >15.4 Nm of knee abduction, while ACL injury risk increased with peak landing knee abduction torque >25.3 Nm. **Conclusions:** Females who demonstrate >15 Nm of knee abduction during landing may be at increased risk for the development of PFP and those who demonstrate >25 Nm of knee abduction during landing may be at increased risk for both PFP and ACL injury. The increased incidence of PFP relative to ACL injury is likely associated with the reduced threshold of knee abduction associated with increased risk of PFP. Focused pre-season exercise intervention may be warranted for females who land with greater than 15 Nm of knee abduction, while those females who land with >25 Nm of knee abduction may benefit from increased treatment dosage gained from both pre-season and in-season neuromuscular training protocols aimed to reduce knee abduction and PFP/ACL injury incidence.

The Effects Of Compliance With Neuromuscular Training On Anterior Cruciate Ligament Injury Risk Reduction In Young Female Athletes: A Meta-Analysis

Sugimoto D, Myer GD, Bush HM, Klugman MF, Medina McKeon JM, Hewett TE: Cincinnati Children's Hospital Medical Center, Cincinnati, OH; University of Kentucky, Lexington, KY; Ohio State University, Columbus, OH

Context: Although neuromuscular training (NMT) programs are often prescribed to reduce the incidence rates of noncontact anterior cruciate ligament injuries (ACL) in young female athletes, the influence of compliance to these programs on ACL injury outcome remains unclear. **Objective:** To systematically review and synthesize previously published studies to determine the effect of NMT compliance on reduction of ACL injury incidence. **Data Sources:** A computerized search was performed using PubMed, SPORT Discus, CINAHL, and Medline(1995-2010) in February, 2010. Key words were "anterior cruciate ligament prevention", "ACL prevention", "knee prevention", "neuromuscular training", "neuromuscular intervention", and "prospective knee prevention". **Study Selection:** Criteria for inclusion required that 1) actual number of ACL injury incidents were reported, 2) a NMT program was utilized, 3) studies included females, 4) studies were prospective, controlled trials, and 5) compliance to programs were documented. **Data Extraction:** Study quality was assessed using the PEDro scale. Extracted data included: the number of ACL injuries (#ACL), total numbers of subjects in each group (#Total Subjects), observation time periods (Months), number of subjects who completed each session, number of sessions completed by an entire team, and number of total sessions. ACL injury incidence rates (ACL-IR) were calculated [#ACL/#Total Subjects x Months]. The variable Athlete

Attendance Rate (Attendance) was calculated as the reported number of subjects who completed each session converted into a percentage of the total number of subjects in the intervention group. The variable Session Completion Rate (Completion) was calculated as the reported number of sessions completed by an entire team converted into a percentage of the total number of training sessions in the intervention period. These data were used to calculate Overall Compliance Rate (Compliance) [Compliance = Attendance x Completion]. Compliance was initially dichotomized into high or low using the mean Compliance as the cutoff. Compliance was further broken down to high (>66%), moderate (33-66%), or low (<33%). Incident rate ratios (IRR) were used to compare ACL-IRs among the binominal and tertiary Compliance categorizations. The quality of evidence was assessed using the Centre of Evidence Based Medicine (CEBM)–Levels of Evidence. **Data Synthesis:** Six of 205 studies were included. The average PEDro score was 5/10 (range: 4 to 7). Results are presented as IRR [95% Confidence Intervals]. The IRR analysis with dichotomous compliance categorization demonstrated statistically lower ACL incidence rates in high compliance studies compared to the ACL incident rates in low compliance studies (IRR 0.27:[0.07, 0.80]). The IRR analysis with tertiary break down indicated statistically lower ACL incidence rates in high compliance studies compared to moderate and low compliance studies (IRR 0.18:[0.02, 0.07]). The CEBM recommendation reached evidence level 2a. **Conclusions:** Results of this meta-analysis demonstrated a potential dose-response relationship between NMT compliance rates and ACL incidence rates. Attending and completing prescribed NMT sessions appears to be an important component for preventing ACL injuries in young female athletes.

The Effects Of A Comprehensive Soccer Specific Warm Up Program On Lower Extremity Injury Rates

Grooms D, Palmer T, Grindstaff TL: College of Mount Saint Joseph, Cincinnati, OH; Northern Kentucky University, Highland Heights, KY; Creighton University, Omaha, NE

Context: Soccer is a popular sport, but has a risk of lower extremity injury including thigh muscle strains and ligamentous injuries to the knee and ankle. A number of injury prevention programs have been developed, but many are not sport specific or are performed outside of practice settings. A soccer specific program known as “the 11” was developed by an expert group in association with FIFA (Federation Internationale de Football Association) Medical Assessment and Research Centre (F-MARC) to require minimal equipment and implementation as part of regular soccer training. “The 11” program has shown the potential to reduce injury risk in youth female soccer players but has not been studied in an American male collegiate population. Previous studies utilizing “The 11” program have suffered from non-compliance issues, minimal exercise supervision and the lack of exercise progression. **Objective:** To assess the effect of “the 11” program on incidence of lower extremity injuries in male collegiate soccer players. **Design:** Retrospective cohort study. **Setting:** Male soccer team: Division III NCAA. **Participants:** Forty-one Division III collegiate male soccer players (age= 20 ±2.3 years, mass= 73.6±11 kg, height= 177.4 ±6 cm). **Interventions:** A comprehensive warm-up program (“The 11”) with exercise progressions was used to improve strength, body awareness, and neuromuscular control during static and dynamic movements. The program was implemented into the 2010 soccer season and included exercise progressions and ATC supervision at each session to ensure proper exercise technique. In the 2009 season (control) the team completed a warm up that consisted of light jogging

followed by dynamic stretching of the lower extremity. **Main Outcome Measures:** The number of lower extremity injuries over each season was the outcome variable of interest and was defined as an injury which required at least one day time loss from activity (practice or game). Athlete exposures were defined as participating in one practice or game situation. Injury rates were calculated for each season to determine the odds ratio (OR) and the relative risk reduction (RRR) between seasons. **Results:** There were 8.1 injuries per 1000 exposures in the control group (2009 season) and 2.2 injuries per 1000 exposures in the intervention group (2010 season). In the intervention season (2010) the risk of lower extremity injury was significantly reduced compared to the control season. There were 13 lower extremity injuries during the control season and 4 during the intervention season (OR=.28, 95% CI=.09-.85; RRR=.99, 95% CI=.989-.999; P=.014). **Conclusions:** This study demonstrated that “the 11” soccer specific exercise warm up program reduced the overall risk of lower extremity injury compared to the control season. An exercise based soccer specific warm up maybe more effective than a general dynamic warm up for the prevention of soccer lower extremity injuries.

Free Communications, Oral Presentations: Shoulder Diagnoses and Outcomes

Monday, June 20, 2011, 8:00AM-9:00AM, Room 218; Moderator: Kelly Blivens, PhD, ATC

New Vs. Recurrent Shoulder Injury Time To Return-To-Play Timelines For Interscholastic Sports From 2007-2009

Hagedorn EM, Uhl TL, Bush HM, Medina McKeon JM: University of Kentucky, Lexington, KY

Context: Epidemiological information that focuses on upper extremity (UE) injuries in high school athletics is extremely limited. **Objective:** To examine the effect of injury history on time to return-to-play (T-RTP) timelines for new vs. recurrent shoulder injuries in high school athletes. **Design:** Descriptive, retrospective, epidemiology study. **Setting:** Data were collected from seven high schools of Central Kentucky during the 2007-08 and 2008-09 academic years by ATs employed at each high school. **Patients or Other Participants:** High school athletes (freshman, junior varsity, or varsity level) who participated in at least 1 of the following interscholastic sports (football, soccer, volleyball, cross-country, basketball, cheerleading, swimming/diving, wrestling, baseball, softball, track, tennis, golf) during the 2007-08 and/or 2008-09 academic years. **Interventions:** Incidence of shoulder injury was documented and reported per 10,000 athlete-exposures (AEs). Kaplan-Meier survival analyses using censored data were used to examine T-RTP curves for new and recurrent shoulder injuries. If one athlete had multiple recurrent injuries, only the most recent injury was used for analysis. Statistical comparison of differences between these survival curves were evaluated by log-rank analysis. Estimated survival probabilities for T-RTP was determined by Kaplan-Meier Estimator using censored data. Statistical significance for log-rank analysis was set at $P < .05$. **Main Outcome Measures:** Shoulder injury

frequencies for new and recurrent shoulder injury frequencies were documented and used for analyses. For the survival curve analyses, variables included frequency of those who returned to play versus those who did not (return, no return) at specified time points (next day return, 3-days, 7-days, 10-days, 22-days, no return by season's end[censored]). **Results:** During the 2007-2009 school years there were a total of 1536 injuries recorded; these occurred during 188,925 AE. There were 135 shoulder injuries documented, with 21 that were reported as recurrent. Out of the 21 recurrent injuries reported, 1 athlete had 2 recurrent shoulder injuries, so 20 athletes with recurrent injuries were included in the analysis. There were 5 medical disqualifications for new shoulder injuries, whereas for recurrent injuries there was 1. Comparison of the survival analyses revealed that recurrent injuries required significantly longer T-RTP timelines compared to new injuries ($p=0.04$). For new injuries, T-RTP survival estimates for probability of return were: next day: 48.7% [37.0, 59.2]; 3-day: 69.9% [57.3, 80.5] 7-day: 78.8% [62.3, 89.3], 10-day: 89.4% [73.0, 97.3], and 22-day: 94.7% [73.5, 99.8]. For recurrent injuries, T-RTP survival estimates for probability of return were: next day: 30.0 [12.8, 58.1]; 3-day: 55.0% [28.9, 77.0] 7-day: 60.0% [29.9, 86.3], 10-day: 70.0% [34.2, 91.5], and 22-day: 80.0% [54.1, 99.6]. **Conclusions:** Evidence from this study suggests that recurrent shoulder injuries have a slower RTP compared to new injuries. This indicates that injury prevention and appropriate rehabilitation after injury to prevent recurrence are imperative for improving outcomes of sports-related shoulder injuries in this population.

Item Reduction And Factor Distribution Of The Functional Arm Scale For Throwers (FAST)

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Context: Upper extremity injuries in throwers may result in diminished health-related quality of life. The Functional Arm Scale for Throwers (FAST) is a region-specific patient self-report scale currently under development using a three-stage scale development process. During stage I, a 54-item scale was developed that reflects aspects of the disablement model (pain, impairment, functional limitations, disability and societal limitations). **Purpose:** To complete stage II of scale development, including item reduction, factor distribution and discriminability assessment, thereby reducing the scale to less than 25 items, while preserving the variance characteristics and factor structure of the 54-item scale. **Design:** Cross-sectional. **Setting:** Paper-based survey in athletic training facilities. **Patients or Other Participants:** Convenience sample of 267 injured ($n=122$) and non-injured ($n=145$), male baseball ($n=192$) and female softball ($n=75$) players (age= 19.5 ± 1.1 years, 11.9 ± 4.8 years of experience) from multiple levels of competition (high school, college, professional). **Interventions:** Participants completed a demographic questionnaire and the original 54-item FAST. Pitchers ($n=117$) also completed a 9-item module. **Main Outcome Measures:** FAST item response distributions, along with subscale and total scale Cronbach's alpha, inter-item correlations, factor structure, correspondence with the 54-item version and association with known groups (injured vs non-injured). Items were selected from each subscale based on distributional characteristics (mean,

variance, non-missing). Remaining items were examined with respect to inter-item correlation and item-to-scale correlations. Cronbach's α was calculated for each subscale and items that lowered α were considered for exclusion. Discrimination of injured vs non-injured athletes was also tested. **Results:** Exploratory factor analysis (maximum likelihood, varimax rotation) of the original 54-item scale yielded 4 factors: Throwing (21 items), Activities of Daily Living (10 items), Psychological Effects (7 items) and Advancement (9 items). Following item reduction, 22 items were retained. The number of items retained and Cronbachs were: Throwing (10, $\alpha=.95$), Activities of Daily Living (5, $\alpha=.84$), Psychological Effects (4, $\alpha=.85$) and Advancement (3, $\alpha=.94$). A Pain subscale, crossing factor dimensions, was also tested (6 items, $\alpha=.85$). Receiver operating characteristic curves were calculated, using known group (injured vs non-injured) as the state variable. Areas under the curve (AUC) were: Throwing (.92), Activities of Daily Living (.85), Psychological Effects (.79) Advancement (.93) and Pain (.91). For the full 22-item scale, AUC=.93. The factor structure was preserved and the 22-item scale accounts for 98% of the variance in the original scale. The 9-item pitching module was retained ($\alpha=.98$, AUC=.89). **Conclusions:** The FAST was reduced from 54 to 22 items using an empirical item-reduction process. The shortened scale will be more efficient to administer and score, has preserved the factor structure of the original scale and shows excellent discriminability for upper extremity injury in throwing athletes. Stage III of the scale development process will evaluate the measurement properties of the FAST.

Clinically Important Difference-Success (CID-Success): Defining Success With Patient-Rated Outcome Tools For Patients With Shoulder Impingement Syndrome

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Context: The minimal clinically important difference (MCID) defined for the Disabilities of the Arm, Shoulder and Hand (DASH) and Pennsylvania Shoulder Score (PSS) patient-rated outcomes (PRO) are used to determine if minimal meaningful change has occurred. However, meaningful change associated with a successful treatment outcome, the clinically important difference-success (CID-success), has not been defined. **Objective:** To determine the percent change in the DASH and PSS associated with a successful treatment outcome, the CID-success, in patients undergoing care for shoulder subacromial impingement syndrome (SAIS). **Setting:** Outpatient clinics. **Participants:** Consecutive patients (n=74; female=52.7%; age=50.2±14.2 years) recruited for a clinical trial. **Intervention:** Standardized treatment of manual therapy and exercise for 6 weeks. **Main Outcome Measure:** The DASH and PSS were completed at initial evaluation (IE) and discharge 6-weeks post-initial visit (DC). The Global Rating of Change(GROC) was completed at discharge and again 12-weeks post-initial visit. The DASH is a region-specific PRO for upper extremity disability with 30 questions rated on a 5-point Likert scale; scores range 0-100 and higher scores indicative of less disability and fewer symptoms. The PSS is a region-specific PRO consisting of 3 subscales: pain, satisfaction, and function; total score range 0-100 with higher scores indicative of less pain and greater satisfaction and function. The DASH and the PSS have excellent reliability (ICC=0.96 and 0.94

respectively). The GROC, a 13-point transitional scale ranging from a 'very great deal worse' to 'a great deal better,' was used to ascertain the patient-perceived magnitude of change in health status. Means, standard deviations and percent change from initial to discharge for the DASH and PSS were calculated. Patients were dichotomized into two groups: Successful outcome (Success) and non-successful outcome (Non-Success); Success= GROC 'quite a bit better' or higher at DC and again at the 12-week follow-up, and Non-Success= GROC less than 'quite a bit better' at either time point. CID-success for the DASH and PSS was determined through receiver operator characteristic curves by identifying the point of maximum sensitivity and 1-specificity. Area under the curve (AUC) determined discriminative ability of the cut point, with values ≥ 0.70 considered satisfactory. **Results:** Patients were seen for an average of 9 visits over 5 weeks. There were 42 patients were defined as Success (DASH: IE-26.3±11.6; DC-8.5±7.9; PSS: IE-58.6±11.8; DC-86.1±10.5), and 32 patients as Non-Success (DASH: IE-31.4±13.0; DC-20.1±14.1; PSS: IE-56.6±10.9; DC-68.4±18.4). CID-Success percentage cut points for the DASH and PSS were 40% and 20% with AUC of 0.79 and 0.76 respectively. **Conclusion:** CID-success is a different metric of change than the MCID. The CID-success values for the DASH and PSS of 40% and 20% change can be helpful to define success, interpret change over the course of care and inform treatment decision-making.

Early Phase Shoulder Rehabilitation Exercises: Activation Of Scapular Muscle Ratios Between Glenohumeral Pathology Patients And Healthy Controls

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Context: Alterations in scapular muscle [i.e. upper trapezius (UT), lower trapezius (LT), middle trapezius (MT), serratus anterior (SA)] activation commonly occur in patients with glenohumeral (GH) pathology. Addressing muscle imbalances collectively as ratios (UT/LT, UT/MT, UT/SA) is imperative for restoring functional shoulder stability. Recommendations for early phase exercises to correct scapular ratios are currently based on research in healthy subjects. **Objective:** To determine if scapular ratios (UT/MT, UT/LT, UT/SA) differ between exercise type and exercise phase in patients versus healthy controls. **Design:** Mixed crossover design. **Setting:** Laboratory. **Participants:** Twenty-nine subjects [Control: n=14 (6 males, 8 females), age=23.5±11.6 years, height=170.2±11.05 cm, mass=62.3±15.45 kgs; GH patients: n=15 (8 males, 7 females), age=24±5.7 years, height=170.2±12.5 cm, mass=78.2±22.1 kgs]. **Interventions:** All measures were compared between control and GH patient groups. Inclusion criteria for GH patients required shoulder pain ≥1 week that interfered with daily activities and for which patients sought medical attention. Two exercises for each scapular ratio were examined: exercises for UT/LT: prone horizontal abduction with external rotation and sidelying forward flexion; UT/MT: sidelying forward flexion and prone extension; and UT/SA: standing forward flexion and sitting diagonal. Each exercise was separated into concentric and eccentric

phases using an electrogoniometer (Noraxon USA). The average of 3 repetitions for each exercise was used for analyses. Statistical tests included 3-way analyses of variance, multivariate approach, with repeated measures, alpha=0.05. **Main Outcome Measures:** Electromyography (EMG) was used to collect muscle activity from the UT, LT, MT, and SA during exercises. Ratios were calculated by dividing normalized mean EMG values of the UT by normalized mean EMG values of the MT, LT, and SA to generate ratios UT/MT, UT/LT, and UT/SA, respectively. Ratio values were multiplied by 100 to obtain relative activity of the UT (%) compared to the other muscles. A high value corresponds with increased UT activity; a low value represents less UT activity with respect to MT, LT, and SA. **Results:** For the UT/LT ratio, a significant exercise x phase interaction was found (p=0.012). The UT/LT ratio was higher during the eccentric phase of prone horizontal abduction with external rotation (concentric = 145.61±173.61%; eccentric =162.04±188.10%). No significant differences were found for UT/MT (p=0.08 to 0.44) and UT/SA (p=0.09 to 0.79) ratios. **Conclusions:** The higher UT/LT ratio during the eccentric phase of the horizontal abduction with external rotation exercise indicates an imbalance of high UT and corresponding low LT activation, which is undesirable. Therefore, it is recommended that, if used to address UT/LT imbalances, the eccentric phase of this exercise be modified or eliminated. Overall, no group differences exist, suggesting the exercises tested elicit similar activation regardless of injury. Examining the effect of performing exercises over time on ratios is warranted. Funded by the Master's Grant Program of the NATA Research & Education Foundation.

EBF: Shoulder

Monday, June 20, 2011, 9:15AM-10:15AM, Room 218

Free Communications, Oral Presentations: Finalists Doctoral Oral Presentations

Monday, June 20, 2011, 10:30AM-11:45AM, Room 218; Moderator: Brian Ragan, PhD, ATC

Identifying Acute Impairments Following Concussion: Is There A Case For Baseline Testing?

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Context: Many athletic trainers are challenged to complete preseason baseline testing with limited financial, physical, and personnel resources. Some believe identifying post-concussion impairments may be difficult without individual baselines. The utility of using normative data for clinical decision-making during a multifaceted post-concussion evaluation has not been fully studied. **Objective:** To compare the agreement between acute impairments identified using individual baselines compared to normative data in concussed athletes. **Design:** Prospective longitudinal study. **Setting:** Clinical research center. **Patients or Other Participants:** 1,204 male and female collegiate student-athletes completed preseason baseline testing as part of an ongoing clinical program. Sport- and gender-matched normative data (means and SD) were obtained from the original baselines of a smaller subset of 678 athletes with no history of self-reported concussions, learning disabilities, and attention deficit disorders. Athletes diagnosed with concussion in our sample (n=100) completed their first post-injury assessment within 4 days. These athletes had preseason baseline data available. **Interventions:** Our multifaceted preseason concussion test battery consisted of a computerized neurocognitive test (ANAM; Automated Neuropsychological Assessment Metrics), postural control assessment (SOT; Sensory Organization Test), and a 17-item graded symptom checklist (GSC). This test battery was repeated following

injury as part of an ongoing clinical program. Impairments for each outcome measure were determined by calculating two standardized test scores for each concussed athlete. The first standardized score compared the athlete's post-injury score to their preseason baseline measures [$Z_{BL} = (\text{post-injury score} - \text{baseline score}) / \text{SD}$]. The second compared their post-injury score to normative data [$Z_{NORM} = (\text{post-injury score} - \text{normative mean}) / \text{SD}$]. Standardized scores lower than 1.50 SD below the mean represented an "impaired" state. All others represented an "unimpaired" state. **Main Outcome Measures:** Standardized test scores (Z_{BL} , Z_{NORM}) were computed for the SOT composite score, GSC total symptom severity score, and the following ANAM throughput scores: Simple Reaction Time-1, Simple Reaction Time-2, Math Processing, Memory Search, Match-to-Sample, Procedural Reaction Time, Code Substitution, and Spatial Processing. A McNemar test for paired proportions was employed for each pair of standardized test scores with an a priori alpha level of 0.05. **Results:** Disagreements were observed for total symptom scores ($X^2(1) = 10.00$; $P = 0.002$) and ANAM Match-to-Sample ($X^2(1) = 5.33$; $P = 0.039$). No other disagreements were observed. Ten percent of our sample was considered symptomatic relative to baseline, yet asymptomatic relative to normative data. **Conclusions:** Comparing post-injury outcomes to normative data appears effective in identifying acute impairments following concussion. However, we recommend baseline evaluations should include a GSC at a minimum because comparisons of post-injury symptom severity scores to normative data may incorrectly identify an athlete as unimpaired and promote premature return-to-participation

decisions. Athletic trainers without the resources necessary to complete baseline testing may consider utilizing normative neurocognitive and postural control data for comparison in a multifaceted evaluation of concussion.

A Survey Of Knowledge Differences Of Sport-Related Concussion Between Contact And Non-Contact Sports In South Korea

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Context: While much research has been conducted concerning concussions in the United States, there have been few studies about individuals' knowledge of sport-related concussions reported in South Korea. **Objective:** To examine knowledge differences of sport-related concussion between contact and non-contact sports athletes in South Korea. **Design:** Cross-sectional survey. **Setting:** High schools and Colleges in South Korea. **Patients or Other Participants:** Participants were from Seoul Physical Education High School (n=141, 91 male:18.3 ± 0.76 years, and 48 female:18.2 ± 0.74 years), and Korea National Sports University athletes (n=269, 225 male:20.9 ± 1.12 years, and 42 female:20.9 ± 1.13 years). Valid surveys were returned by 34.6% of the high school athletes and 28.8% of for collegiate athletes. **Interventions:** A survey was developed based on previous studies and an expert committee provided content validity. The survey consisted of 22 self-administered items and was administered to athletes prior to or following practice. Athletes were

categorized by contact sports (n=332) and non-contact sports (n=78). The survey consisted of two domains 1) signs and symptoms and 2) return-to-play criteria. Chi Square analyses were performed to ascertain the difference of concussion knowledge between groups with $\alpha = .05$. **Main Outcome Measurement:** Knowledge differences in recognition of specific signs and symptoms of concussion and knowledge of return to play criteria post-injury between contact and non-contact athletes. **Results:** Contact sports athletes reported significantly increased concussion knowledge for amnesia ($X^2 (1, N = 410) = 3.365, p=0.043$), nausea ($X^2 (1, N = 403) = 4.046, p=0.028$), and “drowsiness” ($X^2 (1, N = 406) = 3.756, p=0.033$) than non-contact sports athletes. However non-contact sport athletes reported significantly more knowledge about the concussion symptom “feeling in fog” ($X^2 (1, N = 406) = 3.903, p=0.03$) than contact sports athlete. Non-contact athletes also considered concussion as a more serious head injury than contact sports athlete ($X^2 (1, N = 408) = 17.002, p<.001$). Of respondents, 8.9% reported a history of sport-related concussion. Of that 8.9%, 50% did not report their post-concussion signs and symptoms to anyone and 36.1% of athletes reported their post-concussion symptoms to the coaching staff. Furthermore, 63.3% of the athletes who reported concussions made return-to-play decisions by themselves, while 22.2% of the cases the coaching staff made return to play decisions. **Conclusions:** Our study reflects limited knowledge regarding concussion management procedures in South Korea. The limited knowledge of concussion signs and symptoms and making return-to-play decisions is of greatest concern. The lack of medical staff in athletic facilities, coupled with unreported signs and symptoms may increase the risk of cumulative or catastrophic effects from recurrent concussions. Concussion education should be implemented to increase the

knowledge of South Korean medical personnel, coaches and athletes to improve their understanding of sport-related concussions along with return to play guidelines.

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Cortical Excitability Of The Quadriceps Is Decreased In Individuals With Unilateral Anterior Cruciate Ligament Reconstructions
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Context: Lower extremity neuromuscular control alterations are common following Anterior Cruciate Ligament Repair (ACLR). While quadriceps dysfunction is often reported following ACLR, the neural origin of these deficits is not completely understood. Previous hypotheses suggest that spinal level neural modulation plays a significant role in altering neuromuscular function following joint injury, but little is known about how higher brain centers, like the motor cortex are affected in those with ACLR. **Objective:** To determine if a difference in cortical excitability of the quadriceps exists in those with unilateral ACLR compared to a healthy matched controls. **Design:** Case control. **Setting:** A controlled research laboratory. **Patients or Participants:** Nine unilateral ACLR (3 males, 6 females; age=24.3±5.27years; height = 173.9 ±10.8cm, mass=70.45±14.8kg, 67.5±42.6 months post surgery) and nine healthy matched control participants (3 males, 6 females; age= 25.0±5.20 years; height= 171.9±10.4cm, mass= 68.1±11.9kg) were included in this study. **Interventions:** Measures of cortical excitability were tested bilaterally (injured, uninjured leg) among both groups (ACLR,Control). The order of leg tested was randomized. Limbs of the healthy group were matched as “injured” to an ACLR counterpart. Cortical excitability was measured in a seated position in 90° of knee flexion using Transcranial Magnetic Stimulation (TMS). Motor

evoked potentials (MEP) were assessed bilaterally with electromyography over the vastus medialis during a standardized isometric quadriceps contraction at 5% of their maximal contraction. Active motor thresholds, defined as the lowest TMS intensity to elicit a measurable (> 100µV) MEP in 5 of 10 consecutive trials, were used to determine the TMS intensity for peak to peak outcome measures. A 2 by 2 (Group, Side) ANOVA was performed to assess the difference in cortical excitability of the quadriceps. Alpha level was set *a priori* at $P<.05$. **Main Outcome Measures:** Amplitudes for five peak to peak MEPs at 120% of each subject’s active motor threshold were averaged and normalized to muscle responses (MEP:M ratio) derived from electrically evoked stimuli from over the femoral nerve. **Results:** MEP: M ratios were significantly lower in the ACLR injured (0.016±0.007) and uninjured (0.016±0.008) limbs, compared to their matched control injured (0.029±0.014) and uninjured (0.023±0.012) limbs ($F_{1,16} = 6.71, P=0.02$). There was no significant main effect for Side ($F_{1,16}=1.0, P=0.33$) or Side by Group interaction ($F_{1,16}=0.77, P=0.39$). **Conclusion:** Lower MEP:M ratio in ACLR subjects supports a decrease in cortical excitability of the quadriceps muscle bilaterally in individuals with ACLR. It is unknown if these bilateral deficits are caused by the unilateral injury or if the deficits may have contributed to the ACL injury. This data is fundamental in understanding the genesis of neuromuscular deficits following ACLR. Future research should focus on the cortical aspect of neuromuscular control to determine appropriate prevention and rehabilitation programs following ACLR.

Pain And Associated Neuromuscular Alterations During Stair Ambulation In Those With Patellofemoral Pain Syndrome

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Context: Hip abductor muscle weakness has been implicated as a contributing factor for patellofemoral pain syndrome (PFPS). However, little evidence exists for how hip adductor, vastus medialis and gluteus medius muscle function is affected in those with PFPS. **Objective:** Determine if hip and quadriceps muscle activation and self-reported pain differ between those with and without PFPS during stair descent. Secondly, we assessed the relationship between pain and muscle activation in those with PFPS. **Design:** Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty PFPS (13F/7M, 21.45±3.90years, 169.96±10.47cm, 71.30±14.50kg) and twenty healthy participants (13F/7M, 21.35± 3.76years, 172.21±9.24cm, 69.68± 9.78kg). **Interventions:** Participants descended four-step stairs while surface electromyography was collected on the vastus medialis oblique (VMO), adductor longus (AL), and gluteus medius (GMed). Participants rated the maximum pain on the symptomatic knee during the task using a 10-cm visual analog scale (VAS). Healthy participants' legs were matched to the PFPS participants by side. **Main Outcome Measures:** Bilateral activation onset and duration of VMO, AL, and GMed, and VAS score on the symptomatic limb were collected during stance phase of the second step of stair descent. An independent-samples t-test assessed the group difference on the VAS score. A separate two-way ANOVA was utilized to detect group and side differences for each dependent variable. Pearson product-moment correlations assessed relationships between muscle activation measures and VAS in the PFPS group. Significance level was set

a priori at $P < 0.05$. Effect sizes (Cohen's d) were calculated with 95% confidence intervals. **Results:** The symptomatic leg demonstrated significantly shorter VMO activation duration compared to the asymptomatic leg, regardless of the group (Symptomatic = 782.90-±279.47 ms, Asymptomatic = 936.27 ±340.49ms, $F_{1,35} = 6.247$, $P = 0.017$, $d = -0.48$ [-1.11, 0.15]). There was no group difference for AL duration or onset ($P > 0.05$). The PFPS participants demonstrated significantly later GMed onset (PFPS = 33.13 ± 76.85ms, Healthy = -60.43 ± 90.66 ms, $F_{1,35} = 18.835$, $P < 0.001$, $d = 1.12$ [0.43, 1.76]), and shorter GMed duration (PFPS = 295.61 ± 133.21ms, Healthy = 518.54 ± 229.41ms, $F_{1,35} = 18.127$, $P < 0.001$, $d = -1.19$ [-1.84, -0.49]). The VAS scores were significantly different between groups (PFPS = 2.24 ± 1.83, Healthy = 0.00 ± 0.00, $t = -5.471$, $P < 0.001$, $d = 1.73$ [0.97, 2.42]). There was a strong negative correlation between VAS and VMO onset on the symptomatic leg ($r = -0.611$; $P = 0.007$). There was a strong positive correlation between VAS and AL duration on the symptomatic leg ($r = 0.607$; $P = 0.010$). There was a moderate negative correlation between VAS and asymptomatic leg AL onset ($r = -0.496$; $P = 0.043$) and a moderate positive correlation between VAS and asymptomatic leg GMed duration ($r = 0.472$; $P = 0.048$). **Conclusion:** Pain was associated with earlier activation onset of VMO and longer activation duration of AL on the symptomatic leg. Also, pain on the symptomatic leg was correlated with earlier onset of AL and longer duration of GMed on the asymptomatic leg. The study suggests caution when implementing rehabilitation exercises that promote excessive activation of the hip adductors, as it may be a contributing factor for painful symptoms of PFPS.

Perceptions Of Approved Clinical Instructors: Strategies For Overcoming Barriers In The Implementation Of Evidence-Based Practice

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Context: Approved Clinical Instructors (ACIs) are in a position to teach and mentor athletic training students in their clinical experiences. As evidence-based practice (EBP) becomes more prevalent in athletic training education there is a need to understand the barriers ACIs experience in implementation of EBP with their students. **Objective:** The purpose of this study was to investigate the barriers ACIs face when implementing EBP concepts in their clinical practice and in teaching EBP to professional athletic training students. In addition to the barriers, information on how best to address the barriers from an ACI perspective was investigated. **Design:** Emergent design interviews with phenomenological and modified grounded theory perspectives were used for this inquiry. **Setting:** Individual phone interviews were conducted with all participants. **Participants:** Sixteen ACIs (11 males, 5 females; 10 ± 4.66 years AT experience; 6.81 ± 3.94 years ACI experience) with at least one year of ACI experience were interviewed to determine the barriers faced and potential strategies to overcome these barriers. Criterion and snowball sampling were used to identify potential participants. Data collection ceased when saturation of the data was obtained due to repetition of participant responses. **Data Collection and Analysis:** Telephone interviews were conducted by the researcher and transcribed verbatim by a professional transcriptionist. Interview data were analyzed and coded for common themes and sub-themes regarding barriers and educational emphases to improve the barriers. NVivo 8 software (QSR International,

Cambridge, MA) was used to manage the data and develop codes. Peer review, member checking, and transcript verification were conducted to triangulate and ensure trustworthiness of the data. **Results:** ACIs reported barriers related to both resources and personnel when it came to implementing EBP within their own clinical practice. Time, equipment, and access to current literature were all sub-themes that emerged from the resource barriers discussed by the ACIs. Unwillingness to accept evidence regarding advancements in treatment in co-workers, clinicians, and coaches respectively were personnel barriers expressed by the ACI. These challenges in the ACIs' own clinical practice therefore affect their ability to utilize EBP while mentoring students. Education or emphasis on EBP within the ACI workshops was only experienced by three of sixteen ACIs (18%). ACIs reported the need for better integration between the clinical setting and the classroom, and also expressed the need for EBP to be integrated throughout the athletic training education program. **Conclusions:** Integration of the classroom and clinical experience is important in advancing ACIs' use of EBP with their students. A collaborative effort within the clinical and academic program could help address the barriers ACIs face when implementing EBP. This collaboration could result in a positive effect of the ACIs ability to implement EBP within their own clinical practice.

Baseline Self-Report Symptoms And Health-Related Quality Of Life In High School Athletes Differ With Prior Concussion History And Sex
Leach CA, Bay RC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Due to enhanced monitoring and recognition of sequelae, concussion during adolescence is of growing concern. Concussions may manifest not only through immediate physical and cognitive symptoms, but also through enduring changes in the athlete's health-related quality of life (HRQOL). Recurrent headaches, in particular, may negatively affect an individual's HRQOL. **Objective:** To determine if history of prior concussions is related to self-reported symptoms and HRQOL, and if this relationship is moderated by sex. A secondary objective was to assess the relationship between headache-related symptoms and headache-specific HRQOL. **Design:** Cross-sectional. **Setting:** High school athletic facilities. **Patients or Other Participants:** Interscholastic athletes with a positive ($n=1665$, 1416 males, 249 females, age= 15.6 ± 1.6 years, grade= 10.3 ± 1.1) or negative ($n=1633$, 1132 males, 501 females, age= 15.6 ± 1.5 , grade= 10.3 ± 1.1) self-reported concussion history. **Interventions:** Participants completed a concussion history questionnaire, the Sport Concussion Assessment Tool-2 (SCAT2) symptom scale and the Headache Impact Test (HIT-6) during preseason baseline assessments. The symptom scale and HIT-6 have published reliability and validity. Subjects were grouped as positive (POS) or negative (NEG) according to their self-reported concussion history. The independent variables were group (POS vs. NEG) and sex (male vs. female). Separate 2x2 analyses of variance were conducted for each dependent variable. Significance was set at $\leq .05$, two-tailed. A Pearson correlation was used to assess the relationship between two

headache-related symptoms (headache, pressure in head) and the HIT-6 total score. **Main Outcome Measures:** Dependent variables included the total symptom score (TSS) and the HIT-6 total score. Higher scores indicate greater symptom severity on the symptom scale and a greater impact of headache on HRQOL as measured by the HIT-6. **Results:** A significant interaction was noted for TSS ($p=0.014$) with POS females reporting a significantly higher score (18.3 ± 18.5) than NEG females (10.2 ± 13.5), POS males (11.8 ± 13.7) and NEG males (6.6 ± 9.9). POS males also reported a significantly higher TSS than NEG males. The interaction between concussion history and sex was not significant for the HIT-6 ($p=0.11$), but significant main effects were noted for group ($p<0.001$; POS= 46.6 ± 7.8 , NEG= 43.8 ± 6.8) and sex ($p<0.001$; female= 46.4 ± 8.1 > male= 44.9 ± 7.2). Significant correlations ($p<0.01$) were found between the HIT-6 total score and headache ($r=.52$), HIT-6 total score and pressure in head ($r=.46$), and between headache and pressure in head ($r=.68$) among the entire sample. **Conclusions:** Female adolescent athletes reported higher TSS and HIT-6 scores than males, indicating that they are more symptomatic and have lower headache-specific HRQOL, when otherwise healthy. Athletes with a concussion history reported more symptoms and higher HIT-6 scores than those without prior concussions. Concussions may have an enduring impact on an athlete's physical health and HRQOL and should be considered during administration and interpretation of baseline assessments. Baseline testing should include symptom checklists and HRQOL assessments to assure adequate post concussive care.

Effects Of Kinesio Taping On Endurance Ratio And Circulation Of The Gastrocnemius Muscle
Haynes HL, Kroskie RW, Docherty CL: Indiana University, Bloomington, IN

Context: Kinesio Tex Tape® (KT) is a new therapeutic taping method that is being used in orthopedic and sports medicine settings. One of the potential benefits of using KT is that the tape increases blood circulation to the muscle and subsequently improves muscle function. To date, there has been very little research done on how KT affects muscle performance. **Objective:** To determine the effect of Kinesio Tex® on the endurance ratio of the gastrocnemius muscle. A secondary purpose was to evaluate how KT may affect lower leg blood flow, circumference, and volume measures. **Design:** Repeated Measures. **Setting:** Research laboratory setting. **Patients or Other Participants:** Sixty-one healthy, active subjects, (38 female, 23 male; 23.0 ± 5.2 years; 170.8 ± 22.2 cm; 78.4 ± 30.0 kg) volunteered to participate. Subjects were randomly assigned to one of three groups, these included: proper KT, sham KT, no tape. **Interventions:** Subjects were tested over three days: Day 1 (Baseline), Day 2 (24 hours after baseline), and Day 3 (72 hours after baseline). On each day of testing blood flow, circumference, volume, and endurance ratio were recorded. A laser doppler (LDF 100C, Biopac Systems) was used to evaluate blood flow. Maximum circumference of the gastrocnemius was determined by a spring circumference measuring tape. Volumetric water displacement was used to measure leg volume. Lastly, a Cybex NORM dynamometer (Cybex International Inc, Ronkonkoma, NY) was used to evaluate the endurance ratio of the gastrocnemius. Depending on group assignment, tape was applied after Day 1 (baseline) data were obtained. Subjects in the proper KT

group received the ankle tape technique as described in the KT manual. Subjects in the sham group received one strip of KT around the circumference of the proximal gastrocnemius. Subjects in the no tape group did not receive any tape application.

Main Outcome Measures: The dependent variables were blood flow (BPU's), volume (ml), circumference (cm), endurance ratio (J). Separate Repeated Measures Analysis of Variance (RMANOVA) with one within subject factor (day at 3 levels) and one between subjects factor (group at 3 levels) were conducted on each dependent variable. The alpha level was set at $p < 0.05$. **Results:** For endurance ratio, results of the RMANOVA revealed no significant main effect for group ($F_{2,58} = 2.61, p = .08$), main effect for day ($F_{2,116} = 2.22, p = .11$) or day by group interaction ($F_{4,116} = 1.99, p = .10$). Specifically, when evaluating the Proper KT group we found no differences between testing prior to tape application (Day 1 = $55.8 \pm 20.0J$) compared to following tape application (Day 2 = $64.6 \pm 21.4J$ or Day 3 = $61.6 \pm 16.2J$). Blood flow, volume, and circumference measurements also yielded no significant differences ($p > .05$) between groups or test days. **Conclusions:** KT does not enhance muscle endurance of the gastrocnemius muscle in a healthy population. Furthermore, we found KT did not affect blood circulation, circumference, or volume of the gastrocnemius muscle.

The Star Excursion Balance Test As A Predictor Of Lower Extremity Injuries In High School Basketball Players

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Context: Prevention of injury is vitally important to the clinician. While limited investigation suggests

the star excursion balance test (SEBT) may provide strong predictive capabilities for lower extremity injury, more information is needed to further substantiate the predictive outcomes that have been suggested.

Objective: To determine if the SEBT can be used as a lower extremity injury prediction tool for adolescent basketball players. **Design:** Prospective cohort **Setting:** High school athletic training rooms. **Patients or Other Participants:** Sixty-six boys' and girls' basketball players (42 boys; 24 girls; 15.71 ± 1.18 yrs; 176.13 ± 10.66 cm; 70.98 ± 14.96 kg) were recruited from three high schools. **Interventions:** Prior to the season, all athletes performed maximal reaches on the SEBT in three directions: anterior (ANT), posteromedial (PM), and posterolateral (PL). Certified Athletic Trainers at the schools recorded acute lower extremity injury occurrences during the competition season. After the season, players were stratified into an injured or non-injured group depending on the recordings by the ATC's. **Main Outcome Measures:** The average of three reaches (cm) were normalized to leg length (cm) and reported as a percentage for each reaching direction (%MAXD). Additionally, a composite score (CS) of the average of the three normalized reach scores was calculated. Independent samples t-tests were used to detect differences between the groups (injured, non-injured) for ANT, PM, PL and CS. Significance was set at $P < 0.05$. Receiver-operator characteristic curves were used to determine %MAXD for each of the four SEBT measures that maximized specificity and sensitivity. Additionally, positive and negative likelihood ratios (+LR and -LR) were calculated. **Results:** Sixteen subjects (24.24%) experienced acute lower extremity injuries. Fourteen injuries (87.5%) were inversion ankle sprains, and two injuries (12.5%) were muscle strains. For ANT, there was no statistically significant Group difference ($t_{1,64} = 1.15, P = 0.26$; Injured: $65.84 \pm 8.13\%$; Non-Injured: $68.36 \pm 7.44\%$). A %MAXD of

64.8% was associated with a sensitivity of 0.56 and a specificity of 0.74 (+LR = 2.17, -LR = 0.59). For PM, there was no statistically significant Group difference ($t_{1,64} = 0.94, P = 0.35$; Injured: $75.12 \pm 11.21\%$; Non-Injured: $78.14 \pm 11.23\%$). A %MAXD of 72.95% was associated with a sensitivity of 0.44 and a specificity of 0.72 (+LR = 1.56, -LR = 0.78). For PL, there was no statistically significant Group difference ($t_{1,64} = 1.52, P = 0.13$; Injured: $65.74 \pm 11.16\%$; Non-Injured: $70.34 \pm 10.30\%$). A %MAXD of 67.45% was associated with a sensitivity of 0.56 and a specificity of 0.64 (+LR = 1.74, -LR = 0.59). For CS, the Group difference approached statistical significance ($t_{1,64} = 1.93, P = 0.058$; Injured: $67.52 \pm 9.42\%$; Non-Injured: $72.31 \pm 8.41\%$). A %MAXD of 69.53% was associated with a sensitivity of 0.75 and a specificity of 0.64 (+LR = 2.08, -LR = 0.39). **Conclusion:** While no significant differences in SEBT reach distances were found between subjects that incurred a lower extremity injury and those that did not, the CS did demonstrate good sensitivity (0.75) and moderate specificity (0.64). Clinicians can consider using the SEBT as predictor of lower extremity injuries for high school basketball players if a composite score is employed.

Student Retention in Undergraduate Athletic Training Education Programs within NATA District Four

Young AM, Klossner JC, Docherty CL, Dodge TM, Mensch JM: Indiana University, Bloomington, IN; Springfield College, Springfield, MA; University of South Carolina, Columbia, SC

Context: A better understanding of why students leave an undergraduate athletic training education program (ATEP), as well as why they persist is critical in determining the future membership of our profession. **Objective:** To understand how clinical experiences affect student retention.

Design: Descriptive study using qualitative and quantitative mixed methods. **Setting:** ATEPs across NATA District Four. **Participants:** We used purposeful criterion sampling methods. Criteria for selection included those senior students in a 3-year ATEP within NATA District 4 as well as those who have dropped out of the ATEP. Program directors who participated sent us a list of names and email addresses for senior students and students who voluntarily left the program. Identified students were sent an email explaining the study as well as a link to an on-line survey. Seventy-one persisters (27 males, 44 females, age=21.81±1.17 years) and 23 dropouts (10 males, 13 females, age=20.25±0.90 years) representing 24 ATEPs participated. We achieved a 42% and 26% response rate from persisters and dropouts, respectively. **Interventions:** The independent variable was matriculation status at two levels: persisters and dropouts. Students completed the Athletic Training Education Program Student Retention Questionnaire (ATEPSRQ), which has been previously utilized and published in the AT literature. The ATEPSRQ included questions which measured responses on a 6 point likert scale within 5 construct areas. The constructs included: anticipatory factors (AF), academic integration (AI), clinical integration (CI), social integration (SI), and motivation (M). The ATEPSRQ also included qualitative questions. **Main Outcome Measures:** The responses to each question were summed and the total for each construct was used as the dependent variable. Multivariate Analysis of Variance (MANOVA) was performed on the quantitative data followed by univariate ANOVAs on any significant findings. A priori alpha level was set at p<.05. Qualitative data were analyzed through inductive content analysis. Trust-worthiness was ensured through peer debriefing. **Results:** The MANOVA identified a significant difference between the persisters and dropouts, (Pillai's Trace=.42, $F_{(1,92)}=12.95$, $p=.01$). The follow-up

ANOVAs revealed that the persisters and dropouts differed significantly on AF (persisters =11.63±.41, dropouts =13.35±.72, $p=.04$), CI (persisters =45.76±1.45, dropouts =38.01±2.55, $p=.01$), and M (persisters =28.90±.53, dropouts =21.91±.93, $p=.01$) scales. Qualitative themes suggested time commitment was a retention barrier for both groups. Support networks, authentic experiential learning, and role identity facilitated retention for persisters, however a lack of authentic experiences was a barrier for dropouts. Major or career change also led to attrition for dropouts. **Conclusions:** There is a perceived difference in how athletic training students are integrated into their clinical experiences between those students who leave an ATEP and those who stay. Results suggest educators may improve retention by emphasizing authentic experiential learning opportunities rather than hours worked, allowing students to take on more responsibility and by facilitating networks of support within clinical education experiences.

The Sleeper Stretch: Effects On Range Of Motion And Injury In Baseball Players

Grow KK, Butryn TM, Plato PA, Brown HL, Douex AT: Athletic Training Research Laboratory, San José State University, San José, CA

Context: Glenohumeral internal rotation deficit (GIRD) may be an underlying cause of shoulder pathology in overhead athletes. The Sleeper Stretch (SS) is popular among clinicians to prophylactically increase shoulder internal rotation (IROT) range of motion (R-O-M). If increased IROT deters the development of GIRD, perhaps overhead athletes can utilize the SS regimen to decrease the incidence of shoulder injuries. **Objectives:** To examine the effects of a SS protocol on glenohumeral IROT R-O-M over the course of 12 weeks. Secondly, to determine the efficacy of a SS regimen for reducing the incidence of non-traumatic shoulder

injuries over the course of one baseball season. **Design:** A single group, repeated measures design was employed. **Setting:** All measurements were ascertained in a climate-controlled laboratory, while the stretching protocol was performed on a collegiate baseball field. **Patients or Other Participants:** Thirty-five male collegiate baseball players (age: 19.0±2.0 yrs; height: 181.6±6.4 cm; mass: 85.3±13.1 kg) from a single NCAA Division I institution. **Interventions:** The SS protocol, the experimental intervention, was incorporated into each participant's daily routine. All participants received standardized training in the proper stretching mechanics. Upon demonstration of the correct technique, each athlete was instructed to utilize the SS on every day of athletic participation for 12 weeks. Following data reduction, differences in R-O-M were explored with repeated measures analysis of variance (RM-ANOVA) across sessions, where $P<.05$. For all statistically significant main effects, post hoc paired t-tests were used to elucidate significant differences between sessions. The Fisher Exact Test was conducted to identify any disparities of shoulder injury frequency between past and present baseball seasons. **Main Outcome Measures:** Using a universal 2-armed goniometer (Baseline, Irvington, NY), a single researcher obtained 3 dominant shoulder IROT measurements per session, across 4 sessions (pretest, week 4, 8, and 12). Additionally, the number of time-loss (≥ 8 days or 4 games) shoulder injuries incurred during the 2010 baseball season was compared to the number of injuries per season for the previous 3 baseball seasons (2007-2009). **Results:** Overall, participants gained approximately 9° of shoulder IROT over 12 weeks (pretest =46.78°±9.64, week 12= 55.23°± 7.23; $P=.001$); the most clinically significant gain (6.05°) occurred between weeks 8 and 12 (49.18°±7.49 vs. 55.23°±7.23; $P=.001$). Importantly, there were no shoulder injuries in 2010 which, when

compared to low injury frequencies in previous seasons (4, 3, 1), rendered a trend towards significance ($P=.057$).

Conclusions: Meaningful gains in shoulder IROT can be obtained over a 12-week period when utilizing the SS; however, it may take up to 8 weeks for significant increases to occur. The resultant increase in motion, coupled with the absence of shoulder injury is clinically important. This suggests that the SS could be a promising preventative measure for overhead athletes to utilize.

Comparison Of The Effects Of Aquatic And Land-Based Balance Training Programs On The Postural Control Of College-Aged Recreational Athletes

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Context: Land-based balance training has been shown to improve postural control in healthy individuals. An aquatic environment contributes several properties that may increase the effects of balance training on postural control. **Objective:** To determine if aquatic and land-based balance training programs created significantly different improvements in levels of postural control measured among college-aged recreational athletes. **Design:** A two-group pretest-posttest study. **Setting:** Testing was performed in a laboratory setting and the interventions took place in the university student athletic center. **Participants:** Eighteen healthy, recreationally active males (n=6) and females (n=12), (age=20.56±2.59 years, height=167.6±7.2 cm, mass=66.66±7.90 kg) with no history of vestibular or other balance-influencing disorders were recruited for participation. **Interventions:** Subjects were randomly assigned to an aquatic (n=12) or land-based (n=6) balance-training group. These groups performed a preset program of balance exercises three days a week for six weeks. **Main Outcome Measures:** Pre- and posttest measurements of postural control were made using three tests available through Neurocom's Smart Equitest Balance System. The testing batteries included the Limits of Stability (LOS) test, the Unilateral Stance (US) test, and the Sensory Organization Test (SOT). A 2(group) x 2(pretest-posttest) mixed analysis of variance was performed to determine statistical significance, which was set *a priori* at (p<.05). **Results:** In the US test, a significant

main effect for time was found for the left foot/eyes open condition (p=.030). The center of pressure sway velocity improved significantly (p=.013) between pre- and posttest in the land group (pre=.855±.157°/s, post=.661±.118°/s) while no improvement was found for the aquatic group (pre=.783±.152°/s, post=.817±.63°/s). Between-group effects for this condition were not significant (p=.549). No other conditions associated with the US test revealed significant time or between-group differences (left-foot eyes closed, p=.851; right foot eyes open, p=.820; right foot eyes closed, p=.660). In the LOS test, a significant (p=.033) time by group interaction was present for maximum excursion. The aquatic group improved significantly (p=.003) between pre- and posttest (pre=94.44±6.41%, post=97.69±5.23%) while no differences were found for the land group (pre=98.97±5.09%, post=97.73±4.63%). No other findings were significant for the LOS test (reaction time, p=.156; movement velocity, p=.431; directional control, p=.137). In the SOT, no significant differences were found between pre- and posttest scores for either balance group (p=.054). No significance was found between groups (p=.973). **Conclusions:** While the current study was limited by a small sample size and unevenly numbered intervention groups, it appears that neither the aquatic nor land-based training environment was superior to the other when attempting to enhance postural control in healthy, active individuals using a 6 week balance program.

The Effect Of A 4-Week BAPS Rehabilitation Program On Subjects With Functional Ankle Instability

Linens SW, Ross SE, Arnold BL: Georgia State University, Atlanta, GA, and Virginia Commonwealth University, Richmond, VA

Context: Rehabilitation protocols using multiple exercises have been shown to improve balance and decrease ankle sprain incidence in individuals with functional ankle instability (FAI). While these outcomes are desired, evidence is lacking on how each specific exercise in rehabilitation programs contribute to improving clinical outcomes. **Objective:** To quantify improvements in clinical impairments using a single ankle rehabilitation exercise as a therapeutic intervention. **Design:** Prospective, randomized controlled experimental design. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-four subjects with "giving way" and a history of ankle sprains (i.e. FAI) were participants. Subjects had to score ≤27 on the Cumberland Ankle Instability Tool (CAIT). Seventeen subjects (170.22±8.71 cm, 75.57±13.55 kg, 22.94±2.77 yrs; CAIT=16.94±5.08) were randomly assigned to a rehabilitation group (REH) and seventeen subjects (168.57±9.81 cm, 77.19±19.93 kg, 23.18±3.64 yrs; CAIT=17.18±4.43) were randomly assigned to a control group (CON). **Interventions:** Pretests were administered in a counterbalanced order. The foot lift test (FLT) required subjects to close their eyes and stand quietly on their limb with FAI for 30 seconds. Subjects were asked to minimize both foot wobbles and touching their contralateral limb to the floor. The posteromedial reach test (PMR) required subjects to stand on their limb with FAI and reach with their contralateral limb as far as possible while maintaining stability. The side hop test (SHT) required subjects to hop 0.3 m side-to-side on their limb with FAI

for 10 repetitions. Pretesting was either followed by 4 weeks with no intervention for controls or wobble board rehabilitation, consisting of 3 sessions per week. Subjects performed 5 wobble board repetitions, with each repetition consisting of 20 seconds of clockwise circles and 20 seconds of counterclockwise circles on the limb with FAI. Both groups were posttested 4 weeks after their pretest. Two by two 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 included average number of foot lifts (FLT), average reach distance (cm) normalized by leg length (PMR), and time (s) to complete testing (SHT). Fewer foot lifts, longer reach distances, and shorter times indicated improved performance. **Results:** Main effects for time were significant for all measures ($P<0.05$), but main effects for groups were not ($P>0.05$). Significant interactions were found for FLT ($REH_{pre}=5.61\pm2.59$, $REH_{post}=3.82\pm2.25$, $CON_{pre}=5.00\pm1.73$, $CON_{post}=4.61\pm1.77$; $F_{(1,32)}=4.55$, $P=0.041$), PMR ($REH_{pre}=0.85\pm0.12$, $REH_{post}=0.98\pm0.12$, $CON_{pre}=0.88\pm0.08$, $CON_{post}=0.86\pm0.09$; $F_{(1,32)}=23.79$, $P<0.001$), and SHT ($REH_{pre}=19.55\pm9.54$ s, $REH_{post}=12.40\pm6.15$ s, $CON_{pre}=16.20\pm7.95$ s, $CON_{post}=15.18\pm7.95$ s; $F_{(1,32)}=8.37$, $P=0.007$). Post-hoc testing showed that the REH group improved performance on all measures at posttest, whereas the CON group did not. **Conclusions:** Wobble board rehabilitation improved clinical impairments. We suggest utilizing this program to improve balance and performance deficits associated with FAI. Funded by the Doctoral Research Grant Program of the NATA Foundation.

Bell DR, Padua DA: University of Wisconsin-Madison, Madison, WI, and University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Knee valgus is theorized to increase the risk of anterior cruciate

ligament injuries and patellofemoral pain. Knee valgus can be caused by muscle imbalances throughout the lower extremity, including the ankle and lower leg. Exercise interventions that alter these muscle imbalances could improve knee valgus and potentially reduce injury risk. **Objective:** To determine if an exercise intervention targeting ankle and lower leg muscle imbalances can improve knee valgus alignment and ankle dorsiflexion range of motion (ROM). **Design:** Randomized Control Trial. **Setting:** Laboratory. **Patients or Other Participants:** Participants must have displayed visual evidence of knee valgus during a double leg squat that was corrected when performed on a 2" heel lift. Visual evidence of knee valgus was defined as the midpoint of the patella moving medial to the great toe. Participants meeting these criteria were randomly assigned to a control (n=16, 168.2±6.7cm, 62.6±9.3kg, 20.5±2.8yrs) or intervention group (n=16, 169.8±6.3cm, 66.2±12.1kg, 20.7±2.8yrs). **Interventions:** The intervention group completed 10 directed exercise sessions over a 2-3 week period. The program consisted of common rehabilitation exercises implemented according to the National Academy of Sports Medicine guidelines: 1) inhibit tight muscles, 2) stretch tight muscles, 3) strengthen weak muscles, and 4) perform integrative exercises with proper form. The control group did not undergo training and returned for testing 2-3 weeks later. Participants had dorsiflexion range of motion assessed and performed 5-trials of a double leg squat before (PRE) and after (POST) the intervention period. For the double leg squat, participants started with their feet shoulder width apart and hands overhead and squatted to 90° of knee flexion. An electromagnetic tracking system assessed knee valgus alignment during the double leg squat task. Ankle dorsiflexion ROM was measured with the knee extended (DFKE) and knee flexed (DFKF) using a standard goniometer. **Main Outcome Measures:** Change scores (POST-PRE) were calculated for knee valgus angle at the 0, 10, 20, 30, 40, and 50% phases of

the squat and ankle ROM. A group (2-levels) by phase (6-levels) repeated measures ANOVA was used to analyze knee valgus angle. Independent samples t-tests were used to compare change scores in ankle ROM ($P<0.05$). **Results:** The intervention group significantly improved knee valgus angle ($P=0.001$, $F(1,150)=4.43$). Tukey post hoc testing revealed a reduction in knee valgus angle from 30% (Control: PRE=-1.9±5.0°, POST=-2.8±6.1°; Intervention: PRE=-8.0±7.2°, POST=-3.7±8.4°) to 50% squat phase. Ankle DFKE increased the intervention group ($P=0.009$, $t(1,30)=2.8$) (Control: PRE =5.0±4.6°, POST=3.5±5.2°; **Intervention:** PRE=6.9±4.7°, POST= 10.5±4.6°) while DFKF ($P=0.64$) did not. **Conclusions:** In this population, knee valgus is at least somewhat attributable to a lack of ankle motion. This exercise program could benefit clinicians attempting to correct dynamic postural alignment and potentially limiting injuries.

Cardiovascular Outcomes Of Active Gaming: Applying The Wii To Athletic Training Rooms

An YW, Hedderson W, Naugle KM, Wikstrom EA, Naugle KE: University of Florida, Gainesville FL, and University of North Carolina, Charlotte, NC

Content: Active gaming has become a trendy rehabilitation tool in athletic training settings; with devices such as the Nintendo Wii suggested to produce cardiovascular responses similar to traditional physical activity. One appealing aspect of Wii games is the potential enjoyment of athletes using these systems to combine entertainment with aerobic fitness, allowing for potential increases in rehabilitation compliance. However, the aerobic capability of Wii games in athletic training settings is yet to be substantiated. **Objective:** To determine the cardiovascular effects of selected Wii games compared to traditional cardiovascular activities (treadmill

walking and stationary biking). Hypothesis: Wii games will provide equal cardiovascular training outcomes as treadmill walking and stationary biking at moderate intensity. **Design:** A cross-sectional study design determined the relationships between Cardiovascular Intensity (HR), and Perceived Exertion (RPE scores) of multiple Wii games. **Setting:** University Fitness Center (field setting). **Participants:** Fourteen college-aged volunteers (M=6, F=8). **Interventions:** Participants completed multiple exercise sessions, with two exercise activities performed during each session for 20 minutes each. During session one, participants walked briskly on a treadmill and rode a stationary bike at a light to moderate pace. During sessions two and three participants performed a total of four Wii games, including tennis, boxing, step-aerobics, and cycling. The order of the Wii games was randomized and counterbalanced across the two sessions. Participants reported their RPE and level of enjoyment following each exercise activity. **Main Outcome Measures:** Change in HR from resting (bpm), Borg scale of Perceived Exertion (RPE), and rating of enjoyment on a 10cm visual analog scale. Each outcome measure was analyzed with a separate repeated measures one-way ANOVA ($p < .05$). **Results:** Differences existed between the exercise activities on RPE, HR, and level of enjoyment (p 's $< .001$). Follow-up tests revealed significantly greater RPE on the stationary bike ($12.79 \pm .89$) compared to all other exercise activities except for walking. Additionally, RPE was significantly greater for walking (12.43 ± 1.22), boxing (11.21 ± 2.25), and cycling (11.43 ± 2.21) compared to tennis (9.57 ± 2.06) and aerobic-step (9.64 ± 2.10). All activities increased HR at least 20 bpm. Stationary biking ($57.43 \text{ bpm} \pm 5.51$) and treadmill walking ($56.93 \text{ bpm} \pm 4.60$) lead to significantly greater increases in HR compared to Wii Games. Boxing ($39.71 \text{ bpm} \pm 5.52$) and cycling

($31.43 \text{ bpm} \pm 4.03$) lead to a significantly greater increase in HR compared to aerobic-step ($25.71 \text{ bpm} \pm 3.62$) and tennis ($22.57 \text{ bpm} \pm 4.93$). Participants' enjoyment was significantly greater for boxing ($8.13 \text{ cm} \pm 1.63$) compared to walking ($5.76 \text{ cm} \pm 2.21$) and stationary biking ($5.51 \text{ cm} \pm 2.48$). **Conclusions:** Results suggest that these Wii games, when played at a beginner level, produce a slightly lower cardiovascular response than the traditional exercises performed at a moderate intensity. Wii boxing produced the greatest increase in HR among the Wii games and was rated more enjoyable than traditional exercises. Future studies are needed to determine Wii's effectiveness as a cardiovascular rehabilitation tool in athletic training settings.

Free Communications, Oral Presentations: Tissue Response to Damage and Treatment

Tuesday, June 21, 2011, 9:15AM-10:15AM, Room 218; Moderator: Chad Starkey, PhD, ATC

The Effect Of Antihistamine On The Signs And Symptoms Of Eccentric Muscle Damage

Jutte LS, McIntosh ID: Ball State University, Muncie, IN

Context: Eccentric exercise causes muscle damage and induces inflammation via chemical mediators. Histamine is a chemical mediator responsible for pain and edema. **Objective:** The purpose was to determine the effects of antihistamine on the signs and symptoms of eccentric muscle damage. **Design:** Double-blinded, randomized controlled laboratory study **Setting:** Biomechanics Laboratory **Subjects:** Twenty-four sedentary males (age=20.5±2.6yrs) participated. Individuals with loratadine allergies or using any type of medication were excluded. **Interventions:** Signs and symptoms of eccentric muscle damage were assessed 24 hours prior, immediately after (post), 24, 48, & 72 hours post-eccentric exercise bout. The exercise bout consisted of 6 sets of 10 repetitions of eccentric hamstring curls on an isokinetic device. Participants were randomly selected to either a 10mg loratadine (active ingredient in Claritin®) or placebo group (N=12/group). Dosing occurred twice, 12 hours before and after exercise. **Main Outcome Measures:** Dependent variables were change scores for pain, leg girth, knee passive range of motion, knee flexion isometric strength (expressed relative to body weight), and serum creatine kinase (CK) levels from 24 hours pre-exercise. Pain was measured with a 10-cm visual analog scale. Leg girth was measured using a standard measuring tape at the femur's midpoint. A goniometer was used to measure knee range of motion with 90° of hip flexion. Isometric strength was determined by an isokinetic device. Serum CK levels were measured from venous blood samples.

Each variable's change from baseline was compared between groups using repeated measures ANOVA followed by Tukey-Kramer post-hoc testing when appropriate. A priori significance was set at P-value <.05. **Results:** Increases in pain were significant post (1.9±2.2cm), 24hr-post (2.6±2.1cm), and 48hr-post (2.4cm±2.3cm; $F_{4,88}=14.60$, $P<.001$). Increased creatine kinase levels were significant 48hr-post (1248±2668μ/L; $F_{4,88}=5.19$, $P<.001$). Decreased knee range of motion was significant 24hr-post (-8.5±10.7°; $F_{4,88}=2.52$, $P=.025$). Decreased isometric strength was significant post (-0.23±0.34NM/kg) and 24hr-post (0.19±0.31NM/kg; $F_{4,88}=5.19$, $P<.001$). Group had no effect on changes in pain; range of motion; strength, or creatine kinase levels after eccentric exercise. However, leg girth changes were significantly greater in the antihistamine group (post=0.98±1.45cm, 24hr post=0.95±1.07cm, 48 hrs post=1.15±1.46cm, 72 hr post=0.82±1.33cm) compared to the placebo group (post=0.09±0.55cm, 24hr post=0.22±0.40cm, 48 hrs post=-0.18±0.96cm, 72 hr post=-0.03±0.62 cm; $F_{4,88}=3.58$, $p=.009$). **Conclusions:** Although, leg girth increased more with antihistamine, this increase was not associated with changes in pain or function. Therefore, the over-the-counter dose of Loratadine had minimal effect on the signs and symptoms of eccentric muscle damage. Future research should investigate other types of antihistamine, dosing, and timing of dosing. Loratadine at over-the-counter dosing is not an effective treatment for the signs and symptoms of eccentric muscle damage. Funded by GLATA Research Assistant.

Skeletal Muscle Blood Flow And Volume Are Not Reduced In The Gastrocnemius After Ice Application

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Context: Ice is commonly applied after acute injury with the expectation that intramuscular cooling decreases blood flow to help reduce edema and secondary hypoxia. Contrast-enhanced ultrasonography (CEU) is an innovative method to measure microvascular perfusion using microbubbles as a contrast agent. CEU has not been previously used to assess the effect of modalities on skeletal muscle microvascular perfusion. **Objective:** To assess skeletal muscle blood flow and volume of the medial gastrocnemius during ice application. **Design:** Crossover. **Setting:** General Clinical Research Center. **Patients and Other Participants:** Sixteen healthy adults (Age: 22.8±2.8 years; Height: 165.9±12.0 cm; Mass: 65.9±15.5 kg) participated. **Interventions:** ECG was used to monitor heart rhythm, and was used as a trigger for the CEU measurements. The participant was positioned prone and a thermocouple was inserted 1cm into the medial gastrocnemius based on skinfold measure. The participant rested 10 minutes then a solution of microbubbles was infused intravenously at a rate of 1.5mL/min for 3 min. CEU measurements were obtained with continuous infusion of microbubbles at baseline and immediately post treatment. The treatment condition was randomized to ice (750g crushed ice) or sham (750g candy corn) and application time was dependent on the medial gastrocnemius skinfold thickness, which ranged from 10-60 minutes. The investigator recording CEU measures was blinded to the treatment condition. The opposite treatment condition was

administered at least 48 hours later. **Main Outcome Measures:** Three 2x2 repeated measure ANOVAs were used to determine the effect of cryotherapy on blood flow (dB/sec), volume (dB) and intramuscular temperature ($^{\circ}\text{C}$) immediately following the treatment condition. **Results:** There was no difference in blood flow following cryotherapy treatment (2.79 ± 0.28 dB/sec) compared to baseline (3.14 ± 0.21 dB/sec) ($p = .293$). Following the sham condition, blood flow increased after treatment (3.43 ± 0.25 dB/sec) compared to baseline (2.59 ± 0.23 dB/sec) ($p = .003$). There was no difference in blood volume following cryotherapy treatment (7.55 ± 0.75 dB) compared to baseline (9.47 ± 0.92 dB) ($p = .10$). Following the sham condition, blood volume increased after treatment (10.42 ± 0.98 dB) compared to baseline (7.32 ± 0.81 dB) ($p = .01$). Intramuscular temperature was significantly different following cryotherapy treatment ($27.0 \pm 5.1^{\circ}\text{C}$) compared to baseline ($36.4 \pm 1.8^{\circ}\text{C}$) ($p < .001$). Following the sham condition, intramuscular temperature was not different after treatment ($39.09 \pm 1.39^{\circ}\text{C}$) compared to baseline ($36.64 \pm .70^{\circ}\text{C}$) ($p = .171$). **Conclusions:** This study is the first to examine microvascular perfusion of skeletal muscle with therapeutic cold. Although cryotherapy did not reduce blood flow and volume in the muscle, as was previously theorized, the cooled muscle maintained microvascular perfusion characteristics similar to those at baseline, suggesting that cryotherapy may attenuate blood flow and volume increases with acute inflammation.

Preliminary Investigation Of Quadriceps Intramuscular Temperature And Femoral Artery Blood Flow And Vascular Conductance During The Application Of Cryotherapy And Compression

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Context: Cryotherapy and compression are recommended for reduction in tissue temperature and control of hemorrhage and edema. However, limited information exists related to the amount and duration of vaso-constriction and reduced blood flow that accompanies cryotherapy treatment. **Objective:** To examine the effect of 30 on/30 off/30 on/30 off Game Ready[®] with medium compression applied to thigh/knee on intramuscular temperature (T_{IM}), skin surface temperature (T_{SK}), femoral artery blood flow (FBF) and femoral vascular conductance (FVC). **Design:** Within repeated measure designs. **Setting:** Controlled laboratory setting. **Participants:** Four males (age = 22 ± 1 yr, mass = 88 ± 9 kg, height = 184 ± 7 cm, thigh skinfold = 14.2 ± 4.2 mm) volunteered for study. All had no current injury involving their thighs or knees and were not taking prescription medications. **Interventions:** Game Ready[®] with ice water ($3\text{--}11^{\circ}\text{C}$) was used with standard knee sleeve. Treatment used manufacturer preset in two successive cycles of 30 minutes of cooling with medium compression ($5\text{--}50$ mmHg) followed by 30 minutes passive recovery (knee sleeve left in place). A thermocouple inserted 1.5cm below the subcutaneous adipose layer sampled T_{IM} and a surface thermocouple sampled T_{SK} . Thermocouples were interfaced to a computer through an Isothermex[®]. Heart rate and blood pressure were collected using a 3-lead ECG and automated blood pressure device. A hand-held probe was placed on the skin over the common femoral artery where Doppler ultrasound measures of femoral blood velocity

and femoral diameter were used to calculate FBF. Measurements were taken at predetermined time points from both the cryotherapy treated leg and the non-treated leg. **Main Outcome Measures:** Change from baseline in T_{IM} and T_{SK} ($^{\circ}\text{C}$). Total percent change in FBF and FVC (ratio between leg blood flow and mean arterial pressure). Repeated measure ANOVA with four levels of time (30, 60, 90, 120 minutes) investigated T_{IM} and T_{SK} . A repeated measures ANOVA with leg (Treated and Non-treated) investigated overall percent changes in FBF and FVC. Alpha set a priori at 0.05. **Results:** T_{IM} was colder at 90 minutes compared to 30 minutes ($p = 0.02$), but no further cooling occurred at 120 minutes. T_{IM} maximum change was $-10.5 \pm 1.9^{\circ}\text{C}$ (occurring at 93.4 ± 5.4 minutes). Thirty-minute T_{SK} change was significantly greater than other time points ($p < 0.001$) with a maximum change of $-21.7 \pm 0.5^{\circ}\text{C}$. During the 2-hour treatment, the average change in FVC was significantly different ($p = 0.015$) between Treated ($-47.9 \pm 8.8\%$) and Non-treated ($0.3 \pm 3.2\%$) legs. Additionally, the average change in FBF was significantly different ($p = 0.01$) between Treated ($-46.2 \pm 10.9\%$) and Non-treated ($2.1 \pm 2.0\%$) legs. **Conclusions:** Our preliminary investigation demonstrates that cycled cold and compression produces lower blood flow and increased vaso-constriction, which may provide protection against excessive hemorrhage, edema, and secondary metabolic injury. However, more research is warranted to clarify the time course of and magnitude of these changes in relation to changes in tissue temperature.

The Magnitude Of Applied Cyclic Compressive Load Influences Inflammatory Cell Infiltration But Not Lymphangiogenesis In Healthy Skeletal Muscle

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Context: Muscle trauma initiates an inflammatory response, often resulting in secondary hypoxic injury and prolonged reduction in force. Massage therapy is a commonly utilized manual modality for the treatment of inflammation and muscle pain. The application of massage as a modality includes a variety of techniques, each varying in the magnitude, duration and frequency of the applied load. Recently, we have shown that muscle damaged through repetitive eccentric exercise exhibited significant improvements in form and function following cyclic compressive loading (CCL) as an analogue to massage, when compared to damaged control muscles. However, the mechanisms of the improved function and reduced damage following CCL remain unknown. **Objective:** Investigate the influence of various magnitudes of CCL on inflammatory cell infiltration and lymph vessel growth in healthy skeletal muscle. **Design:** Cross-over control design, with three pure-controls analyzed for possible systemic effects. **Setting:** This experiment took place within a controlled basic science laboratory setting. **Participants:** Twenty one Male Wistar Rats (200g). **Interventions:** Rats were placed in one of 4 groups based on load: 0.0N, n=3; 1.4N, n=6; 4.5N, n=6; and 11.0N, n=6. Rats receiving treatment underwent CCL to one tibialis anterior for 30 minutes per day for 4 consecutive days, with the contralateral limb serving as control. On day five, rats were euthanized and muscles were harvested, and frozen for further analyses. Tissue samples were sectioned at 0.08mm and stained for cellular infiltration via hemotoxylin and eosin staining and

immuno-histochemistry. Stereological point-counting techniques were used to quantify cell nuclei, and differentiate to muscle nuclei. Larger sections of tissue were used for Western Blot analysis to identify markers of lymphangiogenesis using antibodies VEGF-C and LYVE-1. **Main Outcomes:** Leukocyte infiltration and lymphangiogenic markers were quantified with standard stereology and western blot analyses. Dependent variables were leukocyte number and protein abundance. **Results:** Four days of CCL resulted in a disparate cellular infiltration response in all 3 groups, with no differences found in lymphangiogenic markers: The 1.4N load exhibited less cellular infiltration when compared to the contra-lateral control (14.2 ± 1.4 cells/ 0.60 mm² vs 24.8 ± 3.2 cells/ 0.60 mm², $p=0.005$); the 4.5N load exhibited greater infiltration compared to contra-lateral control (41.3 ± 4.7 cells/ 0.60 mm² vs 22.6 ± 3.2 cells/ 0.60 mm², $p=0.003$); and the 11.0N load exhibited greatest cellular infiltration compared to contra-lateral control (61.9 ± 9.7 cells/ 0.60 mm² vs 20.8 ± 2.4 cells/ 0.60 mm², $p=0.001$). There were no systemic effects of CCL on lymph vessel growth and inflammation. Simple linear regression indicated magnitude of load was an excellent predictor of the difference in cellular infiltration ($R^2=0.99$). **Conclusions:** Our findings indicate the inflammatory response to CCL in skeletal muscle is associated with the magnitude of load applied. Interestingly, at optimal load (1.4N in this study) there is a potential anti-inflammatory response to massage. There was no evidence of increased lymphangiogenesis at any CCL load or a systemic effect. Funded by the Master's Grant Program of the NATA Research & Education Foundation.

EBF: Modalities

Tuesday, June 21, 2011, 10:30AM-11:30AM, Room 218

Free Communications, Oral Presentations: Patient Oriented Outcomes

Tuesday, June 21, 2011, 4:30PM-6:00PM, Room 218; Moderator: Luzita Vela, PhD, ATC

Comparison Of Health-Related Quality Of Life In Interscholastic Adolescent Athletes Participating In Fall, Winter, Or Spring Sports

Califano KM, Snyder AR, Lam KC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Due to increased emphasis on evidence-based practice and whole person healthcare, attention has been given to the evaluation of health-related quality of life (HRQOL) in adolescent athletes through the use of patient-rated outcome measures (PROMs). However, little is known about HRQOL in this population, including whether HRQOL differs throughout the school year. Knowledge regarding representative values of HRQOL obtained through PROMs is important for accurate scale interpretation following injury.

Objective: To compare preseason HRQOL of adolescent athletes who participate in either fall, winter, or spring interscholastic athletics. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** A convenience sample of single-sport interscholastic adolescent athletes participating in either fall (n=413; male=354, female=59; age=15.5±1.2 years), winter (n=422; male=313, female=109; age=15.9±1.2 years), or spring (n=282; male=162, female=120; age=15.9±1.2 years) sports.

Interventions: Athlete group (fall, winter, or spring) was the independent variable. Participants completed the Pediatric Quality of Life Inventory (PedsQL) (internal consistency=.68-.88) and the PedsQL Multidimensional Fatigue Scale (MFS) (internal consistency=.75-.92) during one testing session at the start of their respective sport season. **Main Outcome Measures:** Dependent variables

included the PedsQL total score (TS) and 5 subscale scores [physical functioning (PF), psychosocial functioning (PSF), emotional functioning (EF), social functioning (SOF), school functioning (SCF)], and 3 subscale scores of the MFS [general fatigue (GF), sleep fatigue (SF), cognitive fatigue (CF)], with higher scores indicating better HRQOL. One-way ANOVAs were conducted to compare total and subscale scores between the athlete groups and alpha was p<0.05, two-tailed. Means and standard deviations (SD) were calculated for all scale scores and data are reported as (mean±SD). **Results:** Spring athletes reported significantly higher scores than fall athletes for TS (p=.003, spring: 91.2±9.0; fall: 88.8±10.2) and GF (p=.001, spring: 89.3±13.0; fall: 85.2±15.8), winter and spring athletes reported significantly higher scores (p<.001) for PF than fall athletes (winter: 92.7±10.4; spring: 94.1±7.8; fall: 89.9±11.9), and spring athletes scored significantly higher (p=.04) than winter athletes for SCF (spring: 85.4±14.8; winter: 82.5±15.5). There were no differences (p>.05) between athlete groups and PSF, EF, SOF, SF, and CF. **Conclusions:** Our results indicate that spring single sport adolescent interscholastic athletes report better health status than single sport athletes participating in fall and winter season sports on several measures of HRQOL, including school functioning, general fatigue, and overall health. These findings suggest that adolescent athlete HRQOL may vary depending on sport season, with better HRQOL reported later in the school year. As a result, it may be necessary to evaluate HRQOL at the start of each new sport season. Future research is warranted to determine if multi-sport athletes exhibit similar differences in HRQOL

and whether differences are due to certain sports.

Changes In Health Related Quality Of Life In Active Females One Year After ACL Tear

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Context: Anterior cruciate ligament (ACL) tears occur with higher frequency in female athletes and limit their ability to fully participate in athletics for 6 to 8 months. However, there are limited data about how health related quality of life (HRQOL) is affected following an ACL tear.

Objective: To identify changes in HRQOL in female athletes one year after an ACL tear using the SF 12 v2.0, a widely accepted self report survey used by healthcare providers and researchers to measure HRQOL.

Design: Prospective cohort. **Setting:** Data were collected at a sports medicine clinic and university health service.

Patients or Other Participants: Participants were a convenience sample of 90 high school and college females (age = 16.8 ±1.7 years) who sustained an ACL tear while participating in a sport or regular fitness activity and subsequently underwent ACL reconstruction surgery. **Interventions:** Each subject completed the SF12 v2.0 at multiple intervals over the course of one year. The Physical Composite Score (PCS) and the Mental Composite Score (MCS) of the SF12 v2.0 measure eight domains of physical and emotional health and are recognized as valid measures of patient outcomes after treatment of orthopedic injuries. The test-retest reliability of the SF12 v2.0 has been reported to be good to excellent (0.760 to 0.890) in patients

with various orthopedic injuries. **Main Outcome Measures:** Dependent variables included the paired differences in the composite scores (PCS and MCS) between the pre-injury and 12 months post injury intervals. Differences were assessed with the Wilcoxon Signed-Rank Test ($p \leq 0.05$) reported as the median (inter-quartile ranges [IQR]: 25th and 75th). **Results:** The paired PCS scores (-1.61[-5.3, 0.87]) were significantly lower ($p = 0.001$) 12 months post ACL tear (pre-injury = 56.61 [56.61, 58.53]; 12 months post injury = 55.78 [52.82, 57.55]). The paired MCS scores (-2.19 [-5.82, 2.95]) were significantly lower ($p = 0.013$) 12 months post ACL tear (pre-injury = 58.9 [53.65, 61.85]; 12 months post injury = 56.6:[51.04, 55.66]). **Conclusions:** Female athletes who sustained an ACL tear rated their physical and emotional health to be worse 12 months after their knee injury as measured by the Physical Composite Score and Mental Composite Score of the SF12 v2.0. Understanding that HRQOL is lower one year after this major knee injury may enable healthcare providers to better affect the physical, psychological and social health outcomes of their female athletes.

Benefits And Barriers To The Use Of Patient-Rated Outcome Measures In Athletic Training

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Context: Evaluation with patient-rated outcome measures is important for driving treatment decisions and determining effective interventions. However, athletic trainers (ATs) rarely use them. Understanding the reasons for disuse of patient-rated outcomes in athletic training may assist in constructing strategies that facilitate routine collection of these important outcomes. **Objective:** To identify the benefits and barriers to the use of patient-rated measures in athletic training. **Design:** Survey. **Setting:**

Web-based. **Patients or Other Participants:** 1469 randomly sampled ATs (age=36.8±9.8 years; 48% female; 76% practice >5 years) working in the college/university, two-year institution, secondary school, clinic, hospital, or industrial/occupational setting. Non-practicing ATs were excluded. **Intervention:** An email invitation was sent to the random sample of ATs asking them to complete a validated survey, through Survey Monkey, regarding the use, benefits, and barriers of outcome measures in athletic training. The survey consisted of 86 questions split into two question sets. ATs who indicated they used patient-rated outcome measures (AT-PR) completed 65 Likert-style (5pts: 1=strongly agree, 5=strongly disagree) questions about the benefits and barriers to the use of these instruments. ATs who indicated no use of patient-rated outcome measures (AT-NON) completed 21 questions about the barriers of use. Internal consistency was high for each survey factor (Cronbach's alpha=.89, .90, and .71, respectively). A reminder email was sent to all potential subjects at 2-weeks post-initial invitation. **Main Outcome Measure:** Dependent variables were the endorsements for the benefits and barriers to the use of patient-rated outcome measure questions. Likert questions were classified as endorsed when a rating of "agree" or "strongly agree" was selected by a participant. Data are reported as percentage endorsed (%). **Results:** 458 ATs initiated the survey (response rate=31.2%) and 398 ATs (AT-PR=26.1%, AT-NON=73.9%) completed the survey (response rate=27.1%). The most frequently endorsed benefits of use reported by AT-PR were enhancing communication with patients (89.7%) and other health care professionals (80.4%), directing patient care (86.9%), and increasing exam efficiency (80.4%). The most frequently endorsed problems of use reported by AT-PR were that patient-rated measures are time consuming (44.2%), difficult (35.6%), and confusing (30.8%) for patients and time consuming for clinicians to score

and interpret (28.8%). The most frequently endorsed problems of use reported by AT-NON were that outcomes instruments are time consuming for clinicians to score and interpret (31.2%), time consuming (46.3%) and irrelevant to patients (28.0%), and require a support structure that clinicians do not have (29.3%). **Conclusions:** These results suggest that while there are benefits to using patient-rated outcomes, there are also barriers (eg, completion and scoring time) to their use. Barriers are similar between AT-PR and AT-NON. Future research should investigate strategies to decrease barriers and facilitate use of patient-rated outcome measures in athletic training practice.

Identifying Differences In Health-Related Quality Of Life Between Adolescent Athletes And A General, Healthy Adolescent Population

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

Context: Patient-rated outcome measures (PROMs) are important for assessing health-related quality of life (HRQOL) and providing patient-centered, whole person healthcare. Normative values established for a general, healthy population are often used as a frame of reference when utilizing generic PROMs for patient care and clinical decisions. However, previous studies have indicated that athletes tend to report significantly better HRQOL than a general, healthy population, which may decrease the utility of these normative values when providing medical care for athletes. **Objective:** To identify differences in HRQOL, as measured by a commonly used generic PROM [Pediatric Quality of Life Inventory (PedsQL)], between adolescent athletes and a general, healthy adolescent population. **Design:** Cross-sectional. **Setting:** Athletic training facilities. **Patients or Other Participants:** The athlete group (ATH) was a convenience sample of 1955 (male=1526, female=429; age=

15.1±0.8 years) interscholastic adolescent athletes. The general, healthy group (GEN) was represented by values extracted from a previously published normative dataset by Varni et al. (2007) for 14, 15, and 16 year-old (y/o) healthy adolescent individuals (n=729). **Interventions:** Group was the independent variable. Participants completed the PedsQL Generic Core Scale (GCS) (internal consistency=.68 - .88) during one testing session. **Main Outcome Measures:** Dependent variables included the total PedsQL GCS score (TS) and 5 subscale scores [physical functioning (PF), psychosocial functioning (PSF), emotional functioning (EF), social functioning (SOF), school functioning (SCF)], with higher scores indicating better HRQOL. Independent-samples t-tests were conducted to compare total and subscale scores between ATH and GEN. Groups were matched by age (14, 15, 16 y/o) and alpha was set at p<0.05, two-tailed. Data are reported as (age group: mean±SD for ATH, mean±SD for GEN) **Results:** ATH reported significantly higher scores (p<0.02) than GEN across all age groups for TS (14y/o: 89.4±9.6, 85.7±12.0; 15y/o: 89.8±9.6, 84.7±12.7; 16y/o: 89.6±10.1, 85.8±11.4), PF (14y/o: 91.1±10.6, 89.0±13.2; 15y/o: 91.5±11.2, 88.6±13.6; 16y/o: 91.8±10.4, 89.1±12.7), PSF (14y/o: 88.6±10.6, 84.0±13.3; 15y/o: 88.9±10.7, 82.7±14.2; 16y/o: 88.5±11.5, 84.0±13.0), EF (14y/o: 88.8±13.9, 81.0±17.8; 15y/o: 88.8±14.6, 79.7±18.6; 16y/o: 88.4±15.6, 80.2±18.0), and SOF (14y/o: 92.6±11.0, 89.8±14.7; 15y/o: 94.0±10.0, 89.1±14.5; 16y/o: 93.6±11.2, 90.3±12.6). For SCF, 14 and 15 y/o ATH scored significantly higher (p<0.02) than their GEN counterparts (14y/o: 84.1±14.8, 81.2±17.1; 15y/o: 83.9±15.0, 79.3±17.9), but the difference between the 16 y/o groups was not significant (p=0.23; 16y/o: 83.4±15.9, 81.5±17.4). **Conclusions:** Our results support previous findings indicating that adolescent athletes report better HRQOL than a general population of

peers. Our findings also suggest that adolescent athletes may constitute a unique patient population that requires its own set of normative values related to generic PROMs. Healthcare practitioners should be cognizant of these differences and account for them when providing care for adolescent athletes and when utilizing the PedsQL GCS and other PROMs for patient care.

The Relationship Between Clinical Tests For Scapular Dyskinesia And Health-Related Quality Of Life Assessed Via Two Upper Extremity Self-Report Scales In Patients With Shoulder Versus Lower Extremity Pain

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Context: Scapular dyskinesia may be a contributing factor to shoulder pain and disability, and numerous clinical tests purport to assess scapular dyskinesia. However, relationships between scapular dyskinesia and self-reported, health-related quality of life (HRQOL) in patients with shoulder pain and dysfunction are unknown.

Objective: Assess whether three standard clinical tests for scapular dyskinesia differentiate between patients with shoulder pain and lower extremity pain (Aim 1), and establish the relationship between these tests and self-reported HRQOL in patients with shoulder pain (Aim 2). **Design:** Cross-sectional. **Setting:** Outpatient clinic. **Patients or Other Participants:** 15 patients being treated for lower extremity pain served as a control group (Con) [(male=11, female=4); age:19.3±4.6yrs; height:176.1±8.8cm; mass:74.7±15.0kgs] and 15 patients being treated for shoulder pain served as the experimental group (Exp) [(male=9, female=6); age: 29.8±13.7yrs; height: 174.9±10.4cm; mass :73.4±13.1kgs]. Inclusion criteria

required leg or shoulder pain ≥1 week that interfered with daily activities and for which patients sought medical attention. **Interventions:** The independent variable was group membership (Con & Exp). Scapular dyskinesia was examined using three special tests: 10 repetitions each of unweighted and weighted flexion bilaterally, and scapular flip sign. These tests performed in combination produce 81-85% agreement, k=0.51-0.59. The Disabilities of the Arm, Shoulder and Hand (DASH) (MDC=12.75pts, scale range:0-100; higher scores represent diminished HRQOL) and American Shoulder and Elbow Surgeons (ASES) (MCID=6.4pts, scale range:0-100; higher scores represent better HRQOL) self-report scales were administered to assess HRQOL. Both scales have been reported to be reliable and valid measures of disability in populations with a broad range of shoulder injuries.

Main Outcome Measures: The dependent variables for aim 1 were the scapular special test findings, classified as positive or negative, based on the visible presence of excessive or asymmetric scapular winging and/or failure to control scapular motion. The dependent variables for aim 2 were patient self-report scores for the DASH and ASES. The Fisher's exact test was used to compare scapular special test findings between groups and Mann Whitney-U tests were used to analyze differences between groups on DASH and ASES scores. Alpha was p=0.05, two-tailed. **Results:** Groups did not differ significantly on the scapular special tests (unweighted flexion, p=1.00; weighted flexion, p=0.07; scapular flip sign, p=0.68). Significantly lower HRQOL was observed between groups for the DASH-Total (Exp =23.7±13.5pts, Con=0.7±1.1pts, p=0.02) and ASES-ADL (Exp=34.8±10.1pts, Con=49.4±1.4pts, p=0.04). Patients with a positive weighted flexion test displayed significantly different scores on the DASH-Total (positive =12.2±15.0pts, negative=6.6±11.1pts, p=0.017) and ASES-ADL (positive =39.3±11.1pts, negative =45.4±8.5pts, p=0.038), indicating lower

HRQOL. **Conclusions:** The three tests for scapular dyskinesis in this study did not differentiate between shoulder pain and lower extremity pain patients. A positive weighted flexion test for scapular dyskinesis was correlated with lower self-reported HRQOL in both groups. The relationship between scapular dyskinesis and HRQOL warrants further study.

Critical Review Of Self-Reported Functional Ankle Instability Measures

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Context: Functional Ankle Instability (FAI) lacks a gold standard measure or universally accepted inclusion criteria. As a result, a wide variety of self-reported ankle instability measures have been developed for use in FAI research. **Objective:** Determine which ankle instability measure identifies subjects who meet the minimum accepted criteria for FAI. **Design:** Cross-sectional study **Setting:** University classroom settings. **Participants:** Two hundred and forty-two college aged subjects (104 males, 138 females, and 21.38 ± 1.40 years) volunteered from a large Midwestern university population. **Interventions:** The independent variables were the seven ankle instability questionnaire: Ankle Instability Instrument (AII), Ankle Joint Functional Assessment Tool (AJFAT), Chronic Ankle Instability Scale (CAIS), Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Ability Measure (FAAM), Foot and Ankle Instability Questionnaire (FAIQ), Foot and Ankle Outcome Score (FAOS). Subjects were asked to complete all questionnaires in one testing session. The order of the questionnaires was randomized and subjects were instructed to complete each questionnaire for their dominant limb. All seven of these questionnaires are currently used or appear in the FAI literature in the past five years. **Main Outcome Measures:** The dependent

variable was created based on the minimum acceptable criteria for FAI. Based on current literature this criterion was established as at least one ankle sprain and at least one episode of giving way (MC_FAI). Data were modeled using chi-square and multinomial logistic regression. 95% confidence intervals (CI) were calculated for the resulting odds ratios. **Results:** 53.30% of participants experienced a dominant limb ankle sprain, and 48.22% of participants with a dominant ankle sprain reported at least an episode of giving way. The model revealed that all questionnaires were better at determining when a participant did not meet the minimum criteria for FAI (no MC_FAI=95.7%, MC_FAI=55.6%). Backwards stepwise reduction of the model revealed in the final step that only the CAIT ($X^2 = 8.22$, odds ratio=0.31, CI 0.14-0.69, $p=.004$) with the AII ($X^2 = 29.70$, odds ratio=0.10, CI 0.04-0.23, $p<0.001$) had a significant relationship with the dependent variable (MC_FAI). **Conclusions:** The model illustrates that no single measure was able to predict if an individual met the minimally accepted criteria for FAI. However, the model identified that the combined use of the CAIT and AII produced a significantly accurate prediction of ankle stability status. Based on the results of this model we strongly recommend that the CAIT and AII be used in conjunction to determine ankle stability status.

The Perceptions Of Clinical Reasoning Skills And Abilities In Students Who Learned A Student-Centered Clinical Reasoning Technique

Vela LI, Heinerichs S, Drouin J: Texas State University, San Marcos, TX; West Chester University, West Chester, PA; Lock Haven University, Lock Haven, PA

Context: Clinical reasoning (CR) is the process by which knowledge, cognition, and metacognition are combined into the clinical decision making process. Teaching CR enables students to make better clinical decisions during clinical education experiences. SNAPPS is an acronym for a student-centered clinical reasoning and case presentation method used in clinical education. Objective: To investigate entry-level athletic training students' (ATS) perceptions of the SNAPPS technique on clinical reasoning skills and abilities. Design: Descriptive qualitative method using focus groups (FG) Setting: Two undergraduate, entry-level, CAATE accredited athletic training education programs. Patients or Other Participants: Thirteen participants (age = 21.62±1.19; GPA = 3.27±0.25; gender = 8 female, 5 male) were purposively selected based on years of clinical education experiences (>1 year) and completed coursework (completed orthopedic evaluation series) to participate in one of two FGs. FG participation was limited to participants who were assigned to learn and apply the SNAPPS procedure in a clinical education setting over a 4-week period. Data Collection and Analysis: After learning and employing the SNAPPS technique for all authentic orthopedic case presentations over a four-week period, participants took part in one of two (n=4 and n=9), 25-30 minute FG interviews. The FGs were guided by a structured interview guide consisting of 6 open-ended questions. The focus group interviews continued until data

saturation occurred. The data was transcribed verbatim and checked for accuracy. Two investigators independently used a framework analysis method to create a thematic framework and interpret the data. Peer review strategies were used to establish trustworthiness and accuracy of the themes. Results: Participants' comments on SNAPPS centered on areas where SNAPPS improved clinical reasoning and clinical education experiences. Participants commented on the improved ability to process thoughts during an orthopedic injury evaluation with an emphasis on the analysis of a differential diagnosis. Participants also remarked on the notable improvements in organization, detail and communication of the clinical examination findings. The education process was also augmented by clinical instructor feedback and self-directed learning experiences required in the SNAPPS procedure. Participants did comment that time constraints and the detailed nature of SNAPPS were two cons of the technique particularly during busy clinical days. Conclusions: Perceptions of students using SNAPPS were positive indicating that the integration of SNAPPS into clinical education is worthwhile. In addition to improving clinical education experiences, the vocabulary, concepts and deployment of SNAPPS appeared to aid students in the construction of meaning in clinical reasoning.

Clinical Instructor's Perceptions Of A Learner Centered Technique To Express Clinical Reasoning Skills In Athletic Training Students

Heinerichs S, Vela L, Drouin J: West Chester University, West Chester PA; Texas State University, San Marcos, TX; Lock Haven University, Lock Haven, PA

Context: Clinical reasoning skills are valuable for athletic training students

to understand and demonstrate during the clinical education experience. One way for students to express clinical reasoning skills is through their case presentations. However, the time pressured environment of the clinical setting may inhibit clinical instructors (CIs) from engaging in a teacher centered approach. Learner centered approaches have been utilized successfully in medical education for assessing this skill. Objective: To determine the feasibility of utilizing a learner centered technique (SNAPPS) for assessing a student's ability to express clinical reasoning skills in athletic training. Design: Feasibility study Setting: Three undergraduate CAATE accredited athletic training programs. Participants: As part of a larger study 13 CIs (6 males, 7 females) were randomly assigned based on sport coverage, year's experience, and number of students supervising. CIs were involved in a 4 week study utilizing a learner centered technique (SNAPPS) with 15 undergraduate students. Eight participants (62%) had e"10 years experience as a CI and 5 (48%) had <10 years experience. All CIs and students attended a training session that demonstrated the technique, addressed the concept of clinical reasoning, and allowed for questions and answers. Interventions: Thirteen CIs listened to their assigned students utilize the SNAPPS technique for all authentic orthopedic case presentations over a 4 week period. Following the 4 week intervention CIs were asked to complete an online survey, the SNAPPS Perception Survey (Cronbach's = .862). Main Outcome Measures: The SNAPPS Perceptions Survey consists of 8 likert scale items for which 1= strongly disagree, 5= strongly agree and four open ended items centering on the effectiveness of the technique. Data was analyzed using descriptive statistics while trends were ascertained in open ended questions. Results: Twelve of 13 (92.3%) CIs completed the online survey. Twelve (100%) of the

participants strongly agreed or agreed that SNAPPS improved the quality of presentations. Ten (83%) of the participants strongly agreed or agreed that SNAPPS enabled the students to be more concise in their case presentations. Ten (83%) of the participants strongly agreed or agreed that SNAPPS improved the students ability to clinically reason during the evaluations. Ten (83%) of the participants strongly agreed or agreed that SNAPPS enabled students to formulate a differential diagnosis. None of the participants reported any disagreement or strong disagreement with any statements on the survey. Eight (66%) of the participants described that SNAPPS enabled their students to think more critically and allowed for a more organized case presentation. **Conclusions:** It is feasible to utilize a learner centered technique to express clinical reasoning skills in athletic training students during their clinical experiences. CIs felt the technique was thought provoking, allowed for organization, and effective in student's expression of clinical reasoning skills.

Peer Assessment/Feedback Training Has A Positive Effect On The Feedback That Students Provide

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The University of North Carolina at Greensboro, Greensboro, NC, and Ashland University, Ashland, OH

Context: Peer assessment/feedback (PAF) is clearly occurring in athletic training education programs. However, it remains unclear whether students would improve their ability to assess their peers and provide corrective feedback if they received formal training in how to do so. **Objective:** Determine if a PAF training program affected the quality and type of feedback students provided to their peers. **Design:** Descriptive quasi-experimental repeated measures. **Setting:** Undergraduate sports medicine class. **Patients or Other Participants:** Sixteen upper-level

undergraduate sports medicine students were randomly selected from a sports medicine laboratory course.

Data Collection and Analysis: The participants practiced skills in groups of four, they were instructed to assess and provide feedback to their peers. There were three sets of laboratory skills with two days of practice for each set. Eight participants received a two-day PAF training after the first set of labs; eight participants served as the control group. The training consisted of discussion of the background/purpose of PAF, reflection of past peer interactions, discussion of feedback tips, analysis of videotaped scenarios and role playing exercises. The participants were videotaped and audio taped. The feedback was transcribed verbatim and actions that provided feedback were recorded in Excel. Content and quality of the feedback were evaluated with the feedback quality scale (descriptive, general, incorrect or missing). The videotaped feedback was also categorized by the type of feedback (reaffirming or corrective). Content, quality and type of feedback were qualitatively coded for themes using deductive content analysis to determine differences in the feedback given by the experimental group when compared to the control group. Independent analysis yielded 96.30% agreement and 100% agreement after discussion. Independent analysis, member checking and peer debriefing were used to ensure accuracy and trustworthiness. **Results:** The videotaped data analysis suggests that PAF training potentially shaped the consistency of descriptive feedback, use of strategic questioning, staying on task and the amount of reaffirming feedback provided. Findings also suggest that other factors shaped the peer feedback, such as baseline ability to provide quality feedback, difficulty of the skill and the number of errors performed while executing the skills. Some of the strategies discussed in the PAF training were used by the control groups even though they did not receive training. The training could be beneficial for all students to either

reinforce what they already do or to teach new strategies. Participants in the PAF training found it beneficial, which may improve the acceptance of feedback and their willingness to provide feedback. **Conclusions:** The results of this study indicate that PAF training can improve certain aspects of the feedback that students provide to each other while practicing procedures to enhance skill practice.

Standardized Patient Encounters And Case-Based Simulations Improve Students' Confidence And Evaluation Skills

Walker SE, Weidner TG, Armstrong KJ: Ball State University, Muncie, IN, and Georgia College & State University, Milledgeville, GA

Context: Athletic training student's clinical skills are evaluated via many methods, such as role play, case studies, case-based simulations (CBS), and standardized patients (SP). No research has examined the longitudinal effects of these evaluation experiences, particularly on future clinical decision-making. **Objective:** To explore athletic training students' perceptions regarding a small group SP encounter versus an individual CBS on their clinical decision-making abilities. **Design:** Descriptive qualitative method of inquiry with a grounded theory approach. Setting: Individual interviews at one Midwestern University. **Patients or Other Participants:** Eleven athletic training students (4 males, 7 females; 20 + 0.894 years old) who were enrolled in a Lower Extremity Orthopedic Evaluation course during their first or second semester in the athletic training education program (ATEP) participated in this study. All participants received the same classroom and laboratory instruction. Participants' were randomly assigned to one of two groups (Group A completed a CBS, then small group SP encounter; Group B completed a small group SP encounter then a CBS) to control for different semesters in the ATEP. Individual interviews took place

4 weeks following the final evaluation experience. **Data Collection and Analysis:** Semi-structured interviews were recorded, transcribed verbatim and analyzed using open coding, axial and selective coding (i.e., develop themes/threads). To ensure trustworthiness, member checks and peer de-briefing were employed (performed by a qualitative research expert in athletic training). **Results:** Three themes emerged from the participants' responses: 1) increased confidence towards future evaluations, 2) improved organization throughout the evaluation process, and 3) enhanced value of group members during small group SP encounter. Overall, students' perceived that as a result of both the CBS and small group SP encounter they were more confident and felt better prepared realizing they possessed the knowledge and skills to perform future evaluations. Students also perceived that both experiences improved their clinical decision-making skills. Students felt they would perform future evaluations in a more organized manner. Lastly, students reported that they valued interacting with their peers and sharing ideas about questions and evaluation methods during the small group SP encounter. However, students reported a lack of confidence regarding their verbal and non-verbal communication with each other in a group. Overall, students reported difficulty navigating and understanding their role within a group. **Conclusions:** Both the small group SP encounter and CBS increased students' confidence and improved their clinical decision-making skills for future patient evaluations. The small group SP encounter also allowed students to interact with their peers in forming a patient's diagnosis, a necessary aspect of functioning as part of a health care team.

EBF: Education

Wednesday, June 22, 2011, 9:15AM-10:00AM, Room 218

Free Communications, Oral Presentations: Gender Issues In Athletic Training

Wednesday, June 22, 2011, 10:30AM-11:15AM, Room 218; Moderator: Ashley Goodman, PhD, ATC

Gender Bias In The Athletic Training Profession

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MN

Context: Research regarding gender in athletic training is limited; however, the studies that have been published suggest that female athletic trainers (ATs) experience gender bias. Even though the majority of NATA members are females, evidence suggests that female ATs are less likely to work in supervisory positions, earn a lower salary, experience gender bias as mothers, and have less opportunity to work in professional sports compared to male ATs. **Objective:** The primary purpose of this study was to examine gender differences in perceived treatment of male and female ATs. The secondary purpose was to examine the relationship between gender, salary, age and years of experience. **Design:** Cross-sectional survey design. **Setting:** An on-line survey sent via email using Survey Monkey. **Patients or Other Participants:** A total of 3300 ATs were randomly selected from the NATA membership database. Male and female ATs who work with patients were sent a link to an on-line survey that focused on perceived gender issues in athletic training. Approximately 32% ($n=1040$) of the members contacted completed some component of the survey; however 127 participants did not complete the entire survey and their responses were not included. The final sample included 913 athletic trainers (Males = 421, Females = 489, 3 did not indicate gender) with a mean age of 36.2 (SD = 9.76). The participants had worked in the athletic training profession for an average of 12.32 years (SD = 8.67). **Interventions:** The survey was developed based upon the limited research regarding gender in athletic

training. Ten certified ATs provided feedback on the survey to establish face validity, and several questions were clarified based on their feedback. **Main Outcome Measures:** A series of chi-square analyses were calculated to determine gender differences in perceived treatment. A multiple linear regression analysis was calculated to determine the relationship between gender, salary, age, and years of experience. **Results:** Chi-square analyses indicated that compared to males, females were more likely to indicate differences in how they are treated or perceived by coaches (61.1%; $p=.001$), athletes or patients (33.7%; $p=.001$), athletic administrators (32.5%; $p=.001$), parents (27.8%; $p=.001$), and physicians (17.0%; $p=.001$). A multiple linear regression analysis indicated that gender, age and experience were related to salary ($p=.001$; $r^2=.276$). More specifically, females at the same age and years of experienced as males earned on average of \$3,664 less than males ($p=.001$). **Conclusions:** Findings suggest gender bias exists in the athletic training profession. Females report perceived differences in treatment and a lower salary regardless of age and years of experience. More education is needed to increase awareness and promote equality for females within athletic training.

Labor Force In Athletic Training: Age, Gender And Setting Factors

Eberman LE, Kahanov L: Indiana State University, Terre Haute, IN

Context: Gender related occupation or occupational setting shifts may be occurring in Athletic Training. To better understand the labor force and distribution of gender among settings, a comparison of male and female employment patterns should be

investigated. **Objective:** To identify differences among genders between occupational settings and across the occupational life span. **Design:** We used a non-experimental, descriptive research design to observe the trends of the National Athletic Trainers' Association (NATA) membership data in regard to gender, occupational setting, and age. **Setting:** We obtained NATA membership demographic data (October 27, 2009). **Participants:** The population of athletic training members included both full-time and part-time ATs but excluded graduate assistants, retired and non-employed individuals. The sample of ATs has 12,277 female ATs and 13,255 male ATs with an age range of 22 to 66 years old. A majority of Athletic Trainers (70.4%, $N=18571$) were employed in the college/university, clinic, and secondary school setting. The frequencies of the individuals in the other settings were too small for any meaningful statistical analysis. **Intervention:** We calculated frequencies and percentages to determine demographic and descriptive data. We analyzed the data using an ANOVA to identify the differences between genders across age and setting. **Main Outcome Measures:** We observed trends in occupational setting and gender between the ages of 22 and 67 years old. **Results:** We identified significant differences between genders across the ages ($F_{1,18569} = 110818.080$, $P < .001$, $\eta^2 = .068$). Although women account for 42.9% of the total sample population, women occupy a large majority of the profession between ages of 22-28, but then drastically decline between the ages of 28-35. The male population size remains relatively consistent between the ages of 27-42 years old and eventually dissipates. We identified significant differences between genders across the occupational

settings ($F_{1,18569}=61.908$, $P<.001$, $\eta^2=.003$). The male population declines in the college/university and clinic settings, but then increases in the secondary school setting during their mid- to late-forties. We also observed significance at the intercept between setting and gender ($F_{1,18569}=63529.344$, $P<.001$, $\eta^2=.845$) which is enhanced across the ages ($F_{1,18569}=23566787.642$, $P<.001$, $\eta^2=.939$). The intercept of setting and gender accounts for 85% of the variability in occupational setting change and the addition of age increases the accounting for variability in occupational setting change to 94%. **Conclusions:** We identified significant differences among genders between settings and across the ages in addition to an overall decrease among all professionals. A marked decline in female athletic trainers occurs at the age of 27, yet the male population increases at the secondary school suggesting a setting shift. Burnout, fatigue, pay scale and a misunderstanding of professional culture and job duties may influence the exodus or shifting in athletic training.

Is It About Respect? Using Role Congruity Theory To Explore The Challenges Faced By Young, Female Athletic Trainers

Pagnotta KD, Mazerolle SM, Borland JF, Burton LJ: University of Connecticut, Storrs, CT, and Springfield College, Springfield, MA

Context: Athletic training is experiencing an increase in the number of women entering the profession with female ATs representing 46.5% of ATs within the NATA. Despite this increase the collegiate setting appears to only retain one-quarter of these ATs and a limited number assume the role of Head AT. Role congruity theory has been proposed to understand why women are under-represented in leadership positions. **Objective:** To understand challenges and obstacles faced by young, female athletic trainers working in Division I athletics. **Design:** Exploratory study using semi-

structured phone interviews. **Setting:** Division I clinical setting **Patients or Other Participants:** 14 female ATs using both criterion and snowball sampling techniques were included in the study. The mean age was 27 ± 2 with 5 ± 2 years of experience. Criteria included employment at the Division I clinical setting, full-time assistant AT, and at least three years of working experience but no more than nine years to avoid role continuance. Participants represented 5 NATA districts. Data recruitment was guided by data redundancy. **Data Collection and Analysis:** Analysis of the interview data followed inductive procedures as outlined by a grounded theory approach. Credibility was established by member checks, multiple analyst triangulation, and peer review. **Results:** Eleven of the 14 participants described experiences of gender bias, while thirteen of the fourteen encountered issues regarding their age. Two themes emerged to explain experiences of gender bias: 1) gender role stereotyping, and 2) negative past experiences with female ATs. Coaches served as the primary source of gender bias. Participants indicated experiences in which their ability to make clinical judgements were questioned by male coaches, regardless of their past performance as ATs. Other experiences of bias were encountered due to coaches' perceptions of negative experience with previous female ATs, which influenced future relationships with other female ATs. Clear communication with both coaches and players on expectations and philosophies regarding medical care, a supportive head athletic trainer regarding clinical competence, and having and serving as a role model were cited as critical tools to alleviate gender bias in the workplace. **Conclusions:** The female ATs in this study stressed the importance of being assertive with the coach early on in the season with regard to their role on the team. They reasoned that these actions brought forth a greater perception of congruity between their roles as ATs and their gender and age. It is suggested that

female AT students seek out mentors in their industry while they complete their coursework and practica. The ATs in the current study indicated a mentor, regardless of gender, helped them feel empowered to navigate the male-centric terrain of athletic departments by encouraging them to be assertive and not second-guess their decisions.

Free Communications, Oral Presentations: Evidence Based Practice in Athletic Training

Wednesday, June 22, 2011, 11:30AM-12:45PM, Room 218; Moderator: Bonnie Van Lunen, PhD, ATC

Athletic Training Education Program Directors' And Athletic Trainers' Perceptions Of The Psychosocial Intervention And Referral Competencies

Seiler BD, Gentner NB, Wehring SP, Joyner AB: Georgia Southern University, Statesboro, GA, and University of South Carolina, Columbia, SC

Context: Education of the psychosocial intervention and referral (PS) content area is required to be taught within all Athletic Training Education Programs (ATEPs). Research has evaluated athletic trainers' (AT) perceptions of the PS content area, but not ATEP directors' perceptions of this area. **Objective:** To evaluate ATEP directors' and ATs' perceptions of the importance, criticality, and preparedness of the PS competencies, and evaluate participants' ranking of the National Athletic Trainers' Association (NATA) content areas. **Design:** Descriptive survey. **Setting:** Web-based survey including non-collegiate, NAIA, and NCAA Division I, II, and III institutions. **Patients or Other Participants:** A convenience sample of 88 (8.8%) ATs and 53 (15.4%) ATEP directors. **Interventions:** The independent variable consisted of ATs and ATEP directors. ATs included individuals in the graduate assistant, high school, high school/clinic, junior college, and university/college NATA employment categories. ATEP directors included individuals listed on the Commission on Accreditation of Athletic Training Education website at the time of the study. Participants completed the web-based Athletic Training Educational Competency Questionnaire (ATECQ) within 5-weeks. The ATECQ replicated the Board of Certification's Role Delineation Study's content evaluation (5th Ed.). A pilot study was completed to determine content-related and face

validity of the ATECQ. Reliability of the ATECQ was 0.933, and 0.929 with item deletion. **Main Outcome Variables:** Importance (essential to job performance), criticality (degree of adverse effects), and preparedness (perceived preparation) were the dependent variables. One-tailed t-tests were completed to determine importance, criticality, and preparedness of the psychosocial competencies. Alpha was set at a more conservative level ($\alpha=0.017$) after completing a Bonferroni adjustment. Participant demographics and NATA content rankings were expressed as frequencies and percentages. **Results:** No significant results were found between ATs and ATEP directors within the importance ($P=0.14$), criticality ($P=0.38$), and preparedness ($P=0.38$) of the psychosocial competencies. However, ATEP directors rated the roles/function of community based healthcare providers competency as more important (Mean=1.98 \pm 0.80) than ATs (Mean=1.65 \pm SD=0.77) ($P=0.008$), the signs/symptoms of eating disorders competency as more important (Mean=2.62 \pm SD=0.56) than ATs (Mean=2.38 \pm SD=0.63) ($P=0.01$), the basic counseling principles competency as more important (Mean=2.09 \pm SD=0.77) than ATs (Mean=1.83 \pm SD=0.65) ($P=0.015$), and the signs/symptoms of mental/emotional disorders, or personal/social conflicts as more prepared (Mean=1.64 \pm SD=0.86) than ATs (Mean=1.30 \pm SD=0.95) ($P=0.016$). The PS content area was ranked below 50% of the other content areas for all variables. Top ranked content areas included acute care of injuries/illnesses, orthopedic clinical examination/diagnosis, and risk management/injury prevention. **Conclusions:** ATEP directors and ATs do not consider the psychosocial aspects in athletic training as important or critical as other content areas, and are therefore less

likely to spend time preparing students in this area. Therefore, ATEP curriculum should be reevaluated for the inclusion/exclusion of the psychosocial competencies, potentially creating additional space for instruction in more applicable areas of practice.

Program Evaluation Of The Evidence-Based Teaching Model In Undergraduate Athletic Training Education: Student Outcomes

Manspeaker SA, Van Lunen BL, Hankemeier D: Old Dominion University, Norfolk, VA, and Texas Christian University, Fort Worth, TX

Context: While research recommends that health professions expand the instruction and use of evidence-based practice (EBP) due to its individualized approach to patient care, few examples of strategies aimed at teaching the EBP process, or the effects of such strategies on students, exist in athletic training. **Objective:** To evaluate the effectiveness of the Evidence-Based Teaching Model (EBTM) in increasing student knowledge, attitudes, and use of evidence-based concepts. The EBTM presents the EBP process: 1) formulating a clinical question through Patient (P), Intervention (I), Comparison (C), Outcome (O) (PICO), 2) searching for evidence, 3) critical appraisal of evidence, 4) use of clinical expertise, 5) implementing evidence into patient care. **Design:** Within subjects design, pre-/post-test evaluations of students' EBP knowledge, attitudes and intended use through the Evidence-Based Concept Knowledge, Attitude and Use (EBKCAU) survey. **Patients or Other Participants:** Stratified purposeful sample of 82 students enrolled in therapeutic modalities or rehabilitation courses from 9 institutions sponsoring CAATE-accredited programs. Seventy-eight students (95%) completed the knowledge portion of the

evaluation; 68 students (83%) fully completed all sections of the survey. **Interventions:** The EBCKAU survey (multiple choice, Likert scale, and open-ended questions) was developed to assess changes in student knowledge, familiarity, confidence, interest, perceived importance, intended use, and perceived barriers of EBP. Demographic characteristics of students included GPA, number of semesters enrolled in the ATEP, and academic year. Pilot study of the EBCKAU showed reliability of knowledge multiple choice questions through Pearson correlation ($r > .40$). The knowledge fill-in question earned 100% agreement as all students answered incorrectly on both administrations. Cronbach's alpha determined the attitudes section reliability of satisfactory ($\alpha = .669-.814$). **Main Outcome Measures:** SPSS v.16.0.1 (SPSS Inc. Chicago, IL). Normality was attained through descriptive statistics: means, standard deviations, and frequencies; paired t-test determined differences in pre-/post-knowledge scores; Wilcoxon matched pairs signed ranks assessed differences in familiarity, confidence in use, interest, and importance of EBP concepts; Pearson product-moment correlations (r) determined relationships between knowledge change scores and student demographic factors; Spearman's rank correlations (ρ) detected relationships for familiarity, confidence in use, interest, and importance with student demographics. Barriers and future use were analyzed qualitatively for themes. **Results:** Students significantly increased their knowledge ($t(78) = 6.39, p < .001, d = .72$), confidence in knowledge ($z = -7.04, p < .01$), familiarity ($z = -6.55, p < .01$), and confidence in use of EBP skills ($z = -6.37, p < .01$). Pre-EBTM student mean knowledge scores were 50%, and post-EBTM mean scores increased to 66%. Students' interest and importance scores did not increase. Barriers to student use of EBP included time, available resources, ACI open-mindedness, and experience. **Conclusions:** The EBTM was effective in improving student knowledge and

use of EBP concepts. To our knowledge, this is the first study addressing student knowledge, attitudes, and use of EBP relating to a teaching model.

Senior Athletic Training Students' Perceptions And Self-Reported Behaviors Of Evidence-Based Practice

Schneider GP, Stemmans CL, Eberman LE, Brattain Rogers N, Pitney WA: Indiana State University, Terre Haute, IN; Ohio State University, Columbus, OH; Northern Illinois University, DeKalb, IL

Context: Professional athletic training education requires integration of evidence-based practice (EBP) into curricula to justify the clinical practice of athletic training. **Objective:** To determine senior athletic training student (SATS) perceptions of EBP and examine the self-reported behaviors of EBP to gain insight into the instructional methods currently used to educate athletic training students. **Design:** Grounded theory method. **Setting:** Individual telephone interviews of SATS at 13 CAATE-accredited athletic training programs. **Patients or Other Participants:** Thirteen SATS [11=female, 2=male, in their last semester/quarter of their athletic training education program (ATEP)] were interviewed to explore their perceptions and self-reported behaviors of EBP. **Data Collection and Analysis:** Interviews were conducted using a semi-structured guide. The interviews were transcribed verbatim and analyzed using open, axial, and selective coding procedures. Trustworthiness was established using multiple analyst triangulation and an expert peer debriefer. **Results:** The analysis revealed that SATS have a positive perception of utilizing research to guide or supplement their clinical practices. The emerging theory demonstrated that the SATS have knowledge of how to use EBP when providing care to their patients. The instructional methods experienced by

the students focused on acquiring medical literature, with only slight emphasis on appraising and applying it to clinical practice. A portion of the SATS also expressed acquiring medical literature on their own to address a problem faced in their clinical practices, but the SATS did not appraise the medical literature, rather they tended to use self-derived criteria to evaluate the quality of evidence. The SATS did express confidence in their ability to communicate to their patients and establish trust by educating their patients. **Conclusions:** The SATS acquired scholastic knowledge of EBP, but minimally integrated the evidence into practice. Moreover, deliberate appraisal of the quality of evidence was not common. Other medical professions curricula have begun to include instruction on EBP. The changes in athletic training curricula can allow students to incorporate EBP into clinical practice. We can continue to provide justification to our clinical practices through integration of EBP education into all levels of athletic training education.

Athletic Training Clinicians Knowledge And Confidence Of Evidence-Based Concepts For Clinical Decision-Making

Welch CE, Van Lunen BL: Old Dominion University, Norfolk, VA

Context: In order to develop effective strategies for the use of evidence-based practice (EBP) to enhance clinical decision-making, current knowledge levels must be investigated. **Objective:** To assess athletic trainers' (AT) current knowledge of the steps of EBP as well as their confidence in answering each question correctly. **Design:** Cross-sectional survey design. **Setting:** Self-reported online survey. **Patients or Other Participants:** 716 clinicians (18.42% response rate) from a convenience sample of ATs not affiliated with professional or post-professional athletic training education programs (age=37.1±10.3, years of athletic training experience

=13.0±9.4). **Interventions:** Participants were solicited via email to complete the *Evidence-Based Concepts Assessment (EBCA)*. The knowledge section of the EBCA asked participants to answer six multiple-choice questions (MCQ) regarding the steps of EBP. Additionally, participants were asked six Likert scale (range 1-4) questions assessing their confidence in answering each MCQ correctly. Independent variables included type of degree, year of most recent degree, patient care setting, hours of patient care per week, and years of athletic training experience. Reliability for the knowledge section was previously determined to be moderate to excellent (percent agreement: MCQ₁=96.3%, MCQ₂=77.8%, MCQ₃=70.4%, MCQ₄=74.1%, MCQ₅=85.2%, MCQ₆=63.0%). **Main Outcome Measures:** The dependent variables were the scores calculated from participant responses. Knowledge scores were tabulated by awarding 1 point for the correct answer with a maximum achievable composite score of 6. The confidence Likert section scores were achieved by totaling all values and then calculating the average value back to the Likert scale composite score (total divided by four). A higher score indicated participants had a higher confidence level with answering the MCQs correctly. Significant differences ($p<.05$) and correlations were calculated (SPSS 16.0) using one-way ANOVAs, Kruskal-Wallis H tests, and Pearson/Spearman correlations. **Results:** Overall EBP knowledge was 63.92% out of 100%. Characteristics associated with higher knowledge scores were type of degree ($F=14.137$, $p<0.001$) and year in which the most recent degree was received ($r_s=0.11$, $p=0.003$). Individuals with a bachelor's degree had an average knowledge score of 61.21%±0.205, while individuals with a master's degree averaged 63.72%±0.184, and individuals with a terminal degree averaged 75.83%±0.175. Additionally, individuals with recently awarded degrees produced

higher knowledge scores. Overall confidence was 2.67/4.0, indicating participants were "minimally confident" to "moderately confident" in their MCQ answers. Characteristics associated with higher confidence scores were type of degree ($H(2)=63.237$, $p<0.001$), years of athletic training experience ($r_s=0.139$, $p<0.001$), and hours of clinical practice per week ($r_s=0.151$, $p<0.001$). **Conclusions:** Improvements can be made on ATs' knowledge of EBP. Although ATs reported they were "moderately confident" in their answer choices of the MCQs, overall knowledge scores were low. Future development of workshops and teaching modules should focus on improving ATs' knowledge of EBP as well as moderate the effect this knowledge will have on clinical decision-making.

One In Four Athletic Trainers Are Aware And Use Clinical Decision Rules

Ragan BG, Bamer, M, Shinew K, Starkey C: Ohio University, Athens, OH

Context: Clinical Decision Rules (CDR) quantify the relative importance of particular clinical findings and are used to enhance diagnostic and decision accuracy. Many healthcare professionals have adopted and implemented these rules, but little is known about the awareness and use of CDRs by athletic trainers (AT). **Objective:** The purpose was to determine AT's awareness and clinical use of common CDR. **Design:** An observational design was used. **Setting:** Data were collected via an online survey program. **Patients or Other Participants:** One thousand AT were emailed and invited to participate in the study. A total 200 (106 males and 94 females) completed the survey with usable data (20% response rate). The mean age of the sample was 36±10.2 years with 12.2±9.2 years of clinical experience. Forty-eight reported having a undergraduate degree, 136 report

having a master's degree and 16 with a doctoral degree. **Interventions:** A new survey was developed after an extensive literature review of CDR to capture ATs awareness and clinical use of CDR that were identified by the literature and successfully applied to other healthcare professionals. The survey was administered by the online program SurveyMonkey. The validity of the new survey was established by content expert review and pilot testing for readability. Reliability for this type of survey was unwarranted. **Main Outcome Measures:** AT clinical use of CDR, awareness of the Ottawa Ankle Rules, Ottawa Knee, Pittsburgh Knee Rules, Leiden Ankle Rules, Canadian C-spine, Nexus, Canadian CT Head, and the New Orleans Criteria were the primary dependent measures. In addition to the awareness and clinical use for AT who do not use CDR their willingness to learn about them and possibly implement was also captured. **Results:** Overall 52/200 (26%) of AT report using CDR in their practice and 146/200 (74%) responded that they do not use CDR. Ottawa Ankle Rules was the most familiar with 60/200 (30%) ATs reporting they are aware of it. ATs awareness of the Ottawa Knee Rules was 31/200 (16.5%), Pittsburgh Knee Rules was 14/200 (7%), Leiden Ankle Rules = 7/200 (3.5%), Canadian C-spine = 19/200 (9.5%), Nexus = 7/200 (3.5%), Canadian CT Head = 11/200 (5.5%), and the New Orleans Criteria was 7/200 (3.5%). The most commonly use CDR was the Ottawa Ankle Rules with 31/52 (60%). One interesting finding was 26/119 AT that report that they do not use CDR were unwilling to learn and possibly implement in the future. **Conclusions:** CDR are not commonly used by AT and a majority of AT are unaware of the existence of these clinical tools. More research and publicity should be focused on increasing the awareness and use of CDR by AT to help with improving the quality, consistency and efficiency of care by AT to our patients.

Free Communications, Oral Presentations: Measurement of Concussion

Wednesday, June 22, 2011, 1:00PM-2:00PM, Room 218; Moderator: Tracy Covassin, PhD, ATC

Reliability Of A Computerized Neuropsychological Test

Resch JE, Brown CN, Macciocchi SN, Baumgartner TA, Walpert KM, Ferrara MS: University of Georgia, Athens, GA; University of Texas at Arlington, Arlington, TX; Shepherd Center, Atlanta, GA; Georgia Neurological Surgery, Athens, GA

Context: Computerized neuropsychological (CNP) testing is one component of the suggested battery of tests for concussion management. An increase in psychometric evidence and identification of sources of error may lead to increased test-retest reliability and subsequent validity. This psychometric evidence will assist clinicians to more effectively utilize computerized neuropsychological testing for concussion management.

Objective: To provide reliability evidence of a CNP test to support its use in the management of sport-related concussion utilizing clinically relevant time points, while controlling for effort. **Design:** Repeated Measures **Setting:** Athletic Training Laboratory **Patients or Other Participants:** Forty-five healthy participants (17 males, 28 females) : mean age 20.94 ± 1.6 years with no history of concussion or psychiatric problems.

Interventions: Participants were administered ImPACT at three clinically relevant time points, day 0, day 45, and day 50. Green's Word Memory Test (WMT) was also administered pre- and post ImPACT to assess effort for each test administration. **Main Outcome Measures:** ImPACT has five main outcome measures: composite and verbal memory, visual memory, visual motor speed, reaction time and impulse control. Intraclass correlations coefficients (ICCs) were calculated utilizing a one-way random model to assess reliability between each time point. Repeated measures analysis of variance (ANOVA) was utilized to determine significant

differences across time for ImPACT and Green's WMT composite scores. Greenhouse-Geisser corrections were utilized to correct for violations of sphericity. Paired t-tests were utilized for post-hoc analysis. Analyses were performed with $\alpha = .05$. **Results:** Participants were tested approximately 47.27 ± 2.7 days after day 0 and approximately 6.90 ± 1.1 days after the second time point. ICC values ranged from .37 to .45 for composite verbal memory, .52 to .55, for composite visual memory .66 to .76, for visual motor speed, .49 to .71, for composite reaction time and .43 to .82 for impulse control. Results of the repeated measures ANOVA revealed significant improvements over time for visual motor speed ($F(2,88) = 4.078, p = .02$) with significant differences between day 0 and day 50 ($t(44) = -2.122, p = .039$) and day 45 and day 50 ($t(44) = -2.521, p .015$). Interestingly, ImPACT classified 22.2 percent and 28.9 percent of the sample as impaired when they were healthy controls on one or more variables at day 45 and day 50, respectively. All Green's WMT scores exceeded 85 percent suggesting a good effort was provided at all time points. **Conclusions:** This study supports previous findings that suggest the test-retest reliability of ImPACT is poor to good in healthy participants. The results of this study indicate caution is necessary when interpreting repeated CNP test scores over time and support the use of a multi-facet approach to sport-related concussion management.

Self-Reporting Of Concussion Symptoms: Reliability Between The SCAT2 And Impact Symptom Scales In Adolescent Athletes.

Grenz A, Bay RC, Lam KC, Chhabra A, Valovich McLeod TC: A.T. Still University, Mesa, AZ, and The Orthopedic Clinic Association, Phoenix, AZ

Context: The Sport Concussion Assessment Tool-2 (SCAT2) and the ImPACT computerized neurocognitive test both utilize self-report symptom scales to determine normal daily symptoms during baseline concussion assessments. However, there are concerns related to how truthfully athletes self-report their symptoms and whether they are can reliably report symptoms on differing platforms.

Objective: To determine whether adolescent athletes are able to reliably self-report concussion symptoms.

Design: Cross-sectional. **Setting:** High school athletic facilities.

Patients or Other Participants: 1733 high school athletes participating in the fall contact sports of football and volleyball (male=1369, female =364, age=15.8±1.1 years, grade=10.2±2.6) **Interventions:** Participants were administered the SCAT2 and ImPACT in a single-session during the preseason as a baseline concussion assessment. Scales were completed approximately one-hour apart with half of the athletes completing the SCAT2 scale first and the other half completing ImPACT first. Both tools include a self-report symptom scale scored using a 6-point Likert Scale, have seventeen symptoms in common (headache, balance problems, dizziness, trouble falling asleep, drowsiness, sensitivity to light, sensitivity to noise, irritability, sadness, more emotional, feeling slowed down, difficulty concentrating, difficulty remembering, visual problems or blurred vision, feeling mentally foggy, nervous or anxious, and fatigue or low energy), and produce a

total symptom score (TSS) and a total number of symptoms endorsed score (TSE). **Main Outcome Measures:** Dependent variables included the seventeen individual symptom scale item scores common to both the SCAT2 and ImPACT, the SCAT2 TSS and TSE (STSS, STSE), and the ImPACT TSS and TSE (ITSS, ITSE). Kappa coefficients and Pearson r were used to assess exact agreement and reliability of scoring between matched-symptom pairs. Intraclass correlation coefficients (ICC 2,1) were used for the TSS and TSE. **Results:** Individual item agreement ranged from Kappa=0.25 (fatigue) to Kappa=0.41 (irritability) and individual item reliability ranged from $r=0.32$ (feel in a fog) to $r=0.69$ (irritability). The TSS reliability was 0.83 (STSS=7.2±9.4; ITSS=6.2±8.7) and the TSE reliability was 0.77 (STSE=4.0±4.2; ITSE=3.3±3.6). **Conclusions:** Healthy adolescent athletes are reliable in endorsing a similar number of symptoms and similar symptom severity regardless of the platform (SCAT2 vs. ImPACT). However, there is lower agreement among scoring individual items, which may indicate some discrepancy in specific symptom reports. Athletic trainers should be aware of these discrepancies and, if feasible, consider using both platforms when providing concussion-related patient care. Future studies should assess agreement and reliability post-concussion as that situation often presents with a unique set of challenges with athletes wanting to return to play and potentially downplaying their self-report symptoms.

Understanding Athletic Trainers' Beliefs Toward Implementing A Multifaceted Approach After A Sport-Related Concussion: Validity And Reliability Measurements Of An Application Of The Theory Of Planned Behavior

Rigby JH, Vela LI, Housman JM, Gobert DV: Texas State University- San Marcos, San Marcos, TX

Context: Practice guidelines recommend a multifaceted approach for evaluating and managing concussions but only a small percentage of athletic trainers (ATs) follow these recommendations. To understand compliance, it is important to understand ATs' beliefs towards concussion practice guidelines.

Objective: To develop and assess the psychometric properties of an instrument founded on the Theory of Planned Behavior (TPB) to measure the concussion management beliefs of ATs.

Design: Instrument development **Setting:** A three part process was used to assess the instrument: (1) content validity assessment with an expert panel, (2) face validity assessment with an AT focus group, and (3) factor structure and reliability analysis with a sample of practicing ATs. **Patients or**

Other Participants: Five experts (experience =7.5±3.2 years) with research interests in the TPB (n=2) and sport-related concussions (n=3) participated in the content validity process while a focus group of nine ATs (experience=9.00±8.76 years) working in either high school (n=3) or college/university (n=6) settings assessed face validity. Three hundred and fifty practicing high school and college/university ATs randomly selected from the NATA database were e-mailed the instrument after content and face validation. **Interventions:** A 65-item survey was constructed to reflect the current recommended concussion guidelines of the NATA and International Conference on Concussion in Sport to measure the TPB constructs: behavior attitudes, subjective norms, perceived behavioral

control, and behavior intentions of ATs. **Main Outcome Measure(s):** The expert panel performed an item-content relevance analysis for each item. Means, SDs and validity coefficients were calculated for each item to establish fit to the concussion guidelines and TPB constructs. Face validity was assessed by reading each item to the focus group and discussing the item's meaning and clarity. We calculated Cronbach alpha coefficients for the data to assess reliability. We performed a confirmatory factor analysis on the data to verify the loadings of items on the correct component of each TPB construct. **Results:** All included questions in the final instrument had a mean item-content_relevance score above 3.00 indicating an "acceptable" match to the TPB and concussion guidelines. 131 ATs completed (response rate=37.4%; experience=2.66±1.01 years; setting =college[35.9%], high school[60.3%], other[3.8%]) the instrument. The Cronbach's alpha score for the entire instrument was 0.880 and 0.744, 0.795, 0.801, and 0.759 for each TPB construct: attitude, subjective norms, perceived behavior control, and behavior intention, respectively. The confirmatory factor analysis validated the presence of the four TPB constructs. The items that loaded incorrectly were either deleted from the instrument or the wording was changed to better match the TPB resulting in a final survey with 57 questions. **Conclusion:** Evidence for the psychometric properties of the developed survey instrument were demonstrated. The instrument should be used to understand ATs' beliefs toward implementing a multifaceted concussion management approach in patients.

The Relationship Between Traditional Concussion Measures And Health-Related Quality Of Life In Adolescent Athletes

Valovich McLeod TC, Bay RC, Lam KC, Chhabra A, Parsons JT, Snyder AR: A.T. Still University, Mesa, AZ, and The Orthopedic Clinic Association, Phoenix, AZ

Context: Current evidence and guidelines advocate use of a multi-dimensional approach to concussion management, including symptom reports, cognition and postural stability. However, the sole use of these measures neglects obtaining information regarding social, emotional, and school issues, otherwise known as health-related quality of life (HRQOL). The relationship between traditional concussion assessments and HRQOL measures has not been explicated.

Objective: To determine the relationship between traditional concussion assessments and HRQOL measures.

Design: Cross-sectional. **Setting:** High school athletic facilities. **Patients or Other Participants:** Interscholastic athletes participating in contact sports (n=1176; males=929, females=247, age=15.7±1.3, grade=10.2±2.6).

Interventions: Participants were administered the Sport-Concussion Assessment Tool-2 (SCAT2), ImPACT neurocognitive test, Pediatric Quality of Life Inventory (PedsQL), PedsQL Multidimensional Fatigue Scale (MFS), and Headache Impact Test (HIT-6) during a single-session preseason baseline. All measures have established reliability and validity. **Main Outcome**

Measures: Dependent variables included: the SCAT2 total score, 5 composite scores from ImPACT [verbal memory (VEM), visual memory (VIM), visual motor (VIS), reaction time (RT) and impulse control (IC)], ImPACT total symptom score (ITSS), 4 subscale scores of the PedsQL [physical (PF), emotional (EF), social (SOF), and school (SCF) functioning], 3 subscale scores of the MFS [general (GF), sleep (SLF), and cognitive (CF) fatigue], and the HIT-6 total score.

Higher scores on the SCAT2 and the VIS, VIM, and VIS composites and lower scores on the RT and IC composites indicate better performance. Higher scores on the HIT-6 and lower scores on the PedsQL and MFS indicate lower HRQOL. Data were analyzed using Pearson-Product Moment Correlations and multiple regression. Alpha was set at 0.05, two-tailed. **Results:** Preliminary analysis of the relationship between ImPACT composite and HRQOL scores indicated no association; Pearson correlations ranged between $r=0.01-0.15$. However, all zero-order correlations between the SCAT2 and HRQOL measures were significant ($p<0.001$), ranging from $r=0.31-0.54$. Similarly, significant correlations ($p<0.001$) between the ITSS and HRQOL measures were found, ranging from $r=0.32-0.54$. Multiple regression analyses indicated that HRQOL measures predicted 33% of the variability in the SCAT2 score and 42% of the variance in the ITSS scores. The EF, CF, PF, SCF and HIT-6 all significantly ($p<0.02$) predicted the SCAT2 score. The EF, CF, GF, SCF and HIT-6 scores were all significant predictors ($p<0.005$) of the ITSS. **Conclusions:** Baseline measures of HRQOL appear to be primarily related to self-report symptoms rather than cognitive function, with higher PedsQL and MFS scores and lower HIT-6 scores related to higher scores on the SCAT2 and a lower ITSS. These data demonstrate the importance of self-report symptoms in determining one's own health status. Future work assessing these relationships following concussion may be important, as impaired cognitive function could impact the athlete's academic performance.

Free Communications, Oral Presentations: Unique Conditions in Adolescent Athletes

Wednesday, June 22, 2011, 2:00PM-3:00PM, Room 218; Moderator: Mary Barron, PhD, ATC

Cubonavicular Coalition In A High School Football Player: A Case Report

Sulewski AL: Myrtle Beach High School, Myrtle Beach, SC

Background: A 16 year old male football player reported to the athletic trainer complaining of left mid-foot pain during the first week of fall football practice. Patient described pain as insidious with no specific mechanism of injury, noting an initial onset of pain during summer conditioning activities. Pain occurred during his defensive stance and push off; points of maximal dorsiflexion with concentric plantar flexion loading (including sprinting and jumping). Patient described the pain as an 8/10 at its worst, but reported minimal to no pain while weight bearing (static stance and walking). He had no previous history of foot or ankle injury. Mild pain noted during palpation over medial aspect of navicular and on the dorsum of his foot in the cubo-navicular articulation. Foot posture presented with normal medial longitudinal arch and (-) navicular drop test. Tarsal glides elicited mild pain. Foot and ankle active and resisted range of motion were pain free and within normal limits bilaterally. Patient and legal guardian provided consent for presentation of case. **Differential Diagnosis:** Stress fracture, mid-foot sprain, Lisfranc injury, accessory navicular, tarsal coalition. **Treatment:** Initially, management by the athletic trainer included palliative care with therapeutic modalities (e.g., moist heat packs, ice), prophylactic taping to support his medial longitudinal arch for participation, and daily therapeutic exercises to strengthen ankle stabilizers and intrinsic foot muscles. After non-resolution of symptoms after 4 weeks, athlete was referred to an orthopedic surgeon for further evaluation; who subsequently ordered a Computerized Tomography (CT) scan to rule out a stress fracture. Diagnostic imaging

indicated an abnormal articulation between the cuboid and navicular with associated irregularity and arthrosis, suggesting a cubonavicular coalition. The orthopedic surgeon recommended the continuation of a conservative treatment plan and prescribed custom orthotics fabricated by a podiatrist and NSAIDs. Pain management and therapeutic exercise continued with the athletic trainer (as noted above) and participation restrictions included conditioning activities limited by pain (i.e., sprinting, jumping). Significant symptom reduction occurred within 1 week of orthotic intervention and NSAIDs. **Uniqueness:** Tarsal coalition is a genetic malformation of the foot that is estimated to affect less than 1% of the population. The most common tarsal coalitions occur between the talocalcaneal and calcaneonavicular junctions with cubonavicular coalitions accounting for only 1% of coalitions reported in the literature (or .01% of all tarsal coalitions). Typically, symptoms present during adolescence upon osseous maturation. Although not present in this case, bilateral coalitions are estimated to be present in 40-68% of patients diagnosed with a tarsal coalition. **Conclusion:** The case of non-traumatic medial foot pain presented in an adolescent athlete resulted in a diagnosis of a cubonavicular tarsal coalition determined by CT imaging. Conservative management, custom orthotics and NSAIDs significantly reduced symptoms, resulting in minimal activity modifications. Tarsal coalitions are genetic deformities that, although rare, should be considered part of the differential diagnosis by certified athletic trainers working with the adolescent population. Proper recognition, initial management and timely referral for imaging allow for appropriate diagnosis and long term management for safe participation in sport.

Late Detection Of Capitellar Osteochondritis Dissecans In High School Football Player

Benson SB: The Steadman Clinic, Vail, CO

Background: A 17 YO, football player at a rural high school with no athletic trainer complaining of right elbow pain with catching and locking for four years. The patient did not recall a mechanism of injury, but believed the pain began after an ATV accident four years prior causing elbow hyperextension. During exam the patient reported 3/10 pain at rest and 8/10 pain with elbow movement on a 0 to 10 Visual Analog Scale. Pain was characterized as progressively worsening with locking, popping and grinding. The treating orthopedic surgeon was the patient's third opinion subsequent to seeing a general practitioner and orthopedic surgeon. **Differential Diagnosis:** Osteonecrosis, osteochondral fracture, medial epicondylitis, osteochondritis dissecans, hereditary epiphyseal dysplasia and Panner's Disease. **Treatment:** Active range of motion in the involved elbow was 0/3/140 degrees, as compared to the uninvolved elbow at 0/0/145 degrees. Plain radiographic films were benign, revealing no acute or chronic pathology present. MRI revealed multiple loose bodies and a capitellar osteochondral defect (OCD). The orthopedic surgeon diagnosed the patient with capitellar osteochondritis dissecans and recommended surgical treatment due to the severity of the lesion and presence of multiple loose bodies. The patient consented, and a procedure including a synovectomy with removal of two large loose bodies from the anterior compartment, chondroplasty of the capitellum, removal of extensive hypertrophic tissue from the posterior compartment and removal of two small loose bodies from the posteromedial was performed. The patient was

instructed to begin physical therapy immediately after surgery to gain full active range of motion for the initial three weeks and then progress to strengthening as tolerated once full range of motion was achieved. The patient reported back nine days status/post right elbow surgery with no pain or swelling. He reported performing no physical therapy due to vacation, so he presented with 0/30/110 right elbow range of motion. The patient wished to return to activity, but was instructed to begin physical therapy and return in six weeks. He did not return for a follow up appointment to measure range of motion, but is currently ten weeks status/post surgery with no reported symptoms.

Uniqueness: Osteochondral defects of the capitellum can be treated non-operatively when stable and detected early. However, lesions with fragmentation and formation of loose bodies have limited capacity to heal due to growth plate factors and poor blood supply of the distal humerus. Furthermore, degenerative joint disease (DJD) has been reported in up to 50% of those affected long term. In fact, capitellar OCD is one of the leading causes of permanent elbow disability. Most physicians are hesitant to operate on adolescent patients due to the ability to heal non-operatively and possibility of interfering with an open physis. However, this case demonstrates the consequences of leaving an OCD lesion untreated and the importance of early recognition and treatment.

Conclusion: Capitellar OCD is an increasing cause of elbow pain and dysfunction in adolescent athletes who endure repetitive stress. This football lineman fits the profile of an athlete susceptible to such an injury; however, he endured this disorder for four years due to misdiagnosis and inability to detect the disorder by rural medical care. Once appropriately diagnosed and treated, the patient was pain free and able to resume a normal lifestyle. Therefore, athletic trainers working with a high school population must correctly identify Capitellar OCD and properly

refer the athlete for appropriate treatment in order to have a positive prognosis and high quality of life long term.

Range Of Motion Limitations For An Athlete With Nail-Patella Syndrome

Polubinsky RL, Plos JM, Leiting KA: Western Illinois University, Macomb, IL

Background: This case report involves a unique condition known as Nail-Patella Syndrome (NPS) in an 18-year-old male wrestler. Nail-Patella Syndrome is a genetic disorder that causes individuals to be born with several skeletal deformities and abnormalities within the body. Due to his condition, the athlete is aware of the risk involved with participation in the various activities but is determined to compete in the same manner as the other athletes on the team. The athlete reported to the athletic trainer (AT) after he experienced elbow pain while performing weight lifting techniques. Due to the NPS, the athlete had a dislocating radius and restricted ranges of motion at the elbows, forearms, and wrists. In comparison to normative values, the athlete's elbow extension lacked 20-26° (L:R), pronation lacked 2-6° (R:L), supination lacked 64-70° (L:R), and wrist extension lacked 47-53° (R:L). Due to the insufficient range of motion in the upper extremity, the athlete sustained bilateral elbow strains from attempting to lift weights during practice.

Differential Diagnosis: Elbow sprains, contusions, and elbow dislocation.

Treatment: After the injury evaluation, the athlete was initially treated with ice and rest for 3 days. The next step in the treatment protocol was to determine if modification in the lifting techniques could be made to alleviate the athlete's discomfort and strain on the elbow joints. The AT suggested the use of a protective brace with padding to keep the athlete within his normal limits (-26° of extension, -70° of supination). However, the athlete felt too restricted in this brace and refused to be

compliant. Therefore, the AT examined modifications to the weight lifting equipment to address the athlete's limited elbow and wrist extension, limited supination, and the dislocating radius. The AT evaluated the athlete's lifting technique for the bicep curl and bench press lifts. The athlete performed the bicep curl using the straight bar, the easy curl bar, and dumbbells. Due to the athlete's limited supination, he could not comfortably grip the straight bar for the bicep curl technique. This was also true using the easy curl bar, however; the athlete was able to maintain a comfortable grip using the dumbbells for the bicep curl thus relieving the elbow pain. The athlete performed the bench press using the straight bar and dumbbells. No elbow pain was reported with the straight bar, however, due to the limited elbow extension and dislocating radius; the athlete was in an unsafe position with weights overhead. The AT recommended the use of dumbbell weights for the bench press lifts in order to eliminate the risk of injury.

Uniqueness: It is estimated that 1 in 50,000 persons worldwide have characteristics of the NPS condition. It is rare that a child would go undiagnosed with NPS but the possibility exists that ATs may have an athlete with the condition under their immediate care.

Conclusions: Athletes with NPS demonstrate changes in their structural and physical function. However, these athletes still possess a competitive desire, normal cognitive and emotional functions, and a commitment to participate in athletics. Treatments of the musculoskeletal injuries follow similar guidelines for athletes who do not have the NPS condition. However, special consideration must be given to the physical restrictions in his range of motion and the AT must be prepared to make modifications to ensure safe sport participation.

Heterotopic Ossification In A Male Volleyball Player

Yoder A, Kahanov L, Kreiswirth E, Myer G, Martin M: Indiana State University, Terre Haute, IN, and Rocky Mountain University, Provo, UT

Background: A 17-year-old male high school volleyball player reported he repetitively “dove for balls” during practices landing on his left hip. The athlete’s complaint, at initial injury, was persistent left hip and back pain. The assessment by a certified athletic trainer, (ATC) revealed pain at the left ilium and the anterior sacroiliac joint (SI). Signs and symptoms included mild swelling over the ilium with no superficial discoloration or deformities. Range of motion and strength were within normal limits. Joint compression and distraction for SI joint pathology, pelvic fracture and radiculopathy were negative. The mechanism of injury indicated trauma to the ASIS consistent with a hip pointer. The athlete ceased volleyball practice for two weeks due to pain. He received treatment which included passive hip and low back stretching and ice application for 15 minutes. The ATC diagnosed the injury as a left hip contusion (“hip pointer”) with concomitant low back pain. After two weeks, no physical abnormalities to the area were documented and the diagnosis remained, yet the athlete was still in discomfort. At that point, the athlete sought care through his chiropractor and continued to be seen daily by the athletic trainer from 2 to 6 weeks post initial injury. The athlete progressed through sport-specific exercises, including core stability exercises. Six weeks post initial evaluation, the athlete returned to unrestricted in-season practice and competition with a pain scale of 3/10. Six months post-injury, the athlete reported to the athletic trainer with a large mass on his left hip. The patient was referred to his primary care physician for further evaluation. An x-ray was ordered, which depicted a large ossification over the patients left ASIS.

Differential Diagnosis: Based on the mechanism of injury a contusion to the soft tissue and or ilium was diagnosed. SI Joint pathology was ruled out through clinical tests. The chiropractor diagnosed the patient with a left up-slipped ilium and hip contusion. A plain film radiograph revealed a large ossification at the left ilium and a healed fracture at the ASIS. **Treatment** The athlete was initially treated for a contusion/hip pointer by the ATC, including core stability and stretching. The chiropractor treated the patient for an up-slipped ilium on the left and hip contusion. The PCP recommended rest from all aggravating activity and suggested elective surgery to remove the ossification. The athlete declined surgery and rested for two-months based on personal comfort. At two months, the athlete had no complaint of pain and returned to volleyball wearing a protective pad over the ossification. The athlete continued a home program of core stability exercises. Eight-months, after the initial evaluation, the athlete was able to participate in volleyball with no restrictions, however the mass remained visible over the left ilium. **Uniqueness:** Due to the rarity of HO in athletes, and the prolonged evaluative process to identify HO, this case presents unique circumstances that should be considered in the evaluation of repetitive hip injuries. **Conclusions:** The initial evaluation of this athlete presented as a standard “hip pointer” or ASIS contusion. This case highlights the continued need for monitoring of repetitive traumas particularly in athletes who may have open epiphysis. Additionally, bone remodeling can become extreme in some cases leading to excess growth accentuating the need for continued monitoring. Appropriate and timely diagnostic testing is key to conclusive diagnosis; however, prevention may ameliorate the opportunity for like injuries. Preventative hip padding of athletes who incur repetitive trauma may be appropriate.

Free Communications, Oral Presentations: Management of Unique Orthopaedic Injuries

Wednesday, June 22, 2011, 3:30PM-4:30PM, Room 218; Moderator: Kelly Pugh, MS, ATC

Popliteus Tendinitis In A Division I Collegiate Female Tennis Player: A Case Study

Gardner IK, Silvestri PG, Petron DJ, Hicks-Little CA: University of Utah, Salt Lake City, UT

Background: A 20 year old NCAA Division 1 female tennis player presented with lateral knee pain. There was no specific mechanism of injury, but previous history included a hyperextension injury, approximately 7 weeks prior, and contralateral iliotibial band syndrome (ITBS). Her chief complaint was weakness, especially with lateral movements. She was unable to play tennis and had discomfort with activities of daily living (ADLs), including walking up and down hills/stairs. She reported sleeping on her unaffected side increased discomfort. The athlete presented with an antalgic gait, no swelling or mechanical symptoms, and no reported usage of oral medications. Clinical examination revealed non-specific lateral joint line tenderness, and tenderness over the lateral femoral condyle and distal hamstring tendon. The patient had full knee flexion and extension, however, discomfort and difficulty was elicited at 20-45 degrees of active knee flexion. Manual muscle strength was within normal limits. A varus stress test revealed discomfort but no laxity. All other ligamentous testing yielded negative findings. McMurray's test did not reproduce any mechanical symptoms or discomfort. No neurovascular compromise was noted. **Differential Diagnosis:** Fibular collateral ligament sprain, ITBS, lateral hamstring pathology, lateral meniscus tear, and fibular head stress fracture. **Treatment:** An orthopedic referral was made to determine the cause of lateral knee pain. Magnetic resonance imaging (MRI) revealed no damage to the ligaments, meniscus, or cartilage at the knee joint. The MRI showed an

impaction fracture of the anterolateral tibial plateau and a partial tear of the distal posterior IT band, elucidating a diagnosis. After approximately 1 month of conservative management, the lateral knee pain resolved. Approximately 2 weeks later, however, the lateral knee pain returned with similar clinical findings. A follow-up orthopedic referral ascertained a recurrence of ITBS. A regimen of conservative therapy was implemented over the following 8 weeks which yielded improvement in symptoms but not resolution. At this time, the athlete's chief complaint was a feeling of instability and a vague sensation of "something there." The athlete visited a knee specialist, who injected her lateral knee with a partial dose of cortisone to investigate iliotibial band involvement. With no resolution of symptoms, another MRI was taken which revealed an accumulation of fluid related to the popliteus muscle-tendon complex. A final diagnosis was made of popliteus tendinitis. During this time, the athlete's activity was severely limited due to discomfort. The athlete presented to physical therapy for further conservative management, consisting of ultrasound, massage, and a taping technique, which facilitated a functional return to activity approximately 4 weeks after the final diagnosis. **Uniqueness:** To our knowledge, this case is the first reported of its kind in a NCAA Division 1 tennis player. Popliteus tendinitis is uncommon and often misdiagnosed, typically emerging after some form of knee ligament trauma. A clinical diagnosis is difficult due to the complexity of posterolateral knee pain. **Conclusions:** A young, healthy female tennis player presented with lateral knee pain. Clinical diagnosis is difficult for this condition. Although popliteus muscle-tendon pathology is relatively infrequent, it occurs more commonly in the athletic population. Thus a

thorough physical examination is paramount to a successful diagnosis and subsequent management protocol. Effective treatment appears to consist of activity modification, massage techniques, taping, and ice. Rehabilitation should address the biomechanical function of the popliteus muscle in both non-weight bearing and weight bearing conditions.

Posterior Knee Dislocation In A Male Rugby Player

Gour-Provencal G, Dover GC, DeMont RG: Concordia University, Montreal, QC

Background: We present a case of a unique posterior knee dislocation that resulted in the rupture of the four ligaments, medial hamstrings, popliteal artery and a torn capsule without any menisci damage or fracture. A healthy 25 years old male rugby player kicked the ball with his right leg while being tackled. The patient complained of excruciating pain at the right knee, reported a snapping sound, and felt like everything was "gone" in his knee. Extensive swelling and posterior deformity was present. Within two minutes, the athlete complained of decreased sensation on the dorsal aspect of his right foot. A distal pulse was present. The AT in charge decided to call the ambulance, splinted the limb with the use of an air cast and monitored the vitals that were normal (HR: 70bpm, BP: 121/70, BF: 16 breaths/min, T: 36.6C, O2 saturation: 99%). The patient retained a positive attitude and was cooperative immediately post trauma, during hospital care, and through rehabilitation. **Differential Diagnosis:** Possible injuries included inert tissue (tibiofemoral dislocation, rupture to ACL, PCL, LCL, MCL, torn capsule, meniscus tear), contractile tissues crossing the tibiofemoral joint, primary vascular tissue (popliteal

artery and vein), and fracture. Results of the X-rays and MRI showed right knee dislocation, rupture of the ACL, PCL, LCL, MCL, medial hamstrings, popliteal artery (postero-lateral aspect), and a torn capsule. No fracture or meniscus damaged was noted. **Treatment:** A right knee dislocation was confirmed and reduced by a Physician. Following imaging diagnostics, the patient was transferred to a trauma care hospital for repair surgery. The surgery was conducted 2 days post-trauma, and consisted of ACL, PCL, MCL, LCL repair using Ligament Augmentation and Reconstruction System (LARS) artificial ligaments, repair of the popliteal artery, repair of the medial hamstrings and the joint capsule. The patient was then put in a hip-knee-ankle-foot orthosis. The orthopedist provided a standard rehabilitation protocol that stipulates that full weight bearing is contraindicated for the first 3 months post-surgery and range is limited to 120° of flexion to protect the surgical grafts. One week post-surgery, the patient had 90° of knee flexion and -15° of knee extension. Had 3-/5 in knee flexion, 2+/5 in knee extension. A lot of muscle atrophy was present especially at the VMO. At 3 weeks post-surgery, the patient had 97° of knee flexion and -5° of knee extension. He had 3+/5 in knee flexion and 4+/5 in knee extension. The VMO was still atrophied but showed some contraction. The hip-knee-ankle-foot orthosis was replaced by a prophylactic knee brace 6 weeks post-surgery, allowing the patient to weight bear and walk 6 weeks ahead of schedule. **Uniqueness:** Tibiofemoral dislocations with significant damage are exceptionally rare in sports settings. Acute knee dislocations usually present following high velocity trauma, and are accompanied with neurological deficiencies. In this case, the dislocation was without any fractures, menisci damage, and more importantly any tibial or common peroneal nerve damage. **Conclusions:** A male rugby player suffered from a knee dislocation that resulted in the

rupture of the ACL, PCL, LCL, MCL, medial hamstrings and popliteal artery (postero-lateral aspect) as well as a torn capsule. No fracture was noted and the menisci were normal. Successful surgery was performed 2 days post-trauma. We believe that a positive outlook can greatly improve the prognosis for the patient and result in quicker rehabilitation. We learned that it is possible to retain vascularity in such traumatic injury, but attention to these structures remains crucial in our evaluations to prevent additional complications.

Anterior Hip Pain In Three Female Collegiate Track Athletes: A Case Series

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Background: Three 18 year old female freshman (Height: 1.63m +/- .07; Weight: 57.75kg +/- 6.8) on the track team came into the training room in the spring of 2010 with complaints of right anterior hip pain. Two of the athletes were distance runners and one was a pole-vaulter. The two distance runners had been averaging forty miles a week in the fall cross-country season. The pole vaulter had been participating in weight-lifting and conditioning activities of moderate intensity in the fall track off-season. After returning from winter break, the pole vaulter greatly increased her training intensity in an attempt to quickly "get in shape". The two distance runners increased their mileage to an average of 65 miles a week in preparation for the outdoor track season. Two of the three athletes were oligomenorrhic and had a previous history of stress fractures. All three athletes described an insidious onset of pain over their anterior hip, which increased with activity. Upon evaluation, 100% of the athletes had pain with passive hip internal rotation especially at the end range of motion. Two of the three of the athletes had a positive FADDIR test and one athlete had a positive straight leg-raise test and

positive log roll test. Two of the three of the athletes had full strength and only had pain with maximal hip flexion or knee flexion at the end ranges of motion. One distance runner had 4/5 strength for all hip range of motion secondary to pain. There was an average time of 4 weeks of conservative treatment that was administered before a lack of progress caused them to be referred to the team physician. **Treatment:** All X-rays taken came back negative for any stress injury. MRIs were ordered for all three athletes and all came back positive for a femoral neck stress injury. All stress injuries were classified as compression-side stress injuries to the femoral neck. Athletes spent an average of two weeks on crutches and were restricted from all weight-bearing activities during that time. **Results:** Water activities were prescribed for training for the first 4 weeks. Following week 4, 2/3 of the athletes began a rehabilitation program focused on hip and core strengthening and lower-extremity flexibility. The last athlete left for summer and didn't participate. After an average of 6 weeks all athletes had progressed to weight-bearing cross-training activities including biking, elliptical, and the Alter-G treadmill. After an average of 9 weeks all athletes had returned to full activity with no complaints of hip pain. Both distance runners followed a specific running progression to safely increase their training intensity. **Uniqueness:** Femoral neck stress fractures have a low incidence rate compared to other stress injuries to the lower extremity. All three athletes had greatly increased their training intensity in anticipation of the spring outdoor track and field season and could be described as hard-headed who frequently tried to train through pain. They admitted to training despite having pain for at least 1 month before seeking medical help. **Conclusions:** Training errors, menstrual irregularities and a previous history of stress injury may predispose young female athletes to developing another overuse stress injury. Stress fractures can be present without plain radiographic evidence.

Additional imaging techniques such as MRI should be performed when a stress fracture of the femoral neck is suspected. Communication with the athletic training staff about painful symptoms during training is crucial to early recognition of a possible stress injury and proper treatment and early diagnostic testing.

Anatomic Reconstruction Of Posterior Glenoid Deficiency Using Distal Tibial Osteoarticular Allograft In The Treatment Of Recurrent Posterior Shoulder Instability: A Case Series

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Background: Patient population includes two adolescent male athletes (15.5y/o±0.5) who suffered significant bone loss of the posterior glenoid due to a traumatic posterior shoulder dislocation and recurrent posterior glenohumeral instability. Each young athlete had an initial traumatic dislocation playing football and experienced persistent symptoms of instability. The patients had similar clinical presentations: instability, recurrent posterior subluxation, full PROM, no muscle atrophy, 5/5 rotator cuff strength, positive apprehension/relocation test, negative poster load/shift test, and pain with posterior load to the glenoid. Radiographs for both patients showed no remarkable findings. CT scans depicted the deficiency of the posterior glenoid cavity (40%±8%). **Treatment:** Ultimately, both patients underwent surgical treatment of glenoid reconstruction using a distal tibial osteoarticular allograft. The first patient opted for this procedure after an autogenous iliac crest allograft reconstruction failed. The second patient decided to undergo the procedure after a diagnostic arthroscopy. The surgical procedure was fundamentally the same for both patients: a pre-operatively prepared graft was designed based on pre-

operative imaging of each patient; the fresh graft was secured in place using 3 parallel screws. The placement and position was arranged for the best congruent joint mechanics. Under anesthesia after the meticulous placement of the allograft, both patients presented with perfect joint congruency and stable PROM. Post-operative rehabilitation included immobilization for an average of 21 days. At this time, PROM (internal rotation to body, full external rotation, full forward flexion and full abduction) was permitted, as well as pendulum type exercises to facilitate cartilage health and homeostasis. At 6 weeks, active assisted motion was permitted. Return to full activity was allowed at approximately 6-7 months, dependent on how the patient was progressing. **Results:** Post-operatively, both patients report an improvement of symptoms, have no recurrent instability and stable shoulder function. Post-operative CT scans demonstrated complete healing of the tibial bone graft. The first patient (12 months s/p) returned to recreational sporting activities with minimal to no limitations. The second patient (5 months s/p) is starting to progress to light upper body activity. **Uniqueness:** Posterior dislocations represent less than five percent of all shoulder dislocations (Bahk et. al, 2007). When symptoms of instability persist after failed treatments and surrounding soft tissue is intact, further mechanical dysfunction, possibly of bony structures should be taken into consideration. Posterior glenoid deficiency can result from recurrent posterior instability. Due to the rarity of the condition, the options of treatment are not congruent with anterior instability (Burkhart et. al, 2002, Lo, 2004). In previous literature (Provencher et. al, 2009), distal tibial osteoarticular allografts proved to be excellent sources of bone restoration and joint cartilage. These cases are unique due to the nature of the pathology, the type and location of the allograft. **Conclusions:** Both patients presented with symptoms of posterior instability that had previously failed

interventions. The presence of posterior glenoid deterioration limits treatment options. These two cases have had reportedly no complications since surgery. ATs dealing with persisting posterior shoulder instability should recognize when traditional and/or conservative treatments are unsuccessful. If the athlete presents with full strength and full ROM, AT's need to consider the mechanical components of the shoulder and seek imaging for further investigation and diagnosis. In almost all cases, early recognition can improve the prognosis and longevity of the joint. This case series has provided evidence that there is an excellent chance of success with distal tibial osteoarticular allografts when dealing with posterior shoulder instability due to bone loss of the posterior glenoid.

Maturation Does Not Influence Mechanics In Adolescent Male Lacrosse Athletes During An Unanticipated Sidestep Cutting Task

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Context: The incidence of noncontact knee injuries has been studied extensively amongst high school and collegiate athletes. Little research has been focused on the adolescent population and maturational changes in relation to the risk factors of such an injury. **Objective:** The purpose of this study is to determine if there is a difference between Pre-pubescent (PRE), pubescent (MID) and Post-pubescent (POST) male lacrosse athletes as indicated by knee and hip kinetics and kinematics during an unanticipated sidestep cutting task (SS). **Design:** Cross-sectional study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Thirty-one male participants between the ages of nine and fourteen were recruited and categorized into 3 groups; PRE (n=8, 9.88±1.13years, 137.25±8.76cm, 32.74±7.12kg), MID (n=12, 11.42±0.90years, 153.58±10.73cm, 44.47±10.91kg), and POST (n=11, 12.91±0.70years, 165.55±5.93cm, 53.44±8.71kg). All participants were free of lower extremity injury during the time of the study. **Intervention:** The pubertal maturation observation scale (PMOS), which corresponds to Tanner's stages, was used to allot the subjects into their corresponding maturation levels. Three-dimensional motion analysis, coupled with two force plates, was used to capture five successful SS trials. **Main Outcome Measures:** The independent variable of this study was maturation stage with 3 levels; PRE, MID and POST. The dependent variables were knee abduction moment (KAM), knee flexion moment (KFM), hip flexion moment (HFM), hip abduction moment (HAM), knee abduction (KAB), knee

flexion (KF), hip flexion (HF) and hip abduction (HAB) at initial contact (IC) and peak knee flexion (PKF). Separate ANOVA's were performed for each dependent variable to assess statistical differences between groups. Alpha level was set *a priori* at 0.05 **Results:** At IC there was no statistically significant difference found between any levels of puberty for KAB (PRE=-3.58±6.60°, MID=-4.22±3.48°, POST=-4.25±4.00°, $p=0.942$), KF (PRE=-21.30±8.50°, MID=-27.6±7.52°, POST=-23.30±9.39°, $p=0.243$), HF (PRE=53.61±20.59°, MID=62.64±15.13°, POST=50.03±19.65°, $p=0.253$) or HAB (PRE=-10.61±10.46°, MID=-13.86±5.66°, POST=-15.04±4.51°, $p=0.381$). At PKF there was also no statistically significant difference found between any level of puberty at KAB (PRE=-4.84±8.33°, MID=-5.08±5.54°, POST=-8.91±6.54°, $p=0.307$), KF (PRE=-46.96±7.86°, MID=-51.27±5.39°, POST=-54.42±10.11°, $p=0.150$), HF (PRE=45.83±17.89°, MID=54.81±15.16°, POST=44.97±19.88°, $p=0.358$) or HAB (PRE=-14.83±10.19°, MID=-17.45±6.74°, POST=-18.12±5.33°, $p=0.613$). **Conclusions:** In agreement with previous studies viewing adolescent athletes, this study demonstrated that pubertal maturation in males does not demonstrate an effect on lower extremity biomechanics. This shows that there is not a shift toward perilous lower extremity mechanics, which may lead to noncontact knee injuries in males throughout their adolescent maturation phases. Future studies should focus on the differences between genders at different pubertal stages to better understand and quantify the mechanical changes brought about by maturation.

Lower Extremity Biomechanics During Anticipated And Unanticipated Cutting Tasks In Male And Female Preadolescent Athletes

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Context: Anterior cruciate ligament (ACL) injuries frequently occur during sidestep cutting tasks. Unanticipated cutting tasks elicit more knee valgus and rotation compared to anticipated tasks in adults. Sex differences in cutting biomechanics have been shown in adult and youth populations. However, it is unknown if preadolescent males and females respond differently to anticipated and unanticipated cutting tasks. **Objective:** To compare the effects of anticipation between sexes during sidestep cutting tasks in preadolescent soccer athletes. We hypothesized females during the unanticipated task would possess the greatest amount of hip and knee rotation and knee valgus. **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Sixty-three healthy youth soccer athletes (Males: n=35, mass=34.2±5.4 kg, height=143.1±6.3 cm, age=10±1 years; Females: n=28, mass=33.8±5.4 kg, height=141.0±6.6 cm, age=10±1 years) volunteered to participate. **Interventions:** Participants completed three trials of an anticipated (ANT) and an unanticipated (UNANT) sidestep cutting task in a random order during a single test session. A live model acted as a defensive opponent to delineate direction during the unanticipated task. Participants jumped forward from a 30-cm high box a distance of half their body height, landed with their dominant foot on a force plate and performed a 60 degree cut towards their non-dominant limb. An optical motion analysis system was synchronized with the force plate to

measure three-dimensional joint kinematics, kinetics, and ground reaction forces. Separate mixed model analyses of variance were performed for each dependent variable to evaluate differences between cutting tasks and sex ($\alpha \leq .05$). A Bonferroni correction was used to evaluate significant findings. **Main Outcome Measures:** Three-dimensional knee and hip kinematics at initial ground contact, peak angles and moments (normalized to bodyweight and height) during the stance phase, and peak vertical ground reaction force (VGRF) normalized to bodyweight were calculated using the average of the three trials in each condition. **Results:** Significant task by sex interactions were observed for knee valgus at initial contact ($F_{(1,61)}=7.98$, $P=0.006$) and knee rotation at initial contact ($F_{(1,61)}=6.28$, $P=0.01$). Females demonstrated more knee valgus at initial contact during UNANT ($1.67 \pm 2.65^\circ$) than ANT ($-0.69 \pm 2.69^\circ$). Females ($-10.82 \pm 8.70^\circ$) landed with more knee external rotation than males ($-6.59 \pm 8.69^\circ$) during ANT. UNANT resulted in more peak knee flexion ($F_{(1,62)}=11.30$, $P=0.001$), knee valgus ($F_{(1,62)}=4.70$, $P=0.03$), hip flexion ($F_{(1,60)}=18.47$, $P=0.001$), hip internal rotation ($F_{(1,62)}=5.11$, $P=0.03$), and external knee valgus moment ($F_{(1,62)}=12.59$, $P=0.001$). No other significant differences were observed ($P > 0.05$). **Conclusions:** Unanticipated sidestep cutting tasks resulted in more movements associated with ACL injury risk than anticipated cutting tasks in preadolescent athletes. Males and females had similar responses to changes in the anticipatory condition except for knee valgus at initial contact. Injury prevention programs need to modify lower extremity movements during both unanticipated and anticipated cutting tasks.

The Effects Of Instruction And Sex On Landing Biomechanics Of Youth Soccer Athletes

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Context: Postpubertal females demonstrate different landing biomechanics than males, which may put them at increased risk for ACL injury. Limited knowledge is available regarding sex differences in landing biomechanics in younger populations or if males and females respond differently to instructions regarding landing technique. **Objective:** To determine the effects of sex and instruction on landing biomechanics in youth soccer athletes. We hypothesized females would respond more favorably to instructions than males. **Design:** Randomized controlled trial. **Setting:** Research laboratory. **Participants:** Sixty healthy soccer athletes (females: $n=25$, age= 10 ± 1 years, height= 140.34 ± 6.48 cm, mass= 33.06 ± 5.03 kg; males: $n=35$, age= 10 ± 1 years, height= 143.03 ± 6.23 cm, mass= 34.42 ± 5.34 kg) volunteered to participate and were randomly assigned to either a feedback (FB) ($n=19$ males, 13 females) or control (CON) group ($n=16$ males, 12 females). **Interventions:** Two sets of three trials of a jump-landing task were performed during a single testing session. The FB group was provided with instructions regarding proper landing technique prior to each trial of the second set of landings. The task required participants to jump forward from a 30cm high box placed a distance of half their height away from a force plate, land with their dominant foot on the force plate, and immediately jump for maximal vertical height. An optical three-dimensional motion analysis system and a force plate measured lower extremity kinematics and kinetics. Change scores for each dependent variable were

calculated (post-pre). Separate two-way analyses of covariance (group x sex) were performed on the change scores for all dependent variables after controlling for the baseline value ($\alpha \leq .05$). A Bonferroni correction was used to evaluate significant findings. **Main Outcome Measures:** Sagittal and frontal plane knee angles at initial contact and peak values over the stance phase, as well as peak vertical (VGRF) and posterior ground reaction forces (PGRF), anterior tibial shear force, internal knee extension moment, and external knee valgus moment were measured over the stance phase. Forces were normalized to body weight and moments were normalized to body weight and height. **Results:** A significant sex by group interaction was observed for PGRF ($F_{(1,55)}=4.56$, $P < 0.05$). Post hoc testing revealed that males in the FB group significantly reduced their PGRF more than males in the CON group (Change scores: FB= $0.42 \pm 0.52\%$ BW, CON= $-0.02 \pm 0.31\%$ BW). Significant differences were found between groups for VGRF ($F_{(1,55)}=39.301$, $P < 0.001$, Change scores: CON= $-0.17 \pm 0.63\%$ BW, FB= $-1.38 \pm 0.97\%$ BW) and knee valgus moment ($F_{(1,55)}=9.219$, $P=0.01$, Change scores: CON= $-0.0001 \pm 0.06\%$ BW*BH, FB= $-0.04 \pm 0.08\%$ BW*BH). No other significant differences were observed ($P > 0.05$). **Conclusion:** Males are more effective than females with reducing PGRF after receiving instruction. Both sexes are able to reduce VGRF and knee valgus moment after instruction but these young athletes do not appear to be able to modify knee kinematics. Future research should evaluate if instructions can be modified to affect knee kinematics in young athletes.

The Effects Of Fatigue And Gender On Reach Scores In High School Athletes

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Context: More than 7 million students are involved in high school sports annually in the United States. Disturbances in posture as result of fatigue have been postulated to effect male and female interscholastic athletes differently. It is important that this population be studied and the mechanism by which injuries are produced be determined. **Objective:** The purpose of this study was to determine the effect of gender and fatigue on reach scores in a group of healthy high school athletes as measured by a modified version of the Star Excursion Balance Test (SEBT). **Design:** Pre-test/post-test group comparison. **Setting:** A climate-controlled, sports-center. **Patients or Other Participants:** A total of 30 healthy varsity high school athletes; 15 male (age= 17.1±1.0yr; height= 175.8±9.2cm; mass=70.1±8.5kg) and 15 female (age= 16.4±1.0yr; height =166.0±8.2cm; mass=60.6±7kg) participated in this study. **Interventions:** Dynamic postural control (reach distance) was tested using the modified SEBT before and after completing a functional fatigue protocol (FFP) involving running, cutting, and jumping tasks. The Y-Balance Test Kit (Perform Better, Cranston, RI) was used to quantify reach distances (cm) in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions. Three trials in each direction were performed. The FFP circuit was completed until fatigue was reached using a set of published criteria. Post-fatigue SEBT testing commenced immediately upon completion. **Main Outcome Measures:** Height-normalized ANT, PM, PL reaches along with the composite reach scores for both the right and left side were used as dependent variables. A univariate, repeated-measures

analysis of variance (ANOVA) was used to determine if differences existed between group (male vs. female) and time (pre vs. post-fatigue). An alpha level of $p < .05$ was used to determine significance. **Results:** There was a significant group by time interaction (Pillai's trace $F_{1,30} = 4.339$; $P = .047$) for the left composite reach score. Females demonstrated a significant decline in composite reach scores (88.9 ± 2.0 cm to 86.7 ± 2.0 cm) compared to males (91.4 ± 2.0 cm to 92.5 ± 2.0 cm). The right composite reach score also demonstrated a similar trend (Pillai's trace $F_{1,30} = 3.7$; $P = .065$) between males/females post-fatigue. Females demonstrated a decline in composite reach scores (87.4 ± 2.3 cm to 84.8 ± 2.3 cm) compared to males (90.0 ± 2.3 cm to 91.0 ± 2.3 cm). **Conclusions:** These findings suggest that female and male interscholastic athletes respond to the SEBT task post-fatigue in different ways. While reach scores decline in females post-fatigue, intriguingly the male athletes responded with greater reach scores. Sufficient performance on the SEBT requires strength, flexibility, and proprioception, any of which can be affected by fatigue making athletes prone to injury. The implications of this research on the female athlete and proneness to lower extremity injury need to be further investigated.

Age-Related Postural Control Alterations Among PreAdolescents, Adolescents, And Adults

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Context: Postural control deficits have been linked to increased lower extremity injury risk. Postural control has been studied extensively in adults and young children, but little research has examined the adolescent and pre-adolescent populations. Developing an understanding of postural control

changes associated with growth and maturation may provide insight into lower extremity injury risk and prevention. **Objective:** To compare the postural control of adults, adolescents, and pre-adolescents using Time-To-Boundary (TTB). **Design:** Cross-sectional study. **Setting:** Musculoskeletal laboratory. **Patients or Other Participants:** A group of adults (n=35, 14 males, 21 females, age:26.2±6.4 years, range:20-45), a group of adolescents (n=36, 17 males, 19 females, age:15.6±1.0 years, range:14-17), and a group of pre-adolescents (n=36, 17 males, 19 females, age:11.9±0.9 years, range:10-13) were studied. Inclusion criteria for all subjects were no history of lower extremity injury in the past six weeks or history of balance disorders. **Intervention(s):** All subjects performed three, ten-second trials of barefoot single-limb stance on a forceplate with eyes open on their left leg. The mean of the three trials for each measure was used for analysis. **Main Outcome Measure(s):** The mean of TTB minima(s) (MeanTTB) and the standard deviation of TTB minima(s) (SDTTB) in the medial-lateral (ML) and anterior-posterior (AP) directions were the dependent variables. The independent variable was group (pre-adolescents, adolescents, adults). Separate one-way ANOVAs were used to compare each TTB variable. Post hoc Fisher's LSD pairwise comparisons were calculated to explain any significant group effects. Hedge's g effect sizes (ES) were calculated for all pairwise comparisons. Alpha level was set *a priori* at $p \leq 0.05$. **Results:** For the TTBML measures, there were no significant group effects for the MeanTTBML ($p=0.09$) and the SDTTBML Minima ($p=0.45$). For the TTBAP measures, there were significant group effects for the MeanTTBAP ($p < 0.001$) and SDTTBAP ($p > 0.02$). The adults (MeanTTBAP = 5.43 ± 1.18 s, SDTTBAP = 3.26 ± 0.84 s) had significantly higher values than the adolescent (MeanTTBAP

=4.09±1.25s, p=0.006, ES=0.68; SDTTBAP=2.44±0.74s, p=0.05, ES=0.55) and pre-adolescent groups (MeanTTBAP=3.87±1.27s, p<0.001, ES=1.26; SDTTBAP=2.67±1.13s, p=0.008, ES=0.58) The adolescent group had significantly higher values for the MeanTTBAP (p=0.008, ES=0.63), but not the SDTTBAP (p=0.49, ES=0.16). **Conclusion:** Age-related postural control alterations are present among pre-adolescents, adolescents, and adults. In the ML direction, there were no differences between groups. However, the AP direction revealed that adults had significantly higher TTB than both adolescents and preadolescents. The adolescents had higher MeanTTBAP compared to pre-adolescents. These findings indicate that TTB in the AP direction may detect age-related postural control alterations and may be an important factor in understanding how the sensorimotor system matures through adolescents. Future research should examine the relationship between age, skeletal growth, and the onset of puberty as potential mediating factors associated with postural control alterations and their relationship to lower extremity injury risk in adolescents and pre-adolescents.

Ice Slushie Ingestion Decreases Core Body Temperature In Male Football Players Prior To A Standard Pre-Season Practice

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Context: An elevated core body temperature (39.5-40pC) associated with exercise in hot environments hinders exercise performance. Therefore, researchers have studied external methods (cold water immersion or cooling vests) of lowering core temperature (T_c) prior to exercise. Recently, ingesting of ice slurry solutions (internal method of decreasing T_c) reduced T_c and improved endurance performance in runners and cyclists. This has never been studied in large subjects such as American football players. **Objective:** First, to investigate the effect of tea slushie (Slushie) versus cold tea (Tea) ingestion on the percent change in resting T_c ($\%T_c$) in euthermic football players prior to practice; and second, to determine if physical characteristics (mass or BSA/mass) were associated with $\%T_c$ after slushie ingestion. **Design:** Cross-over study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Nine collegiate football players representing many positions (height=181.5±3.4 cm, mass=100.3±21kg, BSA=2.19±.21m² and BSA/mass=223±24cm².kg⁻¹) volunteered. **Interventions:** On two occasions in a counterbalanced order the subjects ingested 7.5g.kg⁻¹ body mass of an identical nutritional formula but in the form of either Slushie (-1°C) or refrigerated Tea (7°C) before an afternoon pre-season practice. Every 5 minutes subjects were given 1.25g.kg⁻¹ of either drink to ensure a standardized ingestion rate during which we measured T_c using ingestible sensors

every minute for a 30min time period. The players ingested the sensors 12±3 hr prior to data collection to ensure that they were in the intestinal tract and therefore would not be directly affected by fluid temperature. The data was collapsed into 4 time periods: 0 to 7.5min (7.5min), 7.5 to 15 min (15min), 15min to 22.5min (22.5min) and 22.5 min to 30 min (30min) for ease of interpretation. Two-way group (Slushie versus Tea) by time (7.5min, 15min, 22.5min and 30min) ANOVA was used. Separate one-way ANOVA with Tukey's *post-hoc* analysis were used when group differences occurred ($\alpha = 0.05$). **Main Outcomes Measures:** $\% \Delta T_c$. **Results:** Ambient temperature and humidity were not different between trials (22.1±.43pC and 27±3.7%). Two-way ANOVA revealed group differences for $\% \Delta T_c$, $P=.013$. In Slushie, $\% \Delta T_c$ was significant over time ($P<.001$) and was different from 0min at 22.5min ($\% \Delta T_c = -.366 \pm .34pC$) and 30min ($\% \Delta T_c = -.425 \pm .37pC$), both $P=.01$. Additionally, the $\% \Delta T_c$ at 15min (-.116 ±.17pC) was different from 30min (-.425±.37pC), $P=.05$. No differences in $\%T_c$ over time occurred in Tea and there were no correlations between $\%T_c$ and mass or $\% \Delta T_c$ and BSA/mass. **Conclusions:** We could not measure performance (energy output) during practice but clearly consuming slushie solutions (-1°C) successfully decreased T_c compared to identical refrigerated fluids. This may be clinically important prior to the afternoon practice when resting T_c are usually higher than in the morning. Ingesting slushies prior to pre-season football practice may enhance performance by decreasing pre-exercise T_c .

The Effects Of Caffeine Consumption On Core Body Temperature In The Physically Active During Exercise: A Systematic Review

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Context: Caffeine has been shown to have a variety of physiological effects including acting as a diuretic, being a stimulant of sympathetic nervous system, and increasing metabolic rate. These effects could lead to increased heat storage and core body temperature. **Objective:** To answer the following clinical question: Does caffeine have an effect on core body temperature in the physically activity during exercise? **Data Sources:** We searched Medline, Sports Discus, CINAHL, and Cochrane between 1967 to November 2010 using the terms *caffeine, core temperature, body temperature, athlete, athlete*, physically active, exercise, and exercise** resulting in a total of 167 articles. **Study Selection:** Studies that met six criteria were included: 1) used an experimental design, 2) investigated physically active/athletic population, 3) defined exercise/activity level, 4) defined type and amount of caffeine consumed, 5) measured core body temperature and 6) reported results for calculation of effect sizes. **Data Extraction:** Two authors independently assessed the articles using the PEDro scale. We reached a consensus score when disputes arose. Effect size (ES) were calculated with the Cohens d and associated 95% confidence intervals (CI) for the comparisons of caffeine on core body temperature. A positive ES indicated an increase of core body temperature when caffeine was consumed. **Data Synthesis:** Six articles provided means and dispersions to calculate ES and 95% CI. The average PEDro score was a 5 ± 1.41 (range: 3-7). One article

demonstrated a moderate negative ES ($d = 1.50$ 95% CI=1.17 to 1.70) indicating that consuming caffeine decreased core body temperature. All other studies ($n=5$) showed positive, weak to strong effects, indicating that caffeine actually increased core body temperature during exercise. Of these studies, none of the CIs crossed zero. The most notable findings were in Ping 2009 (1.50 95% CI=1.17 to 1.70) and Alves, 1995 (2.07 95% CI=2.07 to 2.27) showing a strong clinical effect. **Conclusions:** There were several studies demonstrating that caffeine does have an effect on core body temperature. We noted that the protocols and the amounts of caffeine consumed were inconsistent in each study. In studies where strong to moderate effects were found, the raw data showed that group core body temperature differences were only tenths of a degree different. In addition, all but two articles scored low (5 or below) on the PEDro scale. There is a need for meticulous, well designed studies investigating the effects of caffeine on core body temperature in the physically active.

Core Temperature Responses In NFL Players On Two Different Teams Practicing In Different Environmental Conditions During Pre-Season

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Context: There are previous reports on maximal core temperature (T_{cmax}) differences and percent body mass loss (%mass) between selected positions of professional football players (NFL) on one team. There are also reports of T_{cmax} differences between days 2, 3 and 4 versus day 10 on the same team. Previous research has not examined T_{cmax} and %mass in two separate teams practicing in different environmental

conditions during the same pre-season. **Objective:** To determine if T_{cmax} or %mass was different between players from different teams under different environmental conditions. We hypothesized that the team (T1) with higher intensity practices (i.e. more tackle to the ground periods) would sustain higher T_{cmax} values when compared to a second team (T2) with limited tackle to the ground periods, regardless of environmental conditions. **Design:** Observational cohort study. **Setting:** Identical data was collected during practices on days 2 – 5 of two NFL pre-season training camps in different geographical areas. **Patients or Other Participants:** Thirteen players from each team volunteered and were matched by playing position and physical characteristics [T1 (age: 26 ± 2.6 y, mass: 115 ± 21 kg, height: 188 ± 6.4 cm, BSA: 2.4 ± 0.22 m², BSA/mass: 211 ± 19 cm²/kg) vs. T2 (age: 26 ± 3 y, mass: 112 ± 20 kg, height: 187 ± 8.7 cm, BSA: 2.4 ± 0.28 m², BSA/mass: 219 ± 17.5 cm²/kg). **Interventions:** Subjects ingested a temperature sensor the night before or early morning prior to data collection. Core temperature was recorded before and then every 10 minutes during practices. Pre and post practice body weight was used to determine % Δ mass. Wet bulb globe temperature (WBGT) was recorded at the beginning, middle and end of all practices using the same device. Independent t-tests and Pearson's correlations were performed ($\alpha = 0.05$). **Main Outcome Measures:** T_{cmax} and %mass. **Results:** Physical characteristics were not different between teams. Average WBGT was higher in T2 (83 ± 4.8 pF) vs. T1 (75.4 ± 6 pF), however, T_{cmax} was higher in T1 (102 ± 7 pF) compared to T2 (101.3 ± 8 pF), $P < .001$. There were no differences in %mass between teams and with data combined ($n=125$ pairs), %mass was not related to T_{cmax} ($P = .83$, $r = -.21$). **Conclusions:** The results of this study suggest that hotter environmental conditions did not produce higher T_{cmax} values in NFL players during pre-season training. A

comparison of the practice schedules for T1 vs. T2 during the days of collection does suggest probable practice intensity differences. T1 conducted twice as many practices in full pads with tackling to the ground than T2. Specifically, T1 practiced in full pads consecutively over the 4 days, while T2 practiced in full pads only twice, with two days in between consisting of practice in shells with no live periods. Therefore, the results of this study support the notion that exercise intensity is the most modifiable and influential factor on T_{cmax} .

Examining How Hydration And Intensity Influence Core Body Temperature In NCAA Division I Elite Football Players During Pre-season Practices In The Heat

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Context: Laboratory literature supports the notion that hydration status coupled with high intensity exercise influence core body temperature. There are limited field studies showing the influence of hydration status on core body temperature and virtually no field studies reflecting how intensity influences core body temperature in American football. **Objective:** Observe elite football athletes' gastrointestinal temperature (T_{GI}) as it changes due to distance covered (DC), heart rate (HR), velocity (V), and hydration status. **Design:** Observational field study. **Setting:**

First eight consecutive days (total of nine practice sessions) of preseason Division I football practice in the heat (WBGT: 85.19 ± 2.97 °F). **Patients or Other Participants:** Twenty-nine male DI football players (age = 21 ± 1 years, height = 74 ± 3 in, and mass = 242 ± 52 lbs) voluntarily participated. **Interventions:** An ingestible thermistor was given at least three hours prior to each practice, allowing T_{GI} measures approximately every 5 minutes during practice with a handheld recording device. Subjects were fitted with the Catapult™ unit under their equipment prior to practice. The system consisted of a compression vest with a slot in the upper back for a GPS unit, which provided a continuous measurement of DC, HR, and V. Prior to and after practice sessions, hydration indices of body mass loss (BML) and urine specific gravity (U_{SG}) were taken. **Main Outcome Measures:** Measures of intensity including average HR, V, and total practice DC. V is presented as percent of total practice spent at 2-4 m/s. Maximum T_{GI} and hydration indices including BML and U_{SG} . A multivariate regression analysis was utilized to determine predictor variables for maximum T_{GI} . Collinearity was accounted for and sufficient independence between predictive variables. Statistical significance was set at $P < 0.05$. **Results:** Intensity as measured by (HR (138 ± 9 bpm), V ($0.04 \pm 0.01\%$), and DC (3185 ± 856 m·s⁻¹)) significantly accounted for 32% of the variability observed in maximal T_{GI} (101.89 ± 0.76 °F, $r=0.56$ $P=0.026$). However, hydration status as measured by (percent BML ($1.56 \pm 0.80\%$) and U_{SG} change (0.004 ± 0.004)) was not a significant predictor of maximal T_{GI} ($P=0.45$). Therefore, when combining measures of intensity and hydration status, the prediction of maximal T_{GI} was no longer statistical significance ($P=0.06$). **Conclusions:** These findings suggest that measures of intensity influenced increases in T_{GI} , while hydration indices did not substantially influence T_{GI} . Consistent

with recent literature, our results show a rise in core body temperature resulting from a high level intensity of exercise (high metabolic heat production). All the subjects for this study had *ad libitum* access to fluids, high background knowledge of hydration, and therefore did not have significant level of dehydration. Future research should utilize more of a heterogeneous population.

Perceptual Responses To Intermittent, Superficial Cooling During Exercise In The Heat

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Context: Prevention of heat-related illness using superficial cooling garments during exercise in hot environments has yielded conflicting results relating to attenuation of cardiovascular strain/fatigue. Fatigue, a physical process, may instead be an emotional construct described by perceptual responses. **Objective:** Evaluate the effect of intermittent, superficial cooling on perceptual responses during exercise in a hot-humid environment. **Design:** A randomized, counterbalanced, repeated measures investigation with two conditions (Cooling, Control) during exercise and recovery. **Setting:** Outdoors on artificial turf in a hot, humid tropical climate in the sun (WBGT_o= 27.0 ± 0.8 °C, range= $25.8-28.1$ °C) and in the shade (WBGT_o= 25.4 ± 0.9 °C, range= $24.3-26.8$ °C). **Participants:** Purposeful sample of 16 participants from a pool meeting inclusionary criteria and 10 were included in data analysis (age= 22.6 ± 1.6 y; height= 176.0 ± 6.9 cm; mass= 76.5 ± 7.8 kg; body fat= $15.6 \pm 5.4\%$). **Interventions:** Participants wore one of the following: shorts and t-shirt

(Control) or cooling vest (Cooling) during 5-min rest breaks provided every 20 min during 60 min of intense, exercise in the heat. Participants were monitored every 5 min during 30 min of recovery in the shade. Exercise sessions consisted of typical American football training and conditioning exercises at an average heart rate of 85-95% of heart rate maximum. Participants consumed water *ad libitum* during rest breaks after data were collected. Meals, snacks, and hydration status were controlled. **Main Outcome Measure(s):** We assessed perceptual responses: thermal sensations on a 9-point scale, thirst sensations on a 9-point scale, and RPE on a 15-point Borg scale. Thermoregulation/cardiovascular responses: gastrointestinal temperature (T_{gi}), skin temperature (T_{sk}), and heart rate (HR) were measured for descriptive and safety purposes. We used a 2-way repeated-measures (condition x time) analysis of variance (ANOVA) and reported data as mean \pm SD. **Results:** We found significant ($p=0.026$) decreases in thermal sensations for Cooling (4.4 ± 0.2) compared to Control (5.0 ± 0.2). Thirst responses approached significance ($p=0.051$, partial eta squared= 0.359 , power= 0.517) with less thirst in Cooling (4.5 ± 0.3) compared to Control (5.3 ± 0.4). The RPE responses were not significantly ($p=0.164$, partial eta squared= 0.203 , power= 0.273) different between Cooling (10.4 ± 0.5) and Control (11.4 ± 0.8). T_{gi} for Cooling (38.2 ± 0.2 °C) decreased significantly ($p=0.046$) compared to Control (38.5 ± 0.1 °C). T_{sk} for Cooling (31.8 ± 0.4 °C) decreased significantly ($p < 0.001$) compared to Control (34.4 ± 0.5 °C). HR responses were not significantly different ($p=0.307$, partial eta squared= 0.115 , power= 0.163) in Cooling (147.6 ± 2.6 bpm) compared to Control (150.1 ± 3.5 bpm). **Conclusions:** In an athletic setting, intermittent, superficial cooling was effective in reducing thermal sensations and T_{sk} but was not effective in substantially reducing T_{gi} . No effect was observed for RPE or HR indicating that wearing a cooling vest did not attenuate the

increased cardiovascular strain observed during intense exercise. Coaches, athletic trainers, and strength and conditioning specialists should understand that cooling vests are not effective in reducing cardiovascular strain but may be used to reduce thermal sensations.

Recognition And Treatment Of Exertional Heat Stroke: A Perspective From The Team Physician

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Context: Rectal temperature assessment (T_{re}) and cold-water immersion (CWI) are the gold standards for the recognition and treatment of exertional heat stroke (EHS), but athletic trainers (ATs) are reluctant to implement them regularly into clinical practice. ATs work under the guidance of a physician, but little information is available regarding the perceptions of the aforementioned methods from the team physician's perspective. **Objective:** To investigate team physicians' practice beliefs regarding the recognition and immediate treatment of EHS and the ways to increase the use of best practices. **Design:** Exploratory study using semi-structured focus groups and follow-up phone interviews. **Setting:** College, university, and secondary school clinical setting. **Patients or Other Participants:** 12 team physicians using criterion, convenience, and snowball sampling technique were included in the study. The criteria included the title "team physician" for a college/university or secondary school, at least 3 years of full-time work experience beyond their residency and possession of a family medicine or internal medicine specialization. Seven were involved with the focus groups and 5 completed phone interviews. The mean age was 44.2 ± 3.8 with 10.2 ± 7.1 years of sports medicine specific experience. Participants represented 11 states.

Data Collection and Analysis: Data analysis included open coding procedures by a 3-member research team. Credibility was established by member checks and multiple analyst triangulation. **Results:** Two main themes emerged to explain the viewpoint of the physician on best practices: 1) *Supervisory role of the physician* and 2) *Core body temperature*. Participants strongly agreed that T_{re} was critical for diagnosis, however the role of the physician does not include educating the AT on proper T_{re} implementation, but rather enforcing a protocol that includes evidence-based medicine. Two major themes materialized to explain how ATs could be encouraged to use T_{re} assessment and CWI in clinical practice: 1) *Pre-certification* and 2) *Post-Certification*. Pre-certification was supported by two lower level themes a) *Real-time experience*, and b) *Skill set mandate*, while the Post-certification theme was illustrated by one lower theme: *Professional development*. **Conclusions:** The sports medicine physician supports T_{re} and CWI and believes it should be performed by the AT. Physicians, in recognition of the dichotomy between best and actual practice, believe that to increase the use of best practices the AT must receive formal training with those skills in a structured learning environment as well as gain real life exposure to the implementation of those methods. Physicians also recognize the dynamic nature of medicine and development of best practices, therefore they recommended for the AT to maintain current through professional development. Future studies should investigate the practice beliefs of emergency room physicians as well as those physicians employed within the secondary school setting without a sports medicine specialization.

Exertional Heat Illness During A Single Interscholastic Football Season In Georgia

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Context: Exertional Heat Illness (EHI) is a common occurrence in football, particularly in the southern portion of the United States. There have been very few studies that have been conducted at the interscholastic level to determine EHI injury rates (IR). **Objective:** To determine the EHI IR at the interscholastic level in Georgia by practice type and week of season. **Design:** Prospective design. **Setting:** Interscholastic institutions (n=22) from 5 geographic regions in the state of Georgia (North, Metro Atlanta, Central, Southeast, Southwest) **Participants:** Interscholastic football athletes from 22 schools across the state of Georgia for one competition season. Data collection was for August and September, 2009. **Interventions:** An ATC was identified at each school and recorded all exposure and EHI data. Data included the total number of participants (athlete-exposures, AE), and practice type. EHI types were identified as heat cramps, heat exhaustion, heat syncope, and heat stroke as defined by the National Athletic Trainers Association Position Statement. **Main Outcome Measures:** Dependent variables included EHI occurrences and exposure information. IR was calculated using the following equation: number of injuries/number of athlete exposures (AE) x 1000 with 95% confidence intervals (CI). **Results:** The total number of EHI's was 213 and total number of AE's was 76673 for one season. The overall IR was 2.78/1000AE (95%CI=2.40,3.15). For EHI type, the IR was 2.15/1000AE (95%CI=1.82, 2.48) for exertional cramps, 2.15/1000AE (95%CI=1.82, 2.48) for heat syncope, 0.39/1000AE (95%CI=0.25, 0.53) for heat exhaustion. There were no reported

incidences of heat stroke. EHI's IR per practice session type were as follows: walk-through was 1.38/1000AE (95%CI=0.60, 2.21), regular practices was 1.86/1000AE (95%CI=1.47, 2.26), split practice was 2.66/1000AE (95%CI=1.57, 3.74), scrimmages was 1.37/1000AE (95%CI=0.03, 2.72), and games was 8.55/1000AE (95%CI=6.77, 10.34). For each week, the highest IR occurred in the fourth official week of practice, 6.72/1000AE (95%CI=4.84, 8.60), followed by the second official week of practice, 4.33/1000AE (95%CI=2.89, 5.76) and then the first official week of practice, 3.83/1000AE (95%CI=2.79, 4.87). **Conclusion:** The greatest number of EHIs occurred during regular practice sessions and games. The highest IR occurred in the fourth official week of practice which generally coincided with the first week of games. Approximately 75% of the total EHI cases occurred during the month of August. Athletic Trainers and coaches should utilize all prevention measures especially during the month of August to minimize the IR for EHI's and potential catastrophic events.

Utilization Of Evidence-Based Practice By Emergency Medical Service Professionals Regarding The Recognition And Treatment Of Exertional Heat Stroke

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Context: Current Evidence Based Practice (EBP) supports the use of rectal thermometry (T_{re}) for an accurate diagnosis and cold water-immersion (CWI) for the treatment of Exertional Heat Stroke (EHS) for an optimal outcome. Emergency Medical Services (EMS) play a critical role for the diagnosis and treatment of EHS as they may be the first to arrive on scene, however there is limited data regarding their implementation of EBP. **Objective:** Investigate current practice regarding EHS by EMS professionals and explore the relationship that exists between

EMS and Athletic Trainers (ATs). **Design:** A basic qualitative design using in-person focus groups. **Setting:** Regionally biased EMS companies. **Participants:** A total of 17 (3 females and 14 males) EMS professionals including Emergency Medical Technicians (EMTs) (n=11) and Paramedics (n=6), age 28±8 years participated in the study. EMS professionals averaged 6.3±5.3years of experience. **Data Collection and Analysis:** Interviews were transcribed verbatim and data was analyzed using open coding procedures. Peer review and multiple analyst data triangulation were conducted to establish trustworthiness. **Results:** Educational preparation emerged as the predominate explanation for the lack of EBP regarding EHS. Three sub-themes help illustrate educational preparation including *temperature assessment* (educational training and knowledge), *rapid cooling* (educational training, knowledge, and logistics), and the *role of the AT/Healthcare professional*. Educational training and knowledge provided for the EMS professional, regarding temperature assessment was limited, in some cases inaccurate as compared to the most current EBP, and highlighted a disparity in the EMS professional's ability to accurately diagnosis EHS. Because the education EMS professionals receive is limited partly due to scope of practice, the knowledge they bring to clinical practice reflects this disconnect. *Rapid cooling* educational training and knowledge illustrates the use of and belief in alternative methods other than CWI such as ice bags, air conditioning, and shaded areas. *Logistics played a* limiting role for the use of CWI as immediate transport is considered more important than immediate rapid cooling as well as impossible in an ambulance. The true *role of the AT/Health care professional* was unknown to many EMS professionals, which created confusion between two separate medical professionals. **Conclusion:** Findings from this research are consistent with previous literature regarding EBP

among medical professionals; a failure to utilize best practices. Unlike the AT, cool first transport second is not considered standard practice for EMS, due to protocol procedures, therefore alternative, but effective methods must be investigated. Proper education consistent with the most current literature regarding EHS must be taught within EMS certification preparation to ensure the most efficient recognition and treatment of EHS. A relationship among EMS professionals and ATs should be formed to create familiarity among the professions and establish emergency treatment protocols ensuring consistent EBP and optimal care.

Free Communications, Oral Presentations: Influencing Factors on the Athletic Shoulder

Monday, June 20, 2011, 12:15PM-1:15PM, Room 219; Moderator: TBD

Scapular Kinematic And Postural Changes In Collegiate Swimmers Due To Swim Training

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Context: Shoulder pain and injuries are common in swimmers due to the demands of the sport. Altered scapular kinematics and posture have been found in swimmers and these alterations have been linked to shoulder injuries. Normal training regimens may be contributing to altered patterns of scapular kinematics and posture that predispose them to injury. To date, how scapular kinematics and posture change with pre-season training is unknown. **Objective:** To assess the alterations in scapular kinematic and postural patterns that occur over 6 weeks of pre-season swimming practice. **Design:** Pre-test/post-test design. **Setting:** University natatorium and research laboratory. **Participants:** Forty division one collegiate swimmers (age=19.0±1.0 years, mass=74.4±11.0 kg, height=179.1±3.39 cm) with no current shoulder injury. **Interventions:** Scapular kinematics on the dominant limb (internal/external rotation, anterior/posterior tilting, upward/downward rotation, protraction/retraction, elevation/depression) were assessed using an electromagnetic tracking device, while the subjects performed 15 humeral elevations in the scapular plane. Forward head and forward shoulder posture were calculated by photographing the subjects' upper torso/head in the frontal plane. **Main Outcome Measures:** Means of the scapular kinematic variables at 0, 30, 60, 90, and 120 degrees of humeral elevation were calculated from the middle five repetitions for each trial. The landmarks in the photographs (C7, tragus, shoulder joint, and two points

on the horizontal plane) were digitized to calculate the forward shoulder angle (inclination of the line extending from C7 to shoulder) and forward head angle (inclination of the line extending from C7 to tragus). Mixed-model analysis of variance and dependent t-tests were used to assess changes in scapular kinematic variables and posture variables (forward head angle and forward shoulder angle) between the testing sessions. **Results:** A significant session main effect was present for internal/external rotation ($F_{(1,27)}=25.085$, $p<0.0005$), protraction/retraction ($F_{(1,25)}=10.88$, $p=0.003$), and elevation/depression ($F_{(1,25)}=4.279$, $p=0.049$) when collapsed across angle. On average, the swimmers' scapulae were $11.1^\circ\pm 2.21^\circ$ more internally rotated, $8.83^\circ\pm 2.67^\circ$ more protracted and $2.85^\circ\pm 1.38^\circ$ more elevated at the post-test compared to the pre-test. Additionally, the swimmers had $4.83^\circ\pm 0.74^\circ$ greater forward head posture at the post-test than pre-test ($t_{(39)}=6.313$, $p<0.005$). **Conclusions:** Subjects moved into a position of significantly greater scapular internal rotation, scapular protraction, scapular elevation, and forward head posture. These alterations in scapular kinematics and posture place the shoulder in a position that may promote impingement and may predispose the swimmers to shoulder pain and injury. Muscle imbalances and tightness that develop due to the swim training may be responsible for these alterations that occur after only 6-weeks of pre-season training. Developing a stretching and strengthening program to counteract these adaptations to swim training is imperative to counteract these negative changes and thus prevent shoulder injuries in competitive swimmers.

Acute Effects Of Dynamic And Static Stretch On The Peak Torque And ROM Of Shoulder Internal And External Rotation

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Context: Previous research suggests that static stretching acutely impairs muscular performance by reducing successive strength and power production in the lower extremity and that it should be replaced with dynamic stretching. However, the complexity of the glenohumeral joint and the difference in biomechanical demands between the upper and lower extremity make it difficult to generalize the results to overhead movements. **Objective:** The primary purpose was to determine if static and/or dynamic stretch techniques affect the peak torque and average power of the shoulder rotators. A secondary purpose was to assess and compare range of motion (ROM) after the two stretching techniques. **Design:** A cross-over design. **Setting:** All subjects were tested in a controlled research laboratory using the same equipment and settings for each session. **Participants:** A volunteer sample of sixteen physically active females (age=20.38 ±1.93 years, height=161.9±5.8cm, mass=61.23±6.43) were recruited for participation. Subjects must have had glenohumeral range of motion within normal limits, been involved in upper-extremity activity within the last year, and had no injury to the upper extremity. **Interventions:** Each subject underwent a baseline (no-stretch) session first and then performed the static and dynamic stretch sessions in a randomized order with 48-72 hours between sessions. **Main Outcome Measures:** Baseline measurements were taken to compare to the post-stretch outcomes of the static and dynamic sessions. These

measurements included internal and external ROM with a universal goniometer and isokinetic measures of peak torque and average power at 60°/second and 180°/second using a Biodex System 3 Isokinetic dynamometer. Statistical analysis was performed utilizing a 2(static, dynamic group) x 2(pre-test, post-test) mixed ANOVA with baseline as the covariate. A probability level of $p < 0.05$ was set *a priori*. **Results:** There were no significant differences in internal ($p = 0.748$) or external rotation ($p = 0.590$) or ROM between baseline (IR=59.12±5.88, ER=82.89±5.18), static (IR=57.91±5.53, ER=86.88±3.44), and dynamic (IR=57.54±5.66, ER=86.59±3.78) conditions. Measurements of isokinetic average power showed no significant difference in mean power output in watts at 60° ($p = 0.356$) or 180°/second ($p = 0.797$) between baseline (IR60°/sec=13.93±4.67, IR180°/sec=20.78±7.13, ER60°/sec= 16.39±3.76, ER180°/sec=28.16±7.46), static (IR60°/sec=14.45±4.00, IR180°/sec= 23.53±9.47, ER60°/sec=16.11±3.47, ER180°/sec=28.71±7.89), or dynamic (IR60°/sec=14.56±3.96, IR180°/sec= 24.61±9.03, ER60°/sec= 16.09±3.68, ER180°/sec= 29.17± 7.91) conditions. No significant differences were found between groups in isokinetic peak torque at 60°/second ($p = 0.646$) or 180°/second ($p = 0.909$) with baseline (IR60°/sec=16.67±4.28, IR180°/sec= 15.01±3.98, ER60°/sec=16.86±3.38, ER180°/sec=17.7±2.64), static (IR60°/sec=17.43±4.55, IR180°/sec=14.90±4.53, ER60°/sec= 16.49±2.82, ER180°/sec= 17.35±3.08), or dynamic (IR60°/sec=17.14±3.8, IR180°/sec=15.00±4.38, ER60°/sec=16.67±3.20, ER180°/sec=17.41±2.83) conditions. **Conclusions:** No significant differences were found in ROM peak torque or power output after static or dynamic stretching. Therefore, neither static nor dynamic stretching appear to be detrimental or beneficial to the measured performance variables.

Descriptive Analysis Of Pitch Volume In Four Division I Collegiate Softball Pitchers

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Context: There is a lack of information describing typical pitch volumes for collegiate softball pitchers. **Objective:** To describe pitch volumes and levels of soreness for four Division I collegiate softball pitchers for one season. **Design:** Prospective and descriptive. **Setting:** Athletic training room. **Participants:** Sample was based on convenience and consisted of four female collegiate softball pitchers (age=20±1 years, weight=67±6 kilograms, height=168±54 centimeters). The subjects averaged 12 years of softball experience. All subjects were healthy at the beginning of the season. **Interventions:** Pitch volume data was collected during practice by catchers recording each pitch with a hand-held counter. Game pitches were collected by the coaching staff; game-day warm-ups were counted by investigators. A pitch was defined as one full revolution of the arm, regardless of the distance from the catcher. Game pitches were classified as: catch throws; game-day bullpen; and game. Practice pitches were classified as: catch throws and bullpen. Subjects filled out a daily exposure sheet to record pitch volumes and shoulder soreness. A numeric rating scale of 0-10 (0=no soreness, 10=pain affecting sleep) was used to measure soreness during softball activity. Softball exposures were categorized as participation in games, practices or injured. **Main Outcome Measures:** Descriptive analyses of softball exposures, cumulative and average pitch totals, percentage of game and practice pitches, average innings pitched, pitches per inning, and soreness levels in each category were calculated. **Results:** The four subjects had an average of 70±16.11 practice exposures, 26±14.75 game exposures and 2±1.64 injured exposures per

subject. Average cumulative pitch total for the season was 13,385 pitches (range=8,690-19,019). Forty-five percent of the total pitch volume was thrown in games (range of game volume=1,444-11,616). On game days, subjects threw an average of 22±6.2 catch throws, 188±8.9 game-day bullpen pitches and 108±27 game pitches. Subjects pitched an average of 5±2.3 innings and 26±26 pitches per inning. Fifty-five percent of total pitch volume was thrown in practice (range of practice volume=4,460-5,244). On practice days, subjects threw an average of 23±6.6 catch throws and 114±10.9 bullpen pitches. Subjects' highest average daily soreness was 0.8±1.0 during softball activity. **Conclusions:** These data are limited due to small number of subjects, however are useful in developing rehabilitation and training programs specific to the demands of these athletes. This is one of few investigations to quantify pitch volume and first to include practice throws, which adds substantially to the total pitch volume. The high volume of throwing does not appear to create an increase in soreness over the season. These data seem to support the concept that the more natural mechanics of underhand softball pitching is less stressful to the upper extremity. Direct comparison to overhead baseball pitchers is needed in the future to confirm this.

Comparison Of Trunk Rotation Flexibility Between Collegiate Softball Players With And Without A History Of Upper Extremity Injuries

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Durham, NC

Context: Limited trunk rotation flexibility may restrict trunk rotation motion during throwing, and thus interfere with energy transfer from the lower extremity to the upper extremity

via the trunk. Ineffective transfer of energy is thought to cause increased stresses on upper extremity joints that lead to injury. No research to date compares trunk rotation flexibility in softball players with and without a history of upper extremity injury. Trunk rotation flexibility is traditionally assessed in a seated position, yet assessment in a half-kneeling position may better replicate a functional movement (throwing) and thus provide a better way to measure trunk rotation flexibility in softball players. **Objective:** To compare trunk rotation flexibility between softball position players with and without a history of upper extremity throwing related injury using three clinical tests. **Design:** Cross-sectional design. **Setting:** University softball facilities. **Participants:** Sixty-five female collegiate softball position players (age=19.5±1.2years, height =165.4±7.0cm, mass=69.1kg). **Interventions:** Trunk rotation flexibility was measured with three clinical tests: half kneeling rotation test with bar in back (HKRT-B), half kneeling rotation test with bar in front (HKRT-F), and seated rotation test (SRT). Trunk rotation flexibility was assessed in both forward (throwing shoulder moving forward) and backward (throwing shoulder moving backward) directions. Additionally, participants completed an injury history questionnaire. **Outcome measure:** Participants were placed into groups with and without an injury history based on the questionnaire response. For each clinical test, trunk rotation flexibility were compared between participants with and without an injury history using independent samples *t*-tests. Additionally, chi-square analysis was used to determine an association between limited trunk rotation flexibility and an injury history when significant group difference was found. **Results:** Softball players with an injury history had significantly limited trunk forward rotation flexibility when measured using the HKRT-B (mean difference =3.1°±4.7°, $t_{63}=-2.24$, $p=.029$). No other rotation tests demonstrated differences between groups. Furthermore, softball players

with limited trunk rotation when measured with the HKRT-B when rotating forward were 3.98 times (CI: 1.2-13.0) more likely to have an injury history compared to those without ($X^2=5.64$, $p=.018$). **Conclusion:** The results suggest an association between limited trunk forward rotation flexibility and throwing-related upper extremity injury. Limited trunk flexibility in the forward direction may inhibit the body's ability to use trunk movement to absorb energy during the deceleration phase of throwing, which could result in greater stress placed on the upper extremity joints, and thus increased risk of injury. HKRT-B was able to demonstrate the difference in trunk rotation flexibility between participants with and without injury history. Clinicians may use HKRT-B to screen for trunk rotation flexibility to identify softball players who may be at increased risk for developing upper extremity injury.

Free Communications, Oral Presentations: Exercise Fatigue & Lower Extremity Biomechanics

Tuesday, June 21, 2011, 8:00AM-9:00AM, Room 219; Moderator: Abbey Thomas, PhD, ATC

Gender Comparison Of Central And Peripheral Neuromuscular Function Following A Sub-Maximal Exercise Protocol

Stern AS, Kuenze C, Cross K, Sauer L, Herman D, Hart JM: University of Virginia, Charlottesville, VA

Context: Noncontact anterior cruciate ligament (ACL) injuries are common in sports that involve rapid changes of directions, including decelerating, pivoting, and landing from a jump. Females are 2 to 8 times more likely to sustain a noncontact ACL injury than males. Both central and peripheral muscle fatigue during exercise may exacerbate neuromuscular factors that increase risk for noncontact anterior cruciate ligament (ACL) injury. **Objective:** To compare lower extremity motor evoked potentials (MEPs), muscle strength, and EMG activation after a standardized exercise protocol in males and females. **Design:** Pre-test, Post-test group comparison. **Setting:** Laboratory. **Patients or Other Participants:** Thirty-four healthy and recreationally active volunteers with no history of lower extremity injury (17 females, age = 21.9 ± 2.3 years, weight = 77.8 ± 3.0 kg, height = 171.1 ± 6.6 cm and 17 males, age = 23.4 ± 6.5 years, weight = 81.6 ± 3.3 kg, height = 179.6 ± 7.3 cm). **Interventions:** Subjects performed a standardized 30 minute exercise protocol that involved 5 repeated cycles of aerobic and anaerobic exercises. Cycles consisted of 5 minutes of uphill walking (aerobic) and 1 minute of body weight squatting and step-ups (anaerobic). Subjects reported ratings of perceived exertion throughout the protocol to ensure the exercise intensity remained at a moderate level. **Main Outcome Measures:** Quadriceps and hamstring MEP peak-peak amplitude (V) and transmission velocity normalized to

subject height (ms/cm) were elicited via transcranial magnetic stimulation and measured via surface electromyography (EMG). Quadriceps and hamstring peak EMG activation (% MVIC) and peak torque (Nm/kg) were measured during respective MVICs. Independent samples t-tests were used to compare groups at baseline for all dependent variables while ANCOVA was utilized to compare groups following exercise while controlling for baseline measurement. **Results:** At baseline, males exhibited significantly higher quadriceps torque (males = 2.50 ± 0.71 Nm/kg, females = 1.88 ± 0.40 Nm/kg, $P=0.01$), quadriceps activation (males = 236.9 ± 126.1 mV, females = $114.2 \pm 84.2\%$, $P=0.01$), quadriceps MEP amplitude (males = 193.3 ± 192.6 mV, females = 88.7 ± 102.9 mV, $P=0.02$) and hamstring MEP amplitude (males = 186.7 ± 135.5 mV, females = 83.8 ± 72.0 mV, $P=0.02$). After exercise, males exhibited a significantly greater decrease in quadriceps torque (males = -8.62% , females = 2.69% , $P=0.03$) and hamstring MEP amplitude (males = -25.80% , females = -5.72% , $P<0.001$) when compared to males. Conversely, females exhibited a significantly greater decrease in quadriceps MEP amplitude (males = -2.10% , females = -33.0% , $P=0.01$) when compared to males. **Conclusions:** Males experienced greater peripheral neuromuscular changes manifested as more pronounced reductions in quadriceps torque following exercise. Females experienced greater central neuromuscular changes manifested as more pronounced reduction in quadriceps MEP amplitude. Reduced central neural drive of the quadriceps coupled with knee extension torque preservation following exercise may create an environment of increased risk for knee injury in females.

A Comparison Of Lower Extremity Neuromuscular Function In Healthy Individuals Following A Sub-Maximal Exercise Protocol

Kuenze C, Hart JM: University of Virginia, Charlottesville, VA

Context: A clear understanding of lower extremity neuromuscular function is essential to injury prevention and structuring of rehabilitation protocols following injury. Non-contact lower extremity injuries commonly occur when athletes become fatigued. While there is growing base of knowledge about neuromuscular function in healthy and injured populations at rest, the effects of sub-maximal exercise on both quadriceps and soleus function are unclear. **Objective:** To determine the effects of sub-maximal lower extremity exercise on quadriceps and soleus neuromuscular function in healthy individuals. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Twenty healthy participants (11 Females, 9 Males; age = 25.0 ± 4.6 yrs, height = 170.2 ± 10.6 cm, weight = 68.7 ± 12.8 kg) with no history of significant lower extremity injury were recruited from the university community. **Interventions:** Subjects performed a standardized 30-minute exercise protocol that involved 5 repeated cycles of aerobic and anaerobic exercises. Each cycle consisted of 5 minutes of uphill walking (aerobic) and 1 minute of body weight squatting and step-ups (anaerobic). **Main Outcome Measures:** Patients performed a seated maximal voluntary isometric contraction with the knee bent to 60-degrees bilaterally. An electrical stimulus was triggered when a force plateau was present resulting in a transient increase in knee extension (SIB torque). Quadriceps central activation ratio (CAR) was calculated

by dividing MVIC torque and SIB torque as an estimate of the proportion of the quadriceps motor neuron pool that can be activated during an isometric MVIC. Soleus Hoffmann reflex (V), M-wave (V) and H:M ratio (%) were measured in the prone position. Progressive electrical stimulation (0-200V) of the tibial nerve was delivered and soleus reflex potentials were recorded via surface electromyography. Individual t-tests were used to analyze differences in the dependent variables from baseline to post-exercise. Pearson's (r) correlations were used to determine the relationship between measures at baseline and for changes from baseline to post-exercise. **Results:** Quadriceps MVIC torque (baseline=3.32±0.73 Nm/kg, post=2.83±0.74 Nm/kg, P<0.001), quadriceps CAR (baseline=88.8±5.7%, post=79.1±11.6%, P<0.001), soleus Hoffman reflex (baseline=6.89±3.47 V, post=5.48±3.42 V, P<0.001), soleus H:M ratio (baseline=63.7±19.9%, post=50.7±26.8%, P=0.001) significantly decreased from baseline to post-exercise. There were no significant correlations between measures at baseline while the change in quadriceps CAR and soleus H:M ratio were positively correlated ("CAR=-11.1±10.0%, "H:M ratio=-23.7±23.9%, r=0.53, P=0.02). **Conclusions:** Thirty minutes of sub-maximal lower extremity exercise resulted in significant decrease in neuromuscular function of the quadriceps and soleus muscles. The lack of significant correlation between measures at baseline implicates unique aspects of neuromuscular function are being explained by each measure. However, the percent change in quadriceps CAR and soleus H:M ratio were moderately correlated which indicates that 30 minutes of general sub-maximal exercise is sufficient to cause measurable decrements in lower extremity neuromuscular function in health individuals.

Changes In Lower Extremity Movement Patterns During Fatiguing Exercise

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Context: Neuromuscular fatigue is a possible risk factor for many musculoskeletal injuries, including the Anterior Cruciate Ligament (ACL). However, the effects of fatigue on lower extremity movement patterns have not been fully explored, particularly how fatigue progressively impacts movement. **Objective:** To determine how increasing amounts of neuromuscular fatigue affects lower extremity movement patterns during a functional fatigue protocol (FFP). **Design:** Single-group repeated-measures design. **Setting:** Gymnasium basketball court. **Patients of Other Participants:** Twenty-three healthy, club-level volleyball, soccer, or basketball athletes (14 F, 9 M; age=19.74±2.09 years, height=1.77±0.10m, mass=72.05±11.47kg) volunteered for the study. **Interventions:** Participants performed the FFP, which consisted of multi-directional sprints, side-shuffles, and back-peddling, followed by five standing broad jumps (SBJs) to at least 75% of their pre-fatigue maximum SBJ distance. During the 5 SBJs, handheld camcorders recorded front and side views as each participant landed. Each participant repeated the above sequence until their time to completion was >150% of their initial time on 3 consecutive trials. **Main Outcome Measures:** The Landing Error Scoring System (LESS) was used to quantify the movements of the lower extremity during the SBJs, using video recordings taken during the FFP. The LESS is a validated and reliable 17-item checklist that examines foot, knee, hip, and trunk postures at two points during landing: initial contact (IC) and peak knee flexion. The participant receives a 'point' for every landing 'error' he/she

makes. Higher LESS scores are indicative of poorer landings. In order to assess changes during the FFP, the SBJs from the first FFP represented 'pre-fatigue' landing (PRE), SBJs during the final FFP represented 'post-fatigue' landing (POST), and SBJs completed during the middle FFP represented '50% fatigue' (50%). Each item score and the total LESS score were averaged for the first 3 SBJs completed in each selected FFP, then analyzed using repeated-measures ANOVAs with Bonferroni post-hoc tests (≤ 0.05). **Results:** Fatigue resulted in a significant increase in total LESS score (PRE=6.07±1.26, 50%=6.64±1.95, POST=7.07±1.68; $F_{2,44}=6.130$, $p=0.004$). Post-hoc tests revealed significant increase between PRE and POST ($t_{22}=-3.430$, $p=0.002$). Item-specific analysis indicated fatigue increased lateral trunk flexion at IC (PRE=0.02±0.10, 50%=0.14±0.24, POST=0.16±0.23; $F_{2,44}=3.778$, $p=0.031$), and increased overall joint displacement stiffness (PRE=1.01±0.34, 50%=1.13±0.42, POST=1.30±0.50; $F_{2,44}=5.966$, $p=0.005$). Post-hoc tests revealed significant increases between PRE and POST for both lateral trunk flexion at IC ($t_{22}=-2.761$, $p=0.011$) and overall joint displacement stiffness ($t_{22}=-2.989$, $p=0.007$). **Conclusions:** Neuromuscular fatigue increased the overall LESS score by a full point between PRE and POST, indicating increased landing errors that may predispose an athlete for lower extremity injury. Lateral trunk flexion during landing, and overall joint displacement stiffness, were the two items most affected by fatigue. These results indicate that fatigue may significantly impair landing postures, and further support the hypothesis that fatigue may increase potential injury risk.

Changes To Frontal And Transverse Plane Lumbo-Pelvic-Hip Running Biomechanics Following Cycling In Triathletes

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Charlottesville, VA

Context: Epidemiological evidence suggests that lower-extremity overuse injuries are common in triathlon. It is possible that adaptations at the trunk and hip due to prolonged cycling effect trunk and hip biomechanics during running. Aberrant hip biomechanics have recently been implicated in the etiology of chronic knee pathologies. Excessive frontal plane trunk biomechanics may also play a role in overuse running injuries. Identifying changes to kinematic and kinetic parameters at the trunk and hip may provide insight into the development of lower-extremity in triathlon.

Objective: To determine the frontal and transverse plane running biomechanic adaptations at the trunk and hip following a cycling intervention.

Design: Descriptive laboratory study.

Setting: Motion analysis laboratory.

Patients or Other Participants: A sample of 28 healthy subjects with prior triathlon experience (height= 1.73 ± 0.09 m, mass= 63.0 ± 7.7kg, age= 24.6 ± 5.8 years) was used.

Interventions: 3D running kinematics and kinetics were obtained before and at 4 time points (2min, 6min, 10min, 14min) following a 30-min stationary cycling protocol performed in an aerodynamic riding position at a self-selected cadence and power output. Ratings of Perceived Exertion were maintained between 12-14 (out of 20) throughout the cycling intervention to minimize the effects of fatigue. A self-selected running velocity was chosen and held constant between baseline and post-cycling run sessions.

Main Outcome Measures: Peak Spine, Pelvis, and Hip Frontal and Transverse Plane Angles and Moments from a sample of 10 gait cycles at each time point were averaged. Data from both limbs

was combined for analysis. 1x5 ANOVA's with follow up pair-wise comparisons were performed to examine the differences between pre- and post-cycling running biomechanics. Statistical significance was set *a priori* at p=.05. **Results:** We observed the following main effects for time: Peak Hip Internal Rotation significantly increased from baseline (21.8° ± 7.2) at each post-cycling time-point (2min=24.8° ± 9.2, 6min=25.2° ± 9.0, 10min=25.6° ± 9.4, 14min=25.3° ± 8.9 p<.001); as did Peak Pelvis Obliquity (baseline=1.1° ± 0.8) (2min=1.5° ± 0.8, 6min=1.4° ± 0.9, 10min=1.6° ± 0.95, 14min=1.5° ± 0.8 p<.001), and Peak Spine Lateral Bend (baseline=3.7° ± 1.3) (2min =4.1° ± 1.4, 6min=4.0° ± 1.2, 10min =4.2° ± 1.4, 14min=4.3° ± 1.4 p<.001); while Peak Hip Abduction Moment (baseline=0.8Nm ± 0.2) significantly decreased (2min=0.7Nm ± 0.2, 6min=0.76Nm ± 0.2, 10min =0.77Nm ± 0.2, 14min=0.73Nm ± 0.2 p<.001) **Conclusions:** Frontal and transverse plane running kinematics of the trunk and hips are altered by 30min of non-fatiguing stationary cycling in an aerodynamic position. The changes to frontal plane spine and pelvis motion may provide a mechanism to minimize external frontal plane moments at the hips as these were significantly lower following cycling.

Free Communications, Oral Presentations: Injury Epidemiology

Tuesday, June 21, 2011, 9:15AM-10:00AM, Room 219; Moderator: Steve Zinder, PhD, ATC

Injury Incidence In Submission Wrestling Fighters During The 2009 Worlds No-Gi Championships

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Context: Submission wrestling (SW) is a modern combat martial art that employs joint locks during competition to submit an opponent and achieve match victory. This martial art is a gateway sport for Mixed Martial Arts (MMA), which is a relatively young, but rapidly growing participant combat sport worldwide. Due to their relatively new infrastructures, there are limited injury incidence reports available for SW or MMA. However, SW may provide a preview of joint injury patterns expected in MMA competitions. **Objectives:** The purpose of this investigation was to determine incidence rates for injury types at SW belt rank levels sustained at an international level SW tournament, and to evaluate the risk of injury by belt rank and body region. **Design:** Prospective cohort **Setting:** 2009 Worlds No-Gi Championships. **Patients or Other Participants:** We studied 951 athletes, aged 18 to 50 years, who competed in the 2009 No-Gi Championships. Participants were categorized into belt graduation levels for group comparisons (belt rank progression level: blue [least experienced], purple, brown, and black [most experienced]). **Interventions:** No intervention – observational. Rate ratios (RR) and 95% confidence intervals (CI) were used to compare belt rank injury rates. **Main Outcome Measure:** A reportable injury was defined as any joint injury that occurred during competition for which an athlete received any level of care from the on-site medical staff (physician, athletic trainer). Other injuries reported such as back, rib, head, fingers, and skin injuries, were also

recorded. Data which met the inclusionary criteria were categorized by joint (elbow, shoulder, knee, and ankle). Incidence rates (IR) per 1000 athletic exposures (AEs) were calculated for overall injury incidence, belt rank, and body region. **Results:** During the tournament there were 58 total reported injuries and 1606 recorded AEs. Percentage and rate of injuries per location were ankle (13.8%, 5.0/1,000 AEs), knee (20.7%, 7.5/1,000 AEs), elbow (20.7%, 7.5/1,000 AEs), shoulder (13.8%, 5.0/1,000 AEs), and other (laceration, head, neck, rib) (31.0%, 11.2/1,000 AEs). Blue/black belt (least/most experienced) competitors had a significantly higher rate of upper extremity (combined shoulder & elbow injuries) than purple/brown belt competitors (RR=3.5, 95% CI: 1.0, 18.7; p=.03). Although nonsignificant, purple/brown belt competitors were twice as likely (RR=1.97, 95%CI: 0.7, 5.4; p=0.14) to incur a lower extremity injury (combined knee/ankle) than blue/black belt competitors. **Conclusions:** The data from this SW tournament indicate that the risk of injury is highest at knee and elbow joints. However, higher belt rank/experience may be associated with increased upper extremity injury incidence during SW competition. Further research is warranted to examine underlying mechanism of injuries to these high risk joints to optimize techniques to reduce their occurrence in SW competition.

A Comparison Of Hamstring Strain Event Data Between Sexes During Practices And Games In NCAA Soccer

Cross KM, Conaway M, Gurka KK, Saliba S, Hertel J: University of Virginia, Charlottesville, VA

Context: Among National Collegiate Athletic Association (NCAA) soccer players, males have a higher incidence of hamstring strains than females. The

causes of this difference are unknown. **Objective:** To compare differences in the distribution of hamstring strain injuries in male and female college soccer players across the time of season, practice or game participation, and specific practice activities. **Design:** Descriptive epidemiology study. **Setting:** Colleges and universities that voluntarily participated in the NCAA Injury Surveillance System (ISS) for men's and women's soccer during fall seasons from 2004-2007. **Patients or Other Participants:** A total of 226 hamstring strains (males=131, females=95) were reported to the ISS during the data capture period. **Interventions:** At each participating institution, athletic trainers reported athlete-exposures and injury event data via the online ISS. For this analysis, we only examined hamstring strain injuries. **Main Outcome Measures:** To examine differences in injury characteristics between male and female soccer players who incurred hamstring strains, Chi-Square or Fisher Exact tests, as appropriate, were used to compare the frequencies of hamstring strains that occurred within levels of the following variables: time of season (pre-season, in-season), activity (game, practice), and practice activity (warm-up, drills, conditioning). Exact proportions (percentages) for each level of independent variable are reported without confidence intervals or other variability estimates because these results represent exact count data of the reported injuries. **Results:** Males had a higher frequency of hamstring strains in-season (males=59%, females=45%), while females had a higher frequency during pre-season (males=41%, females=55%, p=0.04). Males had a higher frequency of hamstring strains during games (males=46%, females=36%), while females had a higher frequency during practice (males=51%, females=62%, p=0.01). Among males, there were no

differences in the frequency of hamstring strains among practice activities during pre-season compared to in-season (warm-up: pre-season=2%, in-season=4%; drills: pre-season=69%, in-season=74%; conditioning: pre-season=29%, in-season=22%, p=0.70) Among females, however, a significantly larger proportion of hamstring strains during practice occurred while conditioning in pre-season (pre-season=43%, in-season=7%) but during drills in-season (pre-season=52%, in-season=86%, p=0.05). **Conclusions:** Differences in the timing of hamstring strains related to time of season, games versus practice participation, and specific practice activities exist between male and female collegiate soccer players. Compared to males, females had a higher proportion of hamstrings strains that occurred during pre-season when the majority of athlete-exposures were during practice. Additionally, hamstring strains in females were more frequent during conditioning activities during pre-season practices compared to in-season practices. These findings may assist clinicians and researchers in the development of sex-specific injury prevention initiatives for collegiate soccer athletes.

Athletic Injuries Classified As Trauma At A Pediatric Hospital From 2004 To 2008

Rogers KJ, Hochstuhl D, Murphy S, O'Brien K, Shah SA: Alfred I duPont Hospital for Children, Wilmington, DE

Context: The rationale for the study was to document trauma related athletic injuries that occurred through a pediatric emergency department (ED) over a five year period. **Objective:** To review distribution of sports and type of trauma with subsequent care. **Design:** Retrospective review of medical charts. **Setting:** Pediatric hospital. **Patients or Other Participants:** Patients between the ages of 1 – 19 years of

age from 2004 to 2008. **Interventions:** The E codes 884.9, 885.9, 886.0, and 917.0 were searched. All diagnoses were included. No person was excluded based on age, gender, or race. **Main Outcome Measures:** The outcome measures were the trauma E codes, sex, age, location of injury, prior history, mechanism of injury, trauma classification, sport, orthopedic injury and joint, medical injury and area, diagnosis number, and surgery. Frequency and descriptive statistics were calculated using SPSS 17 (SPSS Inc., Chicago, IL). **Results:** Three hundred and eighteen patients were identified as having an injury related to sports; 258 were male, and 60 were female and average age was 14.2 years. Intake status was: (1) admitted (152); (2) transferred and admitted (133); (3) transferred (33); and (4) death (0). The most common mechanism of injury (MOI) was player to player contact (166). The balance of MOIs were contact with playing surface (97), contact with playing apparatus (41), and no contact (14). Sport level or locations were: high school / youth league competition (205); recreation (83), school (24), home (5), or camp (1). Twenty-one people had a prior history of the same injury. Twenty different sports were implicated in injuries seen in the ED - the most common were: football (110), soccer (41), and basketball (41). The occurrences of orthopedic and non-orthopedic injuries were 259 and 84 respectively. Twenty-five patients had both an orthopedic and medical injury. Elbow (52) and forearm (38) fractures were the most frequent orthopedic injuries. The most common non-orthopedic injuries were concussions (37) and spleen (11). Thirty-six patients had multiple injuries: 2 (34), 3 (1), and 4 (1). Surgical intervention occurred in 58% of the cases. Five of the 184 surgical cases were medical related. **Conclusions:** No study to our knowledge has classified the pediatric athletic injury trauma frequency and related treatment for both orthopedic and medical injuries. This study

demonstrated that patients may experience multiple injuries (34 patients) and orthopedic and medical injury simultaneously (25). This study may lead to further understanding of the prevalence of traumatic athletic injury in this population with subsequent prevention strategies.

Free Communications, Oral Presentations: Professional Issues

Tuesday, June 21, 2011, 10:15AM-11:30AM, Room 219; Moderator: Jim Mensch, PhD, ATC

A Systematic Review of Case Law: The Legal Foundation for a Standard of Care in the Practice of Athletic Training

Musler J: Northeastern University, Boston, MA

Context: The only true check and balance to professional practice is by way of judicial review (litigation). Judicial review is a reactionary process occurring only after the legal wrong has been committed. Case law serves as society's record of judicial reasoning; however there is no easily accessible resource to present the opinion of the court (case law). This study involved a systematic review of recorded case law at the state and federal level involving an athletic trainer employed by a clinic, secondary school, college or university.

Objective: Conduct a systematic review of case law to: 1. define the legal duty to provide care to individuals participating in athletic activities; 2. define the minimum standard of care that should be offered to individuals participating in athletic activities; and 3. define the legal boundaries in the practice of athletic training. **Data**

Sources: LexisNexis and WestLaw databases were searched for the descriptive phrase "athletic trainer", "athletic training" and "trainer" to identify recorded decisions in the state and federal courts. **Data Selection:** A three phase process was used to identify cases. First, cases were identified with a descriptive word search and entered into a spreadsheet. Second, a review of the case summary was performed to determine the context of the descriptive phrase. Finally, a complete review of the court record was performed to determine the relevance of the athletic trainer or the practice of athletic training. **Data Extraction:** All cases were coded based on their relevance to athletic training. All cases coded as "relevant" were categorized based on their potential influence in three areas: 1. duty to care, 2. standard

of care, and 3. public policy, or their lack of conclusive legal reasoning.

Data Synthesis: Two hundred and eighteen total and 188 unique cases involving athletic trainers were identified. Seventy nine of the 188 cases were determined to be relevant to the practice of athletic training. Eleven cases addressed duty to care, 34 cases addressed standard of care, 3 cases addressed public policy, and 31 cases had no conclusive legal reasoning. **Conclusion:** The case analysis established a clear legal duty for a secondary school, college or university to provide health care to those who are injured during sponsored athletic activities. Case analysis also establishes a minimum standard of care that should be offered by an institution and by the athletic trainer. The analysis produced limited results for the establishment of legal boundaries to the practice of athletic training. The case synthesis resulted in the development of 15 recommendations in the form of standards that should reduce an unfavorable outcome as a result of judicial review. Six standards were developed identifying institutional responsibility, and nine standards were developed identifying minimal clinical practice in athletic training.

Exploring The Constructs Of A Quality Athletic Trainer

Raab SA: Valdosta State University, Valdosta, GA

Context: There is a lack of consensus in the athletic training (AT) literature pertaining to the exact characterization of a quality AT. **Objective:** To conduct a grounded theory qualitative study to conceptualize the latent constructs of a quality AT. To sequentially assess these latent constructs quantitatively.

Design: A sequential exploratory design starting with a qualitative study utilizing a Delphi technique to establish

a grounded theory followed by a quantitative assessment of descriptors using a semantic differential and vignettes. **Setting:** Certified Athletic Trainers. **Patients or Other Participants:** The Delphi panel consisted of ATs with 5 years minimal experience (N=13) stratified across the three largest employment settings and the four largest NATA districts. A stratified random sample of 5% across the 10 NATA districts produced participants (N=301) completing the quantitative survey. **Interventions:** The Delphi panel completed individual open ended audio recorded interviews with the researcher. Questions revolved around descriptions of the best, most successful, and ATs you would or wouldn't hire or let treat people you care about. Transcribed interviews were reviewed for clarity with each panelist, condensed, and reviewed for discussion three times by all members until consensus on the topics was reached. Open coding of transcribed interview text produced descriptive adjectives used in the semantic differential for quantitative assessment and interview concepts were assessed using vignettes covering responses to typical day AT scenarios. The quantitative survey was completed as a web-based application. **Main Outcome Measures:** The Delphi study resulted in the development of the Quality Affirmation Theory (QAT). It depicts care, communication, commitment, and integrity as sub-constructs of affective traits and knowledge as a sub-construct of effective traits in quality ATs. The QAT descriptors were quantitatively assessed using the Quality Athletic Trainer Questionnaire (QATQ). The QATQ is comprised of a semantic differential contrasting adjectives called the Quality Athletic Trainer Scale (QATS) and typical day scenario vignettes called the Quality Athletic Trainer Dilemmas (QATD). **Results:** QATQ summative scores were (M=

101.08±21.24). The QATS ($p=.949$) and the QATD ($p=.764$) indicate homogeneity of the instrument providing measures of validity. Sub-construct factor analysis and internal consistency demonstrated a cohesive measure of the construct quality. The independent variables did not predict summative scores of the QATQ indicating that participants expressed attitudes favoring the positive adjective descriptors of quality regardless of age, sex, years of experience, or educational level. **Conclusion:** This study is a starting point on development of a global understanding of a quality ATC. The study identified important aspects of quality. Further assessment of how these constructs will impact an athletic trainers ability to balance their professional lives with personal lives while providing quality care to patients is warranted.

The Professional Socialization Experiences Of Athletic Trainers In The Clinical Context

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Context: Compared to other sports medicine contexts like the secondary school, athletic trainers (ATs) in a clinical setting find themselves interacting with many other health professionals (e.g. physical therapists) on multidisciplinary teams to provide patient services. **Objective:** To gain insight and understanding about the organizational socialization of ATs working in multidisciplinary, clinical settings. **Design:** Qualitative study using iterative, asynchronous electronic interview questions and follow-up, oral interviews. **Setting:** Clinical environment. **Patients or Other Participants:** 52 (27 female; 24 male; 1 undisclosed) ATs aged 36.6±9.8 with 6.9±7.7 years of experience in their current role. **Data Collection and Analysis:** In-depth interviews were conducted with all participants and 10

individuals participated in follow-up phone interviews. Textual data was analyzed using inductive content analysis. Trustworthiness was established with member checks during the phone interviews and peer debriefing. **Results:** Four themes emerged from this study: 1) AT role in multidisciplinary relationships, 2) wide ranging socialization experiences, 3) perceived improvement of patient outcomes, and 4) factors associated with interpersonal conflict. The first theme, *AT role in multidisciplinary relationships*, consisted of two lower order themes: a) ATs as integral team member, and b) ATs with a relegated role. The majority of participants articulated a team approach with the AT playing a key role in patient care. A smaller portion of the participants had roles whereby they were consigned to assist, support, or aide the roles of other health care providers. The second theme, *wide ranging socialization experiences*, relates to how ATs were oriented to their role in the clinical setting during their induction period. The majority experienced very informal induction processes. Others experienced either a formal or semi-formal induction process. The theme *improved patient outcomes* resulted from participants articulating that working in a multidisciplinary environment expanded their knowledge, skill, and treatment options, and subsequently improved patient care outcomes. Although many positive interactions between ATs and other professionals were noted, the last theme, *factors associated with interpersonal conflict*, identified lack of respect from others, different treatment philosophies, and turf wars as reasons that caused conflict within the clinical setting. **Conclusions:** ATs entering a multidisciplinary clinical context can expect to expand their knowledge, skills, and treatment approaches toward improving patient care outcomes. Although many ATs will work as an integral team member, some may be relegated to assist or support other health care providers and thus, the ATs may not fully employ

their full skill set. Athletic trainers in this setting may experience some level of conflict borne from turf wars, lack of other's understanding of the AT profession, or lack of respect. Because the socialization experiences are largely informal in nature, ATs may have an opportunity to educate others and negotiate the utilization of his/her full level of expertise.

Employment Characteristics Predict Presence Of Team Physician In Secondary School Athletic Training Practice Setting
Huxel Bliven K, Parsons JT, Bay RC, Snyder AR, Lam KC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Emphasis on the practice of secondary school athletic trainers (SSATs) has increased due to intensified scrutiny of injury in high school athletes. Characteristics of the secondary school (SS) practice setting remain unknown, including compliance with practice standards. For example, supervision/direction from a team physician is a common legal requirement and BOC standard of practice. However, the level of SSAT compliance with the team physician supervision/direction requirement is unknown. **Objective:** 1) To determine SSAT compliance levels with the team physician supervision/direction requirement, 2) to identify employment-setting variables that predict compliance. **Design:** Cross-sectional, survey. **Setting:** Web-based survey of U.S. SSs with an athletic trainer. **Patients or Other Participants:** Of the 6875 NATA members working in the SS setting, a voluntary sample of 4024 (58.5%) responded to the survey. 3381 of those respondents (84.0%) answered the survey questions necessary to complete this analysis (Male=1749; Female=1632, Age=35.7 ±9.9yrs). **Interventions:** The National Sports Safety in Secondary Schools Benchmark Study (N4SB) survey was developed by an expert panel and includes demographic, practice, and school-related questions relevant to the SS setting. A mixed sampling strategy targeted 17000+ NATA members to ensure reaching ATs who might work in a SS setting. The independent variables were: time certified (≤5 yrs, 6-15 yrs, ≥16 yrs), practicing with state-regulation (yes, no), type of SS (public, public charter, private-independent, private-parochial, combination, other), school enrollment (≤1000 students,

1001-3000 students, ≥3001 students), presence of football (yes, no). **Main Outcome Measures:** The dependent variable was SSAT compliance with the team physician supervision/direction requirement (yes or no). A frequency analysis was used to determine compliance and a simultaneous logistic regression was used to identify variables associated with compliance. Alpha was set at ≤0.05, two-tailed. **Results:** 88.9% (2975/3347) of SSATs reported practicing with team physician supervision/direction, while 11.1% (372/3347) practiced without team physician supervision/direction. SSATs who were more likely to practice with the supervision/direction of a team physician are those: with BOC certification ≥6 years [6-11 yrs: p=0.002, OR=1.51, 95% C.I. (1.16 to 1.95); ≥16 yrs: p<0.001, OR=1.68, 95% C.I. (1.26 to 2.32)]; with state-regulated practices [p<0.001, OR=3.05, 95% C.I. (2.23 to 4.12)]; who work in a private SS (independent or parochial) [private-independent: p=0.006, OR=2.61, 95% C.I. (1.31 to 5.18); private-parochial: p<0.001, OR=2.16, 95% C.I. (1.49 to 3.13)]; in a SS with ≥1001 students [1001-3000 students: p<.001, OR=2.36, 95% C.I. (1.85 to 3.00); ≥3001 students: p<0.001, OR=3.79, 95% C.I. (1.94 to 7.39)]; and whose SS sponsors football [p<0.001, OR=3.36, 95% C.I. (2.05 to 5.50)]. **Conclusions:** Most SSATs comply with the team physician supervision/direction requirement, although a large percentage does not. The identified employment-setting characteristics that uniquely predict a SSAT's compliance may be used to identify and support those at increased risk for violating laws and practice standards.

Personal And School Characteristics Predict The Employment Model Of Secondary School Athletic Trainers
Nicollelo T, Parsons JT, Huxel Bliven K, Bay RC, Snyder AR, Lam KC, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Interest in the practice of secondary school athletic trainers (SSATs) has increased because of public attention regarding high school sports injuries, but the characteristics of this practice setting have rarely been studied. For example, the two most common employment models for SSATs are direct employment by a school/school district or outreach services provided by a third party. However, little is known about the frequency of these employment arrangements models, or the factors that might predict them. **Objective:** To identify the frequency of the direct and outreach SSAT employment models and the predictors of those models. **Design:** Cross-sectional survey. **Setting:** Web-based survey of U.S. secondary schools with an athletic trainer. **Patients or Other Participants:** Of the 6,875 NATA members working in the secondary school (SS) setting, a voluntary sample of 4,024 (58.5%) responded to the survey. 3,356 (83.4%) of those respondents completed the survey questions necessary to complete this analysis [Male=1,728 (51.5%); Female=1,628 (48.5%) Age=35.8±9.9 years]. **Interventions:** The National Sports Safety in Secondary Schools Benchmark Study (N4SB) survey was developed by an expert panel and includes personal demographic, school demographic, and practice characteristics questions. A mixed sampling strategy targeted 17,000+ NATA members to ensure reaching those ATs who might work in a SS setting. The independent variables were: highest level of education, length of time certified, state regulatory status, type of school, school enrollment, and football sponsored by SS. **Main Outcome Measures:** The dependent

variable was employment model (dichotomous: direct employment vs. outreach). A frequency analysis was used to determine employment model frequency and simultaneous logistic regression was used to identify variables predictive of SSAT employment models. Alpha was $p=0.05$, two-tailed. **Results:** 2,377 (72.5%) respondents reported direct employment by a school or school district. The following variables significantly ($p<.04$ level) reduced the odds of outreach employment: level of education [doctoral degree: RO=0.211, 95% C.I. (.050 to .890)]; years certified [6-15 years: RO=.578, 95% CI (.480 to .694); 16+ years: RO=.339, 95% CI (.274 to .420)]; type of school [charter: RO=.427, 95% CI (.205 to .889); private-independent: RO=.235, 95% CI (.125 to .440); private-parochial: RO=.544, 95% CI (.417 to .710)]; school enrollment [1,000-3,000: RO=.589, 95% CI (.496 to .699); >3,000: RO=.540, 95% CI (.368 to .792)]. Having an additional professional degree ($p=.024$, RO=2.95, 95% CI (1.153 to 7.556) increased the odds of outreach employment. **Conclusions:** Most SSATs are directly employed by school/school districts. Doctorally degreed, experienced ATs working in charter or private schools with larger enrollments are less likely to be employed through an outreach model than lesser educated, novice ATs working in small, public schools. Strategic marketing efforts for AT employment in the SS setting may benefit from this information. Implications for job stability and salary / benefit compensation should be investigated.

Free Communications, Thematic Poster: General Medical Conditions

Tuesday, June 21, 2011, 4:30PM-6:15PM, Room 219; Moderator: Matt McQueen, MD

Tachycardia And Dizziness In A Collegiate Track Athlete With Attention Deficit Disorder

Hart CH, Bernhardt DT: University of Wisconsin, Madison, WI

Background: The athlete is a 19-year-old sophomore male hurdler with the track team. During the summer between his first and second years of college, he sought evaluation at home for his lack of focus and difficulty concentrating. Testing revealed that he had Attention Deficit Disorder (ADD) and was treated with Adderall 20mg. When he was seen by a team physician to document his condition and the use of stimulants, he also reported episodes of dizziness and tunnel vision associated with a series of 30-yd sprints with 2 min rest. He denied chest pain and syncope. He had a history of trivial pulmonic stenosis which resolved as an infant. BP prior to the start of school was 127/82. An examination was not performed by the athletic trainer as the athlete presented this to the team physician when discussing ADD medications. **Differential Diagnosis:** The differential diagnosis included abnormal response to Adderall, anxiety, exercise-induced atypical migraine, and cardiac arrhythmia. **Treatment:** On physician examination, his blood pressure was 127/82 with an elevated resting heart rate of 100 bpm. Resting EKG and complete echocardiogram were unremarkable. Lab values for TSH, Free T4 and CBC were within normal limits. With an exercise stress test he had normal HR (200 bpm) and BP (180/60) elevation with no symptoms. The test lasted 10:56 and was terminated due to fatigue. While wearing a 24 hr Holter monitor, an episode of sinus tachycardia with HR of 200 bpm was recorded. He then received a 30-day event recorder which recorded an event during practice associated with dizziness and narrowed vision and a pulse 178-200 bpm. A second event associated with palpitations and a

resting HR of 102-137 was also recorded and interpreted as sinus tachycardia. While discussing the condition with the athlete's father, it was revealed that the athlete had a brother with similar symptoms who was successfully treated with a beta-blocker. A few weeks later, the Adderall was withheld and the exercise stress test was repeated. At rest, he had a pulse of 96 and BP of 122/70. During the test he had appropriate BP and HR responses (200 bpm; 182/78) but did experience symptoms prior to stopping the test due to fatigue. His symptoms continued over 2 minutes after exercise cessation. Recovery HR was 102 bpm with BP of 122/80. The diagnosis was exercise-related inappropriate sinus tachycardia syndrome. The Adderall was ruled out as a cause of the tachycardia. He was placed on propranolol 20 mg daily. He had no further episodes of symptoms. Within 2 months, he decided to discontinue his participation in athletics partly because of the condition and the medication. **Uniqueness:** This case is unique in that the presence of the stimulants clouded the picture, as the initiation of stimulant therapy coincided with the initial presentation of these symptoms. Another unique feature is that the athlete's sibling had a similar condition. **Conclusions:** An otherwise healthy 19 year old male presents with tachycardia, dizziness and tunnel vision during exercise after starting stimulant therapy for ADD. The stimulants and other serious cardiac conditions were ruled out as the cause of the symptoms. He continued to use stimulants and was placed on propranolol. As the use of stimulants for treatment of ADD becomes more prevalent, it is important for athletic trainers to be aware of the possibility of adverse reactions these medications may cause in our athletes. It is also important to be vigilant for serious cardiac conditions.

Gluten Intolerance In A Female Triathlete: A Case Report

Detwiler K: University of La Verne, La Verne, CA

Background: This case describes a 23-year-old female triathlete and certified athletic trainer (AT) with a history of scoliosis and a family history of celiac disease (CD). The athlete's chief complaint was achy diffuse lower back pain (LBP) that regularly woke her while sleeping. There was no mechanism of injury or change in activity. Her triathlon training did not affect her symptoms; however prolonged sitting and inactivity seemed to increase her pain. The athlete had normal AROM and full strength of the trunk and weakness of the right hip abductors and scapular stabilizers. The athlete was tender to palpation over the thoracic and lumbar musculature, but was not tender over the spine. The slump test was positive on the right leg. The straight leg raise test, valsava test, quadrant test, and stork standing test were all negative. Her neurological exam was normal. Several months after the athlete began experiencing LBP, she began noticing intermittent abdominal cramping, occasional poor appetite, frequent gas, and loosely formed bowel movements. The athlete did not experience any nausea, fever, or sudden weight loss/gain. The athlete denied camping, traveling, or taking any new medication. **Differential Diagnosis:** LBP: possible disk pathology or worsening scoliosis. Digestive symptoms: irritable bowel syndrome (IBS), rule out celiac disease. **Treatment:** The athlete, also a certified athletic trainer (AT), started self-treatment, but when symptoms continued to worsen, she saw her physician and was diagnosed with "lower back pain." She was referred for further rehabilitation. The athlete demonstrated improvement of symptoms, up to 75% at times, and

improved core strength and scapular stabilization. Rehabilitation was discontinued and the patient continued self-treatment as needed. During this time, the athlete also saw her physician for her digestive symptoms. The physician ordered blood work to check for celiac disease. The results were normal other than a slightly elevated IgG antibody level. Due to the grandmother's history of celiac disease and the elevated IgG, the athlete was referred to a gastroenterologist. An upper endoscopy, a duodenal biopsy, and blood tests to check thyroid levels were ordered. The results of these tests were normal, and celiac disease was ruled out. The athlete was diagnosed with IBS. After two years of continued and worsening LBP and insidious onset of right hip pain, the athlete visited a Doctor of Osteopathy (DO) who treated her with manual therapy for three weeks with no improvement. The DO questioned the athlete about menstrual or digestive irregularities, and her previous history was discussed. A two-week trial of a gluten-free diet (GFD) was recommended, and upon return to the DO two weeks later, the athlete reported that her LBP and digestive symptoms had completely resolved. After a follow-up visit one month later, still symptom free, the athlete was diagnosed with gluten sensitivity/intolerance (GS), was discharged, and was advised to continue the GFD. **Uniqueness:** This athlete was experiencing significant LBP which completely resolved after a modification of her diet. It is unusual that diet would be the primary cause of LBP, and this should be of interest to ATs who treat athletes with LBP that does not respond to traditional treatment. **Conclusions:** Should the AT have an athlete who is experiencing chronic pain that does not resolve with the traditional treatment methods, it may be important to ask the athlete about any digestive symptoms, or ask about a family history of CD or GS. If present, GS or CD should be considered. Individuals with GS have

significant dietary limitations, and a knowledgeable AT can assist the athlete in avoiding gluten in the diet, which will improve the athlete's quality of life and athletic performance.

Breathing Difficulty In A High School Athlete

Terhune W, Patel R, Danov Z, Bezold L: University of Kentucky, Lexington, KY; Woodford County High School, Versailles, KY

Background: This case will be discussing recurrent breathing difficulty in a female high school athlete. She is a 16 year old junior high school athlete competing in track and volleyball. The athlete stated that she was experiencing problems while running races during the spring track season. She says that while running a race she began to experience tightness in her chest, numbness and tingling in the arms and hands, and that her throat closes up. The athlete states that by the end of the race she could not breathe and collapsed upon reaching the finish line. The symptoms began around the 100 yard mark and progressed through the finish line (400 yard mark). She reports that she would experience an occasional panic anxiety caused by the difficulty breathing. The athlete was able to recover after a few minutes of rest, but complained of body ache, a headache and a lethargic feeling. The athlete stated that she experienced the same signs and symptoms during her 8th grade track season. She also states that during the recent volleyball season the symptoms would return after doing seven to eight conditioning sprints or while sprinting up the bleachers. She said that when the symptoms did occur during the volleyball season, she was able to recover much faster and without the body aches and lethargy. She does suffer from numerous seasonal allergies as well as animal allergies. **Differential Diagnosis:** Seasonal allergies, exercise induced asthma, laryngopharyngeal reflux, paradoxical vocal fold motion

Treatment: The athlete was prescribed inhalers beginning in eighth grade. She used Advair, Singulair and Albuterol with no effect. She has not been tested or treated for her seasonal allergies. An EKG stress was normal as were a lung function test and ultrasound. A nasal endoscopic examination was performed revealing mild anterior adductor movement of the vocal folds during rest breathing. When shortness of breath was reproduced, complete closure of the true and false vocal folds was observed. Exercises to relieve paradoxical vocal fold motion resulted in an open airway. The patient was given the Reflux Severity Index and scored a 28. Using the Reflux Symptom Index any score over 13 indicates a positive finding for laryngopharyngeal reflux. Using biofeedback of the open airway, the athlete was instructed to achieve an open airway with open throat breathing. The athlete was also instructed in rescue breathing exercise and abdominal breathing excises. She was given a home exercise program to be performed daily and during times when she has an elevated heart rate. The athlete was referred back to her family doctor for allergy testing and treatment. **Uniqueness:** Unfortunately Paradoxical vocal fold motion is often misdiagnosed as asthma or exercise induced asthma. One study showed that 10% of the patients diagnosed with asthma were actually found to have PVFM and an additional 30% were found to have PVFM combined with asthma. Yet another study of 164 patients undergoing rhino-laryngoscopy for any reason found that 20% of the females had PVFM. **Conclusion:** Currently the athlete is symptom free and continues to perform her breathing exercises with no complaints. PVFM is often misdiagnosed as asthma or exercise induced asthma resulting in inappropriate treatment with asthma medication often for long periods of time without symptom relief. PVFM has been shown to occur in a wide range of athletes and is not sport specific.

Certified athletic trainers must be more cognizant of its signs and symptoms to help expedite the diagnosis and treatment.

Vocal Cord Dysfunction In A High School Football Player

MacDonald A, Hosey R, Kanga J: University of Kentucky Orthopaedic Surgery & Sports Medicine, Lexington, KY, and University of Kentucky Pediatric Pulmonology, Lexington, KY

Background: A seventeen year-old Caucasian male twelfth grader was participating in summer football camp two-a-day practices. During the early stages of each practice, the athlete would report difficulty getting air into his lungs with associated complaints of dizziness, blurred vision, and a general loss of energy. The athlete would spend time away from drills for unspecified amounts of time with each episode, and then return to practice until breathing difficulties returned. The athlete tested for a variety of different allergies, which had all returned negative. A cardiology workup had also returned negative. The athlete had received an albuterol inhaler from his family physician who was treating the athlete for asthma, however the albuterol had little to no effect. The athlete began receiving physical therapy for spinal alignment, which also had little to no effect on the breathing difficulty. The parents were finally able to schedule an appointment with a pulmonologist who specialized in working with athletes. **Differential diagnosis:** asthma, exercise induced asthma, vocal cord dysfunction, anxiety, seasonal allergies, general allergies. **Treatment:** The athlete received attention by the pulmonologist who, after ruling out a pneumothorax or pleural effusion through x-ray, referred the athlete to a sports medicine specialist to rule out musculo-skeletal issues. After musculo-skeletal issues were dismissed, the pulmonologist then referred the athlete onto a speech therapist. The speech therapist was

clinically able to recreate the symptoms; therefore able to diagnose the athlete with vocal cord dysfunction and laryngopharyngeal reflux. The athlete accepted a series of breathing exercises to do before and after practice and instructed on proper breathing technique during labored breathing. **Uniqueness:** Vocal cord dysfunction, classified as a rare disorder, affects one in two-thousand people. It estimated that some forty percent of diagnosed athletes with exercise-induced asthma might in fact suffer from vocal cord dysfunction. The disorder in this case was very frustrating for the athlete and his family. They had visited numerous health professionals with no resolution of symptoms. Being able to pinpoint the issue was a huge relief to the athlete and his family. **Conclusion:** The breathing exercises did help the athlete return to more uninterrupted play, they did not, however, stop the episodes in their entirety. The athlete still suffered two to three episodes per week and did have to miss practice time, although not as much as prior to being diagnosed. The athlete is hopeful that by doing the exercises in the winter, he can have an unimpeded senior year of lacrosse in the spring.

Grade Three Liver Laceration In An Intercollegiate Volleyball Player: A Case Report

Milton AE, Hansen PJ, Miller KC, Rhee YS: North Dakota State University, Fargo, ND

Background: A 20 year old, female collegiate volleyball athlete (body mass=74.8 kg; height=177.8 cm), with no previous history of abdominal injury, dove for a ball and was struck in the anterolateral abdominal region during a match by a teammate's knee. She experienced a solar plexus spasm, shortness of breath, and nausea. She was assisted off the court by the Athletic Trainer. On-site evaluation revealed sharp pain in the right upper quadrant and epigastric area, pallor, continued nausea, and excessive

sweating. No radiating pain was noted, but anterior and lateral compression tests of the ribs were positive for pain and crepitus. An ice bag was administered to the right abdominal region and she was transported to the local emergency department. **Differential Diagnosis:** Rib fracture, xiphoid process fracture, costochondral separation, splenic injury, and/or solar plexus injury. **Treatment:** Upon arrival to the emergency department, an abdominal/pelvic CT scan with IV contrast, complete blood count including platelets, Basic Panel 8, and a prothrombin time/International Normalized Ratio (PTINR) tests were ordered. The abdominal/pelvic CT scan showed a small amount of fluid along the posteromedial surface of the liver indicating a subcapsular hematoma. A trace amount of free fluid in the right paracolic gutter and pelvis was also noted suggesting a hemoperitoneum. The athlete was diagnosed with a Grade 3 laceration (>3 cm parenchymal depth) on the right lobe of the liver. She was hemodynamically stable although potassium and bicarbonate were low and glucose was high (potassium, 3.1 mmol/L [normal=3.5-5.3 mmol/L]; bicarbonate, 22 mmol/L [normal= 23-32 mmol/L]; glucose, 132 mg/dL [normal=70-100 mg/dl]). Her vitals were stable approximately 2.5 hours post-injury (BP, 118/76 mm Hg; HR, 68/min; RR, 16/min; tympanic temperature, 36.3°C). The athlete was admitted into the ICU for observation and the attending physician decided on a conservative, non-operative approach to treatment. Forty-eight hours post-injury, a second abdominal/pelvic CT scan and blood work was performed and showed that the athlete was stable. She was admitted for an additional 2 days for observation. After being discharged from the hospital, she was prohibited from practicing until a third abdominal/pelvic CT scan was performed and showed no residual injury to the liver (5 weeks post-injury). The physician cleared the athlete to begin a progressive rehabilitation protocol focusing on cardiorespiratory and low intensity sport-specific exercise. The

athlete returned to play 6 weeks post-injury without complications; however, she continued performing rehabilitation focusing on cardiorespiratory endurance. **Uniqueness:** Blunt abdominal injuries are rare in non-contact sports such as volleyball. Abdominal injury rates in volleyball competitions occur 0.04 per 1,000 athlete exposures and are usually muscular strains. Contact and collision sports have a higher risk of blunt abdominal trauma, which would include liver injuries. **Conclusions:** Blunt abdominal injuries, such as liver lacerations, can occur to any athlete regardless of sport. Athletic Trainers working with non-contact sports must be cognizant that abdominal injuries can occur and can be life threatening. Proper recognition of the signs and symptoms of internal organ injuries, like liver lacerations, and the administration of proper emergency care are critical. If the athlete is hemodynamically stable, a conservative non-operative approach following a liver laceration yields successful results.

Supraventricular Tachycardia (SVT) In A College Female Basketball Athlete

St Julian C, Bobo L, McCary L:
Stephen F. Austin State University,
Nacogdoches, TX

Background: A 22 year old female NCAA Division 1 basketball player sustained a cranial concussion with seizure during a 2010 spring basketball game. A full return to activity was permitted weeks later after physician evaluation and absence of symptoms with and without activity. Hypertension was a secondary diagnosis from this concussion. In the beginning of the following basketball season, the athlete reported to the athletic trainer of pounding chest, difficulty breathing, and dizziness after running in a practice session. Complaints of short bouts of “heart racing” continued to the next day throughout daily activities. Referral to the team physician followed, where a heart murmur was suspected. The

athlete was removed from activity for a week with continued reports of one to two spells with associated palpitations, dyspnea, and chest tightness. No episodes of syncope or near syncope were stated, and there were no alleviating or provoking factors. Referral to a local cardiologist was recommended for further cardiac evaluation. The cardiologist performed an echocardiogram, ultrasound, and placed the athlete on a Holter monitor for 24 hours. Spells of tachycardia with abrupt onset and termination with rates in the 180s and 190s were recorded from the Holter monitor. **Differential Diagnosis:** Heart murmur, Paroxysmal atrial tachycardia (PAT), paroxysmal supraventricular tachycardia (PSVT). **Treatment:** Treatment options were discussed in depth with the patient. Options included pharmacologic suppression or an electrophysiologic (EP) study with radiofrequency catheter ablation. With the third referral, a cardiac electrophysiologist recommended the EP study as a preferred approach with pharmacological suppression as a second-line option. The patient elected for the EP study; it was performed within the week. Localization of arrhythmia was unable to be found during the procedure, so radiofrequency energy was not used. The pharmacologic suppression option was then placed in effect. Hypertensive medication was changed to a beta-blocker as to not to interfere with the new medication. The patient was released from the hospital on the same day as the EP procedure. No activity was permitted for two days. Progressive return to play was implemented with full return to play with no limitations a week later. **Uniqueness:** Supraventricular tachycardia is rarely experienced in young elite athletes. It is also uncommon to be unable to localize an arrhythmia spot. The cranial concussion experienced months before could have opened the door for such conditions to have occurred. **Conclusion:** This case presents symptoms, diagnostic testing, and treatment options for supraventricular

tachycardia, as well as possible predisposing contributing factors.

Ewings’ Sarcoma In A Junior High School Football Player

Bobo L, Tate A: Magnolia West High School, Magnolia, TX; Stephen F. Austin State University, Nacogdoches, TX

Background: A 14 year old male sustained an injury to his right shoulder during a junior high school football game during the fall of 2008. Upon an initial side-line evaluation, the athlete reported with full ranges of motion, normal strength, and only reported of tenderness around the point of impact on his upper humerus. An ice bag was provided to him post-competition. The athlete was still complaining of arm pain the next day that prompted his parents to make an appointment with the family physician who ordered x-ray images of his shoulder. It was then that a tumor was discovered on the upper right humerus. **Differential Diagnosis:** Pathologic fracture, fracture, tackler’s exostosis, bone and/or soft tissue contusion, periosteal contusion. **Treatment:** With an immediate referral, the family traveled to MD Anderson’s Children’s Cancer Hospital where he was diagnosed with Ewings’ sarcoma, a type of bone cancer. The patient’s right humerus was removed and replaced with a cadaver bone. To prevent movement, the patient was placed in a full-body cast with his shoulder immobilized at a right angle. Throughout his convalescing, chemotherapy was being administered and he continued to attend school. Because Ewing’s sarcoma can spread to the lungs, the patient has since had 15 small tumors removed from both lungs. **Uniqueness:** Ewing’s sarcoma usually presents with few symptoms. Pain and occasional swelling at the site of the tumor are common, along with the patient being febrile. Sometimes a “pathologic fracture,” or a break in the bone at the site of the tumor can lead to its discovery. This type of bone cancer usually develops during puberty and

is 10 times as common in Caucasian children as in African-American, African, and Asian children. The bone tumors may arise anywhere, but tend to be located in the long bones of the arms and legs, the pelvis, or the chest. Metastasis occurs to the lungs and other bones occurring in approximately one-third of diagnosed children. **Conclusion:** An early diagnosis of this cancer can increase the possibility of a favorable outcome.

Shoulder Pain In An Adolescent Male

Jacobs D, Ireland ML, Schwartz HS: University of Kentucky, Lexington, KY, and Vanderbilt University, Nashville, TN

Background: A twelve year old male soccer player was referred to the sports medicine clinic with pain and numbness down his left arm after performing soccer throw-ins. Upon initial evaluation he had no pain with palpation over the left AC joint and upper humerus, however, there was fullness noted in the left axilla, which was firm and tender upon palpation. Further evaluation revealed full ROM, no pain with a positive apprehension test, and all other special tests negative.

Differential Diagnosis: Bursitis, cyst, neurofibroma, or synovial cell sarcoma.

Treatment: X-rays revealed no boney abnormalities, but radiolucency on the left shoulder compared to the right shoulder was noted. An MRI revealed a soft tissue mass anterior that did not enter the glenoid humeral joint. The implications of the mass were discussed at length with the patient and his parents, and it was recommended an orthopaedic oncologist evaluate him. The oncologist recommended excision of the mass to rule out a sarcoma. A CT of his chest, abdomen, and pelvis were also performed to rule out other possible masses. Following operative tumor resection, the biopsy revealed synovial cell sarcoma. The treatment for synovial cell sarcoma consisted of four cycles of chemotherapy and repeat x-rays, MRI and CT scans every three months. Four

months following the initial surgery, a second surgery was required. The second surgical procedure revealed a mass 20% large than the mass removed during the first surgery. This mass was negative for residual sarcoma and four more cycles of chemotherapy were prescribed. Three months following the second surgery, the patient had full ROM of his left shoulder with discomfort and atrophy of his deltoid, pectoralis and trapezius muscles, and rotator cuff weakness. Diagnostic tests were negative. Rehabilitation consisted of total body conditioning emphasizing core strength, trapezius and rotator cuff strengthening while limiting aggressive passive ROM. Four months after the second surgery the patient returned to full activity with no serious side effects from the chemotherapy. He remained under the care of the sports medicine physician for 3 years with the chief complaint being limited range of motion in his left shoulder. At this time a MRI revealed osteonecrosis of the humeral head with no evidence of the return of the sarcoma. Six months later a post-op series of MRIs revealed a growing lesion located approximately 5 cm below the tip of the acromion. X-rays of shoulder and chest were normal. He underwent another surgery to rule out bone metastases. A dime size osteotomy was performed on the proximal humerus and sent to pathology. The defect was filled with polymethyl cement, irrigated and closed in layers. The excised tissue was benign. Three months later he returned to the oncologist, where he was released for full activity with the recommendation to continue to do strengthening and stretching exercises. He was also recommended to follow-up yearly with the oncologist. **Uniqueness:** Synovial sarcoma is rare and has a poor prognosis. It occurs mostly in adolescent males and is often missed diagnosed as it mimics other common injuries and is slow in developing. Half of the patients diagnosed will metastasize within two years following initial treatment. **Conclusion:** Early detection of synovial cell sarcoma is important for

successful outcomes. Furthermore, continued radiology testing is necessary to monitor treatment success. In addition to treating the disease pathology, it is important to address any function deficits, such as weakness or loss of ROM, which may occur secondary to chemotherapy.

Free Communications, Oral Presentations: Intervention for Chronic Ankle Instability

Wednesday, June 22, 2011, 8:00AM-9:00AM, Room 219; Moderator: Patrick McKeon, PhD, ATC

Effects Of Ankle Bracing And Stability On Linear And Non-Linear Measures Of Postural Control

Zinder SM, Goerger BM, Burns M, Padua DA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Postural sway is a very common measure used to investigate balance deficits following ankle injury. Practitioners commonly utilize ankle braces in an attempt to minimize the effect of these balance deficits. Traditional linear measures of postural sway have often failed to elucidate significant differences. Approximate entropy, a non-linear measure of signal complexity, has shown promise as a more sensitive measure of postural control. **Objective:** To investigate the effects of ankle bracing on postural control in subjects with stable ankles and subjects exhibiting chronic ankle instability with both linear and non-linear measures. **Design:** A repeated measures pre-post test design. **Setting:** Controlled, laboratory setting. **Patients or Other Participants:** Twenty-eight subjects (14 stable, age = 26.19±6.46 yrs, height = 166.07±12.90 cm, mass = 69.90±13.46 kg; and 14 chronically unstable, age = 23.76±5.82 yrs, height = 174.00±11.67 cm, mass = 68.61±13.12 kg) participated in this study. **Interventions:** Subjects completed four 30-second trials of single leg static balance with eyes open in each of three ankle bracing conditions: no brace (NB), lace-up brace (LU), and semi-rigid brace (SR). All testing was performed on a force platform. **Main Outcome Measures:** Linear measures of sway area (SA), sway path (SP), and sway velocity (SV) along with non-linear measures of approximate entropy (ApEn) in the anterior/posterior (AP) and medial/lateral (ML) directions. **Results:** No differences were found for brace condition (SA: $P=0.142$, SP:

$P=0.289$, SV: $P=0.295$), stability level (SA: $P=0.144$, SP: $P=0.784$, SV: $P=0.788$), or in the brace by stability interaction (SA: $P=0.668$, SP: $P=0.599$, SV: $P=0.592$) on any of the linear measures of postural sway. Significant differences were found in ApEn in the AP direction for brace (NB: $0.30±0.07$, LU: $0.26±0.07$, SR: $0.26±0.06$; $P=0.001$), and in the brace by stability interaction (stable-NB: $0.30±0.06$, stable-LU: $0.25±0.06$, stable-SR: $0.27±0.06$; unstable-NB: $0.30±0.09$, unstable-LU: $0.27±0.07$, unstable-SR: $0.25±0.06$; $P=0.018$). No differences were found for brace condition ($P=0.648$), stability level ($P=0.889$) or in the brace by stability interaction ($P=0.163$) for ApEn in the ML direction. **Conclusions:** While significant differences across brace conditions did exist, specifically in the AP direction, they were only evident when examined via the non-linear measure of approximate entropy. This suggests that ApEn is a more sensitive measure of postural control than traditional linear measures. The two braced conditions constrained the system (lower ApEn score) to a much greater extent than the no brace condition. Contrary to intuitive thought, an over constrained postural control system may be less able to adapt to a particular task or environmental change. In future studies, investigators should consider supplementing the standard measures of postural stability with measures of signal complexity, such as approximate entropy, to determine the state of the postural control system.

Pain Reduction After A Single Bout Of Posterior Talocrural Joint Mobilizations In Acute Ankle Sprain Patients

Cosby NI, Grindstaff TL, Parente W, Hertel J: University of Virginia, Charlottesville, VA, and Creighton University, Omaha, NE

Context: During the acute phase of an ankle sprain, rest, ice, compression and elevation are advocated to reduce swelling and pain. Additionally, clinicians commonly use passive joint mobilizations to reduce pain through modulation of stimulating mechanoreceptors and altering afferent input. Passive joint mobilizations have been reported to relieve pain and improve function in patients with ankle sprain, however little evidence exists on the immediate effects of a single application of joint mobilization and pain relief. **Objective:** To examine the effects of a single bout of AP joint mobilization on pain perception in individuals with an acute lateral ankle sprain. **Design:** Single-blinded, randomized controlled clinical trial. **Setting:** Laboratory. **Subjects:** Seventeen physically active individuals (8 control, 9 treatment, mean age 19.76±1.35 years, mean height 69.10±4.31 cm, and mean mass 71.34±16.45 kg) with mild acute lateral ankle sprains participated. Subjects were immobilized for a minimum of three, but a maximum of seven, days, and had an average of a $6.5°±1.33°$ dorsiflexion ROM deficit compared to the contralateral limb. **Intervention(s):** The treatment group received a single 30-second bout of Grade III AP joint mobilization on the day their immobilization device was removed, while the control group did not receive joint mobilization or physical contact. **Main Outcome Measures:** Self-reported pain as assessed with the pain subscale embedded in the Foot and Ankle Disability Index Activities for Daily

Living (FADI-ADL) scale was assessed at baseline and 24 hours after the receipt of the treatment or control interventions. The FADI pain scale consists of 4 items related to the subject's perception of pain at rest and during ADLs. Each item is scored from 0 (none) to 4 (unbearable), with lower scores within this subscale indicating decreased pain perception. The total scores on the 4 items are converted to a percentage, with a 100% representing no pain. A 2x2 (group by time) repeated measures ANOVA was run to determine the immediate effects of grade III AP talocrural joint mobilizations on pain perception, using the pain subscale components of the FADI-ADL. Pairwise comparisons were conducted as post hoc analyses. **Results:** There was a significant group by time interaction ($p=0.04$). Pain values were significantly reduced in the treatment group ($pre=72.22\pm 10.87\%$, 24 hours $post=84.03\pm 14.36\%$, $p=0.01$), while there was not a significant change in the control group ($pre=81.25\pm 14.94\%$, 24 hours $post=80.47\pm 7.04\%$, $p=0.87$). **Conclusion:** Our findings suggest that a single 30-second bout of grade III AP talocrural joint mobilizations was effective at reducing pain over a 24 hour period in patients with mild acute ankle sprains.

The Influence Of Vestibular-Ocular Reflex Training On Postural Stability, Dynamic Visual Acuity And Gaze Stabilization In Patients With Chronic Ankle Instability

Hilgendorf J, Vela LI, Gobert DV, Harter RA: Department of Health and Human Performance and Department of Physical Therapy, Texas State University, San Marcos, TX

Context: The vestibular-ocular reflex (VOR) is a low latency, reflexive eye movement that allows the eyes to compensate for head rotation in order to stabilize gaze during the movement. The VOR is important during physical activity because it is initiated each time the head starts to move, and causes the

eyes to move in the opposite direction of the head so that the intended image can be centered on the fovea of the eye.

Objectives: To compare the ability of traditional and VOR-enhanced rehabilitation protocols to improve postural stability, dynamic visual acuity and gaze stabilization among chronic ankle instability (CAI) patients.

Design: Randomized controlled trial.

Setting: Research laboratory setting.

Participants: 16 physically-active women and men (age, 22.2 ± 1.5 yrs; hgt, 171.1 ± 7.0 cm; mass, 73.9 ± 18.3 kg) with unilateral CAI, defined as a history of at least two ankle sprains on the same ankle and self-reported feelings of giving way. Participants were free of any neurological or vestibular impairments.

Interventions: Subjects were randomly assigned to 1 of 2 treatments: Traditional rehabilitation group (TRADITIONAL) = utilization of a CAI ankle rehabilitation protocol modified from McKeon et al. (2009) ($n=8$), or VOR rehabilitation group = the modified McKeon CAI protocol with the addition of head movements incorporated into all exercises ($n=8$). Each patient participated in 3 rehabilitation sessions/week for 4 weeks. The 2 experimental groups were tested on 2 occasions: a pretest (Week 0) and posttest (Week 4); we used a Group (2) x Time (2) mixed factorial ANOVA ($p=0.05$). **Main**

Outcome Measures: Motor control tests (MCT) obtained with the NeuroCom EquiTest™; overall stability indices obtained bilaterally from standard (OSI) and modified (mOSI) Athlete Single Leg Stability Tests with a Biodex BalanceMaster™; dynamic visual acuity (DVA) and gaze stabilization (GST) tests using the NeuroCom inVision™. **Results:** Vertical GST scores in the VOR improved significantly pretest to posttest, 136.0 ± 27.1 to 165.0 ± 11.5 deg/sec compared to TRADITIONAL, 122.2 ± 27.3 to 123.3 ± 16.0 deg/sec ($F(1,14) = 11.02$, $p=0.005$). Significant group differences were also observed for the horizontal DVA test ($p=0.038$). Six of the 9 outcome measures evaluating postural stability, gaze stabilization and dynamic visual acuity

significantly improved from pretest to posttest ($p=0.001$). Of particular interest were the OSI and more challenging mOSI dynamic postural stability tests that improved for both right and left limbs over the 4-week intervention: OSI pretest (8.4 ± 3.4) to posttest (3.1 ± 1.8), $p=0.001$; mOSI pretest (11.7 ± 2.4) to posttest (5.5 ± 1.8), $p=0.001$). **Conclusions:** As hypothesized, subjects in the VOR group demonstrated significantly better scores on the horizontal DVA and vertical GST tests. Both the TRADITIONAL and VOR rehabilitative protocols produced significant changes from pretest to posttest, suggesting that both are effective in improving postural stability, gaze stabilization and dynamic visual acuity in CAI patients.

Noise-Enhanced Balance And Functional Performance In Subjects With Chronic Ankle Instability

Ross SE, Arnold BL, Linens SW, Wright CJ, Moody SA, Treadwell KM, Lavery WK: Virginia Commonwealth University, Richmond, VA

Context: Stochastic resonance stimulation (SRS) administered on the skin over ankle muscles at low subsensory intensities has improved static balance in subjects with chronic ankle instability (CAI). In theory, balance improvements with SRS should transfer to other functional activities, which may facilitate rehabilitation.

Objective: Our objective was to determine static balance and functional performance improvements associated with SRS administered at a customized optimal intensity. **Design:** A two-treatment (SRS_{on} , SRS_{off}) cross-over design. **Setting:** Research laboratory.

Patients or Other Participants: Twelve subjects with CAI (171.83 ± 9.31 cm, 82.31 ± 23.27 kg, 27.00 ± 6.37 yrs) who reported sensations of lateral ankle instability and ankle sprains. Subjects had to score ≤ 27 on the Cumberland Ankle Instability Tool (CAIT) to participate in this study (CAIT = 19.67 ± 3.75). **Interventions:** Sub-

jects first performed a static balance test and then performed 3 functional tests (shuttle run, side hop, figure-of-8 hop) without shoes in a counterbalanced method. Vibrating factors were placed over peroneal, anterior tibialis, gastrocnemius, and posterior tibialis muscles on the leg with CAI. A random noise signal generated in a stimulation unit caused these factors to vibrate. Quiet double leg static balance tests without vision or shoes were performed for 20 seconds on a force plate under a control condition (SRS_{off}) and 4 SRS intensities administered at 25%, 50%, 75%, and 90% of each subject's sensory threshold. Three trials were performed for each condition in a counterbalanced order. The SRS intensity that produced the greatest balance improvement (measured by resultant center-of-pressure velocity) was used as the customized optimal intensity (SRS_{on}) and was compared to the SRS_{off} condition for data analysis. Then, 3 trials for each functional test were performed under each condition (SRS_{on} , SRS_{off}) in a counterbalanced method. The shuttle run required subjects to run quickly to complete a 20 m course. The side hop test required subjects to hop quickly side-to-side 0.3 m on the leg with CAI to complete 10 repetitions. The figure-of-8 hop test required subjects to hop quickly through a 10 m figure-of-8 course on the leg with CAI. A stopwatch measured the time to complete each functional test. One-way paired samples *t*-tests compared SRS_{on} and SRS_{off} conditions ($\alpha=.05$).

Main Outcome Measures: Resultant center-of-pressure velocity (cm/s) and time (s) were dependent measures. Slower velocity and less time were indicative of improved static balance and functional performance, respectively.

Results: SRS_{on} improved static balance ($SRS_{on}=0.99 \pm 0.21$ cm/s, $SRS_{off}=1.14 \pm 0.29$ cm/s; $t_{(11)}=-4.03$, $P=0.001$), shuttle run ($SRS_{on}=8.59 \pm 1.45$ s, $SRS_{off}=9.01 \pm 1.62$ s; $t_{(11)}=-2.68$, $P=0.01$), side hop ($SRS_{on}=8.76 \pm 1.36$ s, $SRS_{off}=10.65 \pm 3.82$ s; $t_{(11)}=-1.89$, $P=0.04$), and

figure-of-8 hop ($SRS_{on}=15.25 \pm 4.62$ s, $SRS_{off}=16.19 \pm 5.36$ s; $t_{(11)}=-1.90$, $P=0.04$).

Conclusions: The customized optimal intensity for SRS that improved static balance also enhanced functional performance in subjects with CAI. SRS had the greatest impact on the side hop test by enhancing functional performance by 18%.

Free Communications, Oral Presentations: Ankle Injury and Postural Control

Wednesday, June 22, 2011, 11:30AM-12:45PM, Room 219; Moderator: Alan Needle, MS, ATC

Ankle Kinematic Variability Is Negatively Correlated With Postural Stability Indices

Brown CN, Bowser B: University of Georgia, Athens, GA, and University of Delaware, Newark, DE

Context: Chronic ankle instability (CAI) is a common outcome following a lateral ankle sprain. Ability to stabilize quickly during landing is compromised in those with CAI, and variability of joint motion may play a role in the ability to stabilize quickly during landing. **Objective:** To determine if measures of coefficient of variation (CV) at the ankle joint are negatively correlated with dynamic postural stability indices (DPSI) during a single leg jump landing. **Design:** Correlational. **Setting:** Biomechanics Laboratory. **Patients or Other Participants:** Eighty-eight volunteer recreational athletes divided into 4 groups. Mechanical ankle instability (MAI): 8 males, 13 females, age 19.9±1.0 years, height 172.5±6.7cm, mass 68.7±8.4 kg; Functional ankle instability (FAI): 11 males, 12 females, age 20.3±1.6 years, height 173.4±9.4 cm, mass 70.7±11.9 kg; Controls: 12 males, 12 females, age 20.0±1.2 years, height 171.1±7.1 cm, mass 65.4±9.8 kg; Copers: 8 males, 12 females, age 20.1±1.1 years, height 173.0±11.0 cm, mass 68.9±10.5 kg. MAI, FAI, and Coper groups reported history of previous moderate-severe ankle sprain. MAI and FAI groups reported ≥2 episodes of ankle instability in the last 12 months. MAI participants had clinically lax lateral ankle ligaments while FAI, Copers, and Control participants did not. **Interventions:** Retroreflective markers were attached to the body using a modified Helen-Hayes marker set. Participants stood 70cm from an in-ground force plate and performed an anterior vertical jump to 50% of their measured maximum. Participants landed on the involved leg and balanced for 3s. A 7-

camera Vicon system (240Hz), synchronized with a forceplate (1200Hz), collected kinematics at the ankle in 3 planes and ground reaction forces. Inverse dynamics were used to calculate kinematic data at the ankle. Pearson R correlations were conducted with $\alpha=0.05$. **Main Outcome Measures:** CV values for ankle motion in 3 planes were calculated during landing and averaged over 10 trials, as were stability indices in the anterior-posterior (APSI), medial-lateral (MLSI), vertical planes (VSI), along with a composite indices (DPSI). The relationship between mean CV values and stability indices in 3 planes and the composite were assessed via bivariate Pearson correlation coefficients. **Results:** Ankle sagittal plane CV was negatively correlated with APSI ($r=-0.33$, $p=0.002$) while ankle frontal plane CV was negatively correlated with VSI and DPSI ($r=-0.24$, $p=0.02$ and $r=-0.23$, $p=0.03$, respectively). No other relationships were statistically significant. **Conclusions:** As ankle motion variability increased, performance on stability indices improved, as indicated by decreased values. It appears that sagittal plane ankle variability is related to anterior-posterior stability, while frontal plane variability is related to vertical and composite stability. While the correlations were weak, it appears that increased variability is related to improved landing stability. Lack of flexible landing movement strategies may be related to deficits in landing stability in CAI populations.

Relationship Of Ankle Mechanical Stability To Dynamic Stability

McLeod MM, Ko JP, Pietrosimone BG, Schaffner L, Gribble PA: University of Toledo, Toledo, OH

Context: Joint instability is defined by mechanical (MI) and functional instability (FI) contributions. Arthrometer measured laxity and dynamic stability measured with Time to Stabilization (TTS) are used commonly to define deficits related to ankle instability. While used separately, it is not known if these measures of MI and FI correlate. **Objective:** Determine the strength of the correlation between ankle laxity and TTS. **Design:** Descriptive laboratory study. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen participants with a range of history of ankle injury ($n=16$; 4M, 12F; 20.50±1.18years, 172.56±9.56cm, 69.00±11.98kg). **Interventions:** For dynamic stability, participants performed a single-limb jump-landing task, from a height of 50% of their maximum jump height onto a force plate, and obtained and maintained a stable position for 5 seconds. Ground reaction forces were used to calculate Time to Stabilization (TTS) values, with smaller values indicating better dynamic stability. Laxity of the ankle was quantified with an ankle arthrometer, with larger values indicating more ankle laxity. Means and standard deviations of 3 trials of landing and laxity assessment were used from each subject. **Main Outcome Measures:** Pearson product moment correlations were performed to determine the relationship of TTS measures with sagittal and frontal plane ankle laxity. TTS was calculated in the anterior/posterior (APTTS) and medial/lateral (MLTTS) directions. Additionally, anterior/posterior and medial/lateral TTS values were combined into a single measure, resultant vector TTS (RVTTTS; seconds). Total laxity in anterior/

posterior (APTtotal; mm) and inversion/eversion (IETotal; degrees) served as the other variables. **Results:** The correlations between APTtotal and APTTS ($r=-0.107$, $P=0.69$), IETotal and MLTTS ($r=0.134$, $P=0.62$), APTtotal and RVTTS ($r=-0.068$, $P=0.84$) and IETotal and RVTTS ($r=-0.148$, $P=0.58$) were all weak. **Conclusion:** Ankle laxity and dynamic stability measured with TTS had very weak correlations to each other. It is likely that both are quantifying different contributions to ankle disability, and therefore clinicians should assess both MI and FI rather than assuming that one or the other is more defining of ankle dysfunction. Continued research is needed to determine the most appropriate combination of outcome measures for assessing MI and FI contributions to ankle instability.

Relationship Of Mechanical Laxity And Dynamic Stability To Self-Reported Ankle Disability

Gribble PA, McLeod M, Ko JP, Pietrosimone BG, Schaffner L: University of Toledo, Toledo, OH

Context: Disability related to chronic ankle instability (CAI) is contributed to by both mechanical and functional impairments. Ligamentous laxity is a measure of mechanical dysfunction, and measures of dynamic stability can be considered functional stability. It is unknown how measures of functional and mechanical ankle stability may explain self-reported ankle disability. **Objective:** Determine the amount of self-reported disability that can be explained with measures of dynamic stability during a jump-landing task and mechanical laxity measured with an arthrometer. **Design:** Descriptive laboratory. **Setting:** Research laboratory. **Patients or Other Participants:** Sixteen participants with a range of self-reported ankle injury history ($n=16$; 4M, 12F; 20.50 ± 1.18 years, 172.56 ± 9.56 cm, 69.00 ± 11.98 kg). **Interventions:** The Foot and Ankle Disability Index (FADI) and FADISport questionnaires were

administered to all subjects and reported as a percentage, with lower values indicating more perceived ankle instability. For dynamic stability, participants performed a single-limb jump-landing task from a height of 50% of their maximum jump height onto a force plate, and obtained and maintained a stable position for 5 seconds. Ground reaction forces were used to calculate Time to Stabilization (TTS) values, with smaller values indicating better dynamic stability. Laxity of the ankle was quantified with an ankle arthrometer, with larger values indicating more ankle laxity. Means and standard deviations of 3 trials of landing and laxity assessment were used from each subject. **Main Outcome Measures:** Two stepwise regression analyses were performed to determine the amount of variance in self-reported ankle disability explained by dynamic stability and ankle laxity. The questionnaire scores served as dependant variables, with the FADI representing indices of disability during activities of daily living (ADL), and the FADISport representing indices of disability during physical activity/exercise. Anterior/posterior and medial/lateral TTS values were combined into a single measure, resultant vector TTS (RVTTS; seconds), that served as one independent variable. Total laxity in anterior/posterior (APTtotal; mm) and inversion/eversion (IETotal; degrees) served as the other independent variables. **Results:** For FADI scores, the combination of RVTTS, APTtotal and IETotal explained 49.6% of the variance ($r^2=0.496$, $P=0.036$), while the combination of APTtotal and IETotal explained 49.5% of the variance ($r^2=0.496$, $P=0.036$). For FADISport scores, the combination of RVTTS, APTtotal and IETotal explained 50.7% of the variance ($r^2=0.507$, $P=0.032$), while the combination of only APTtotal and IETotal explained the same amount of variance ($r^2=0.507$, $P=0.010$). Additionally, APTtotal by itself explained 47.1% of the variance in FADISport ($r^2=0.471$, $P=0.003$). **Conclusion:** Ankle laxity appears to be a good indicator of self-reported ankle

disability, while dynamic stability using TTS does not. Clinicians should consider ankle laxity, but perhaps other functional outcomes besides TTS, when addressing patients' ankle disability complaints.

Spatial Postural Control Alterations With Chronic Ankle Instability

Pope M, Chinn L, McKeon PO, Mullineaux D, Sauer L, Hertel J: University of Virginia, Charlottesville VA, and University of Kentucky, Lexington, KY

Context: Postural control deficits have been identified in chronic ankle instability (CAI) individuals as compared to healthy subjects. Although deficits in static balance have previously been reported using center of pressure measures (COP) and, more recently, time to boundary measures (TTB), the underlying mechanism behind these deficits warrants further investigation. It is unclear if there are differences in the spatial distribution of COP data points and TTB minima data points on the planar surface of the foot during quiet single limb balance among individuals with and without CAI. **Objective:** To determine differences in the plantar location of the distribution of the COP data points and the TTB minima data points between subjects with and without CAI. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** 50 healthy subjects (22 males, 28 females; age= 23.0 ± 4.6 yrs; height= 168.3 ± 10.0 cm; mass= 69.8 ± 12.7 kg), and 61 subjects with self-reported CAI (31 males, 30 females; age= 21.5 ± 3.9 yrs; height= 171.8 ± 9.7 cm; mass= 69.1 ± 13.4 kg) participated. **Interventions:** All subjects performed three successful 10-second trials of single leg quiet standing on a force plate in eyes-opened and eyes-closed conditions. **Main Outcome Measures:** COP and TTB minima were recorded for each trial. The plantar surface of each subject's foot was then divided into four regions (anterolateral, antero-

medial, posterolateral, postero-medial). The number of COP data points and the number of TTB minima data points were recorded in each region. For each region, the mean number of data points of the three trials in each condition was used for statistical analysis. For each dependent variable an independent samples t-test was used to compare differences in each region between the two groups. **Results:** During the eyes-opened trials, the CAI group had more COP data points (CAI=178.91±149.93; healthy=100.34±108.92, p=0.003) and TTB minima data points (CAI=16.01±13.66; healthy=8.24±8.74; p=0.001) in the anterolateral region of the foot compared to healthy subjects. When constraining the task to eyes-closed, the CAI group showed greater anterior displacement (total number of anterolateral and anteromedial data points) of the COP and TTB minima compared to the healthy group (COP: CAI=329.14 ±134.54; healthy=250.23±119.60; p=0.002; TTB: CAI=30.02±12.67, healthy=21.69±10.44; p<0.001). **Conclusions:** The CAI group exhibited a more anterolateral positioning of the COP and TTB minima in eyes-opened trials and a more anterior position during eyes-closed trials. The differences in COP and TTB minima distribution may demonstrate possible neuromechanical compensatory mechanisms being developed to help those with CAI maintain postural control during single limb stance. The more anterior positioning of the CAI group may be advantageous because they may be adopting a more dorsiflexed stance in an effort to be in a more stable, closed-packed and rigid position of the foot and ankle. However, further research assessing kinematic differences are needed to evaluate this hypothesis.

Plantar Pressures In Those With And Without Chronic Ankle Instability While Landing A Lateral Hop

Webster KA, Pietrosimone BG, Armstrong CW, Gribble PA: University of Toledo, Toledo, OH, and Boston University, Boston, MA

Context: Previous studies of foot plantar pressure measures in those with chronic ankle instability (CAI) have found alterations in how pressure is distributed during running gait. However, limited exploration exists of in-shoe plantar pressures in CAI patients while performing other individual functional tasks, such as landing from a lateral hop. Alterations in plantar pressure may reflect foot-positioning differences, predisposing CAI subjects to repeated injury.

Objective: To examine plantar pressure measures during landing of a lateral hop in those with and without CAI.

Design: Case-Control study. **Setting:** Controlled research laboratory.

Participants: Thirty-two physically active subjects volunteered for the study. Sixteen CAI subjects (8M, 8F, 172.25 ±10.87cm, 69.13±13.31kg, 20.50±2.00yrs) were matched to 16 healthy subjects (8M, 8F 170.50 ±9.94cm, 69.63±14.82kg, 22.00 ±3.30yrs).

Interventions: Subjects were individually fit for in-shoe pressure inserts, which were positioned between the foot and the inside of the shoe. Subjects were asked to perform 5 lateral hops on each foot, the distance of which was normalized to the length of their lower leg and the height standardized to 5cm. An F-Scan® plantar pressure system collected peak average foot pressures for 6 separately defined areas on the plantar surface of the foot. **Main Outcome Measures:** Peak average pressures in pounds per square inch (PSI) for each area were collected at landing of the lateral hop and averaged across the 5 trials: 1) lateral rearfoot, 2) lateral midfoot, 3) lateral forefoot, 4) medial rearfoot, 5) medial midfoot,

and 6) medial forefoot. A Group by Area, mixed model, repeated measures ANOVA was performed with an alpha level set *a priori* (p<0.05). **Results:** There was no significant Group by Area interaction ($F_{1,30}=0.62$, $p=0.71$) or Group main effect ($F_{1,30}=1.24$, $p=0.27$). Within the main effect for Area ($F_{5,26}=38.68$, $p\leq 0.00$), the medial (47.20±15.17 PSI) and lateral (36.03±12.60 PSI) forefoot displayed the highest areas of pressure across the two groups. **Conclusions:** Previous studies have demonstrated higher midfoot and lateral forefoot forces in CAI subjects during running gait, suggesting a more inverted foot position which may predispose them to lateral ankle sprains. The lack of statistically significant group differences in our study compared to previous work may be attributed to the selected task. CAI subjects may be able to correct patterns during one specific task in a controlled setting to prevent lateral ankle sprain but may demonstrate more lateral pressure during a repetitive type motion such as running gait which would account for the differences in outcomes of this study compared to previous data. More research evaluating in-shoe plantar pressures during various tasks in those with CAI is necessary to determine if consistent patterns exist in this population.

Free Communications, Thematic Poster: Lower Extremity Function & Physiology Following Knee Injury

Wednesday, June 22, 2011, 1:00PM-2:30PM, Room 219; Moderator: Melanie McGrath, PhD, ATC

Contributions Of Central Activation Failure And Atrophy To Quadriceps Weakness Associated With ACL Reconstruction

Thomas AC, Wojtyś EW, Palmieri-Smith RM: University of Michigan, Ann Arbor, MI, and University of Colorado Denver, Aurora, CO

Context: Quadriceps weakness presents and persists after anterior cruciate ligament reconstruction (ACLR) in spite of otherwise successful rehabilitation. The precise contributors to lingering quadriceps weakness are unknown, though muscle atrophy and activation failure have been implicated.

Objective: This study sought to elucidate the roles of activation failure and muscle atrophy in persistent quadriceps weakness after ACLR.

Design: Cohort study. **Setting:** This study was performed in a controlled laboratory setting.

Patients or Other Participants: Twelve individuals (21.08±6.21 years; 1.73±0.09 m; 74.38±14.62 kg) undergoing ACLR six months previously participated.

Interventions: Quadriceps activation was assessed using the burst superimposition technique and quantified via the central activation ratio (CAR). Muscle atrophy was determined as the peak quadriceps cross sectional area (CSA) from magnetic resonance images. Specifically, the borders of each quadriceps muscle were traced in each image in which they appeared using ImageJ software (version 1.43u, NIH, Bethesda, MD). The image yielding the largest CSA was utilized to quantify peak quadriceps CSA. Quadriceps strength assessment was performed on an isokinetic dynamometer. The peak value over three knee extension maximal voluntary isometric contraction (MVIC) trials was normalized to subject body mass (Nm/kg) and served to quantify quadriceps strength. All testing was performed bilaterally. **Main Outcome**

Measures: Hierarchical linear regression analysis was performed to determine the association between quadriceps CAR and CSA and knee extension MVIC in the ACLR limb. One-way ANOVAs were performed to determine if quadriceps CAR, CSA, and MVIC differed between limbs. **Results:** Regression analysis failed to demonstrate a significant relation between quadriceps CAR and CSA and the peak MVIC following ACLR ($R^2=0.164$, $P=0.448$). The CAR accounted for 15.7% ($P=0.20$) of the variance in quadriceps MVIC; subsequent inclusion of quadriceps CSA accounted for the remaining 0.7% ($P=0.79$). Peak CSA (ACLR=68.21 ± 18.35cm²; uninjured=81.19±20.08cm²; $P<0.001$) and the quadriceps MVIC (ACLR=1.96±0.54Nm/kg; uninjured=2.81±0.96Nm/kg; $P=0.001$) but not the CAR (ACLR=0.83±0.13; uninjured=0.79±0.14; $P=0.30$) differed between limbs. **Conclusions:** Though both quadriceps atrophy and activation failure were present in our subjects, neither quadriceps CSA nor CAR was related to knee extension strength. Future studies seem necessary to determine what additional factors may be associated with quadriceps MVIC so necessary modifications to current rehabilitation strategies can be made. Until quadriceps weakness is sufficiently countered during rehabilitation, individuals may be at risk for re-injury and/or joint degeneration. Funded by the Doctoral Research Grant Program of the NATA Research & Education Foundation.

Hip And Knee Muscle Function Following Aerobic Exercise In Individuals With Patellofemoral Pain Syndrome

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Context: Patellofemoral pain syndrome (PFPS) is a common knee disorder associated with altered lower extremity muscle activation. There is little evidence regarding the effects aerobic exercise on quadriceps strength and muscle activation during dynamic tasks in individuals with PFPS.

Objective: To compare knee extension torque and activation of the gluteus medius (GM), vastus medialis oblique (VMO), vastus lateralis (VL) during an anterior reaching task following an aerobic exercise protocol between individuals with PFPS and healthy controls. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Participants:** Twenty PFPS participants (age=20.90 ±1.77years, height =170.69±6.72cm, mass= 70.34± 7.88kg) were divided into two groups: patients reporting a clinically important increase (greater than a 1.4cm on a visual analog scale) in perceived pain (high PFPS=11) and patients who did not report increased pain (less than a 1.4cm),(low PFPS=9) after exercise. Twenty healthy controls (age=22.60±3.62years, height=168.21±6.63cm, mass= 65.50± 7.23kg) were also included in this study. **Intervention(s):** Participants walked at a self-selected speed on a treadmill at 3.0mph for 20-minutes. The treadmill incline was raised 1% grade per minute for the first 15-minutes. Participants rated perceived exertion (RPE) at the start of each minute. During the last 5-minutes, participants adjusted the incline of the treadmill so they would maintained an RPE level of 15-17 through the end

of the exercise protocol. Outcome measures were recorded before and immediately after exercise. **Main Outcome Measures:** Normalized knee extension torque and average root mean square electromyography (EMG) muscle activation of the VMO, VL, and GM during a single leg anterior reaching task was taken pre and post aerobic exercise. A 2x2 repeated measures ANOVA was used to compare knee extension torque between groups after exercise. EMG data violated parametric assumptions, therefore, Mann-Whitney U tests were used to compare groups at baseline and after exercise; Wilcoxon test was used to compare pre-post test within each group. **Results:** Significantly decreased knee extension torque was observed after exercise in PFPS patients experiencing pain (control: pre=1.96±0.47Nm/kg, post=2.25±0.49Nm/kg; High PFPS: pre=1.63±0.62Nm/kg, post=1.73±0.64Nm/kg, Low PFPS: pre=1.90±0.37Nm/kg, post=1.95±0.38Nm/kg, P=0.03). Significant decreases in GM activation during the anterior reaching task were observed in PFPS patients who reported no pain after exercise (control: pre=0.01±0.04, post=0.10±0.04; High PFPS: pre=1.24±1.33, post=1.27±1.26, Low PFPS: pre=1.90±1.33, post=1.62±1.30, P=0.021). Significant decreases in VMO (control: pre=0.24±0.11, post=0.25±0.13; High PFPS: pre=22.05±30.73, post=16.64±19.15, Low PFPS: pre=41.69±58.68, post=32.74±35.61, P=0.010) and VL (control: pre=0.20±0.11, post=0.21±0.11; High PFPS: pre=10.22 ±7.74, post=9.00±7.00, Low PFPS: pre=12.40±9.32, post=11.05±9.11, P=0.021) activation were observed in PFPS patients who reported increased pain post exercise. **Conclusions:** When PFPS patients experience pain during exercise, a reduction in quadriceps activation was observed, however, in the absence of pain proximal adaptations occurred; specifically a reduction in GM activation. Therefore, clinicians should consider the current level of pain when tailoring a

rehabilitation protocol for patients with PFPS.

Quadriceps Function In ACL Deficient Knees After Rehabilitation Exercises Augmented By TENS And Cryotherapy

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Context: Quadriceps muscle activation failure contributed to by reflex muscle inhibition is an underlying factor to rehab-resistant, persistent muscle weakness that threatens long term joint health following injury. Trans-cutaneous electrical nerve stimulation(TENS) and knee joint cryotherapy have each been shown to reverse reflex muscle inhibition thereby providing an optimal environment for rehabilitation exercises. Treatments that restore normal neuromuscular function may be an important prerequisite for optimizing strength gains and maintenance. **Objective:** To compare strength and quadriceps muscle activation in ACL deficient patients who undergo a 2 week rehabilitation program augmented with TENS or cryotherapy. **Design:** Clinical trial. **Setting:** Orthopaedic clinic and sports medicine laboratory. **Patients or Other Participants:** Thirty patients (20 males, 10 females, 31.6±13.0years, 172.8±10.0cm, 75.8±13.0kg) with MRI-confirmed ACL deficient knees consecutively recruited from a single orthopaedic surgery clinic. **Interventions:** All patients attended 4-sessions of supervised quadriceps strengthening exercises over 2-weeks, prior to reconstruction surgery. Patients were randomly allocated (n=10/group) to receive exercises alone (Exerc), exercise while wearing a sensory TENS device on the knee joint for the

duration of each daily session (TENS), or 20-minutes of knee joint cryotherapy immediately prior to each daily exercise session (CRYO). **Main Outcome Measures:** Normalized knee extension force (Nm/kg of body weight) and quadriceps central activation ratio were measured bilaterally before and after the first supervised treatment session and within 24 hours of the last session. An electrical stimulus (10, 0.6ms duration, 125V pulses at 100Hz) was manually triggered during a maximal volitional isometric contraction (MVIC) and delivered through 2 carbon-impregnated rubber electrodes secured to the anterior thigh (proximal-lateral and distal medial) causing a transiently increased superimposed burst force (SIB). % Central activation ratio (CAR) was calculated as (MVIC/[MVIC+SIB]) *100. ANCOVAs were used to assess changes in outcome measures between groups over a 2-week period using baseline values as the covariate. Cohen's d effect size ([post-pre]/pooled standard deviation) was used to evaluate the magnitude of within-group changes over time. **Results:** The following presents the P-value for each ANCOVA followed by within-group effect sizes. There were no statistically significant group differences immediately following the first exercise session for normalized MVIC (P=0.10, d[95%CI]: Exerc: 0.26[-0.62,1.14] TENS: 0.67[-0.23,1.57] CRYO: 0.59[-0.31,1.48]) or CAR (P=0.30, d[95%CI]: Exerc: 0.31[-0.57,1.19] TENS: 0.58[-0.31,1.48] CRYO: 0.68[-0.22,1.58]). There was no statistically significant group differences after the 2-week intervention for MVIC (P=0.92, d[95%CI]: Exerc: 0.84[-0.07,1.75] TENS: 1.27[0.31,2.24] CRYO:0.78[-0.13,1.69]) or CAR (P=0.94, d[95%CI]: Exerc: 0.83[-0.08,1.75] TENS: 1.09[0.15,2.03] CRYO: 0.95[0.03,1.88]). **Conclusions:** Quadriceps strength and central activation in ACL-deficient patients can be improved with exercises.

Although the addition of TENS and Cryotherapy did not result in significant differences compared to exercise alone, strong magnitude effect sizes and 95%CI that don't cross zero in the TENS and CRYO groups only suggest potential benefit to patients.

Analysis Of The Biochemical Environment Of Effused And Non-Effused Osteoarthritic Knees

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Context: Osteoarthritis (OA) has reached epidemic proportions in the United States, affecting over 27 million United State adults (ages 24-74). Traumatic knee injuries (anterior cruciate ligament or meniscal tears) increase the likelihood of early development of OA. Understanding the biochemical environment of OA is fundamental for understanding the early pathophysiologic events and for the identification of "at-risk" OA patients. Several interventions have shown to be palliative among patients with knee effusion; however, not every patient with OA has clinical effusion. There is potential for overgeneralization of results since it is unclear if effused and non-effused joints are biochemically distinct. **Objective:** To measure and compare the biochemical environment of effused (EF) and non-effused (NE) OA knees. **Design:** Cross-sectional. **Setting:** Outpatient

orthopedic practice. **Participants:** Twenty-two knee OA patients with moderate-severe radiographic OA in EF group (n=11, age: 62.9±5.2 years, body mass index [BMI]: 34.2±7.6 kg/m²) or in NE group (n=11, age: 66.1±9.3 years, BMI: 33.6±6.4 kg/m²) **Interventions:** Each subject completed a health history form, the Likert version of the Western Ontario and McMaster Universities (WOMAC) OA Index Score to assess three subscales of function (pain, stiffness, and functional limitations), and had their synovial fluid protein concentrations analyzed with a custom human SearchLight Proteome Multiplex Protein Array. Proteins were measured in pg/μg of total protein content. The independent variable was group (EF vs. NE). **Main Outcome Measures:** Dependent variables of interest were knee synovial fluid protein concentrations of eight specific proteins (pro-inflammatory, protective, catabolic-associated or anabolic-associated with cartilage ossification). Mann Whitney U tests were used on all protein concentrations and functional scores to determine group differences (p≤.006), which is reported as the median [95% confidence interval]. **Results:** EF had significantly higher concentrations of tissue inhibitors for metalloproteinases (TIMP)-1 (NE=.519388 [0.000000-13.457844], EF=52.008696 [38.851239-80.618044]; p<.001), TIMP-2 (NE=.340405 [0.000000-2.521999], EF=4.471101 [3.758427-5.662756]; p=.002), interleukin (IL)-10 (NE=.000017 [.000007-.000039], EF=.000054 [.000037-.000184]; p=.003), and matrix metalloproteinase (MMP)-3 (NE=.131 [0.000-6.932], EF=81.236 [0.000-334.058]; p<.001). No other synovial fluid protein concentrations were significantly different. No significant differences in functional scores were determined between effused and non-effused knee OA groups. **Conclusions:** Biochemical differences between effused and non-effused knees further verifies that these two subsets represent

discreet phenotypes characterized by distinct biochemical characteristics, clinical findings, and clinical trial outcomes. Biochemical distinctions suggest that these patients should be stratified in analyses based on biochemical profiles, rather than disease status, to more accurately understand disease progression, selection of treatments, and efficacy of interventions. Future studies may enable identification of more OA phenotypes, which may allow for earlier diagnosis and interventions of at risk patients, as well as the identification of optimal interventions for at-risk of existing OA patients.

The Effects Of Neuromuscular Fatigue On Knee Biomechanics And Muscle Activity In ACL Reconstructed Patients

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Context: Neuromuscular fatigue alters lower extremity biomechanics and muscle activation, potentially increasing anterior cruciate ligament (ACL) injury risk. Altered neuromechanics post-ACL reconstruction (ACLr) may precipitate re-injury, though the effects of fatigue on individuals following ACLr remain unknown. As individuals returning to activity following ACLr likely experience neuromuscular fatigue, understanding how fatigue impacts knee biomechanics and muscle activation seems imperative so strategies to counter the effects can be implemented. **Objective:** Determine the effects of neuromuscular fatigue on knee biomechanics and muscle activation patterns post-ACLr. **Design:** Case-Control. **Setting:** University Laboratory. **Patients or Other Participants:** Eight individuals 7-10 months post-ACLr (3 male, 5 female; age 20.7±5.9years; 1.7±0.1m; mass 75.9±14.3kg) and eleven controls (3 male, 8 female; age: 22.6±4.2years; 1.7±0.1m;

mass 68.6 ± 12.1 kg) participated. **Interventions:** Fatigue was induced via repetitive sets of double-leg squats ($N=8$), which were interspersed with sets of single-leg landings ($N=3$), until squats were no longer possible. Three-dimensional sagittal plane knee biomechanics and electromyography data were recorded throughout fatigue during the single-leg landing trials. The single-leg landings consisted of a double-leg take-off, single leg landing onto a force platform immediately followed by an aggressive lateral hop to the opposite side. **Main Outcome Measures:** Sagittal plane knee angles at initial contact (IC) and peak stance (PS) and external moments at PS were calculated during landing using a standard inverse dynamics approach. Quadriceps and hamstrings (QH) and quadriceps and gastrocnemius (QG) EMG co-contraction was determined from IC to peak vertical ground reaction force. Pre- and 50%-fatigue trials were analyzed via 2×2 (time \times group) repeated measures ANOVAs. Bonferroni multiple comparison procedures and univariate F tests were used for *post hoc* analyses. **Results:** ACLr patients were less flexed at IC pre-fatigue ($-10.8^\circ \pm 1.61$) than at 50% fatigue ($-14.4^\circ \pm 1.79$; $P=.018$). Both groups demonstrated less flexed PS knee postures at 50% fatigue than pre-fatigue (ACLR pre= $-44.5^\circ \pm 2.70$, 50%= $-14.1^\circ \pm 2.27$; Control pre= $-57.1^\circ \pm 2.30$, 50%= $-13.6^\circ \pm 1.94$; $P_d^{**}.001$). ACLr patients experienced a smaller external flexion moment (ACLR pre= -1.20 Nm/kg* $m \pm 0.089$, 50%= -1.45 Nm/kg* $m \pm 0.096$; Control pre= -1.78 Nm/kg* $m \pm 0.076$, post= -1.49 Nm/kg* $m \pm 0.082$; $P_d^{**}.001$) than controls regardless of fatigue state. QH and QG EMG co-contraction were greater pre-fatigue than at 50% regardless of group (LQH [pre= $.367 \pm 0.048$, 50% = $.210 \pm 0.035$; $P=.006$] LQG [pre= $.620 \pm 0.159$, 50% = $.620 \pm 0.159$; $P=.026$]). **Conclusions:** Our results indicate that in a fatigued state, subjects across both groups landed with reduced knee flexion angles and smaller knee flexion moments. Landing in a more knee extended position places higher strain on the ACL, and has been implicated in the

non-contact ACL injury mechanism. These biomechanics adaptations suggest a need for fatigue-resistance training within ACL injury prevention and post-operative rehabilitation programs.

Knee Joint Laxity And Alignment In Patients With Early Stage Knee Osteoarthritis

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Context: Knee osteoarthritis (OA) is a debilitating disease that affects an estimated 27 million Americans. Changes in lower extremity alignment and joint laxity have been found to redistribute the medial and/or lateral loads at the joint. Further, both joint space narrowing and malalignment have been found to be related to laxity.

Objective: To compare knee joint laxity, knee alignment and a global subjective pain, stiffness and function score in early stage knee OA patients to healthy matched controls. **Design:** Case-controlled, repeated measures design.

Setting: Biodynamics Research Laboratory. **Patients or Other**

Participants: Eighteen subjects with knee OA (7 males, 11 females, age 60.17 ± 9.98 yrs, mass 90.27 ± 16.73 kg, ht 168.41 ± 9.92 cm) and 18 healthy matched controls (7 males, 11 females, age 60.28 ± 10.66 yrs, mass 81.12 ± 21.21 kg, ht 168.28 ± 11.95 cm) participated in the study.

Interventions: The independent variables were group (knee OA, healthy) and sex (male, female). Subjects completed the WOMAC Osteoarthritis questionnaire, and were tested for total anterior-posterior knee

joint laxity (AP) using a KT-1000 knee arthrometer, and knee joint alignment (ALIGN) using an electrogoniometer in their affected extremity. **Main Outcome Measures:** Total anterior-posterior tibial displacement (mm), knee joint alignment ($^\circ$), and global pain, stiffness and function scores from the WOMAC Osteoarthritis questionnaire were measured. **Results:** No significant multivariate group by gender interaction occurred for all variables combined [Wilks' = 0.89 , $F(7,26)=0.47$, $P=.085$]. Significant main effects for group [Wilks' = 0.30 , $F(7,26)=8.58$, $P<0.0001$] and sex [Wilks' = 0.23 , $F(7,26)=12.35$, $P<0.0001$] were found when all variables were combined linearly. Specifically, knee OA patients demonstrated greater Global WOMAC Osteoarthritis questionnaire scores (34.83 ± 17.50), compared to the healthy matched controls (0.00 ± 0.0 ; $P<0.0001$). Knee OA subjects did not differ from healthy controls on ALIGN ($P=0.49$) or total AP ($P=0.66$). When comparing sex differences, males exhibited greater knee joint valgus alignment (178.0 ± 4.1) compared to females (175.0 ± 4.4 , $P=0.05$). Additionally, no sex differences were observed on the ALIGN and total AP measures. No significant relationship was identified between WOMAC scores and ALIGN ($r_{xy}=-0.41$, $P=0.87$) and total AP ($r_{xy}=0.22$, $P=0.38$), as well as ALIGN and total AP measures ($r_{xy}=0.19$, $P=0.45$) in the knee OA group. **Conclusions:** These data demonstrates that early onset knee OA directly influences subjective pain, joint stiffness and function outcomes; however, knee joint alignment and joint laxity remains unaffected. Moreover, these data provide evidence that knee joint laxity and knee joint alignment are not the primary determinants associated with the patients reporting pain, stiffness and functional disability. Other factors such as diminished muscle inhibition could be associated with this decreased ability to perform activities of daily living. Further investigation is needed to identify the

mechanisms underlying subjective pain and disability and overall quality of life in the early stage knee OA patients. Funded by the Doctoral Research Grant Program of the NATA Research & Education Foundation.

Effect Of Sling Exercise Therapy With And Without Vibration On Quadriceps Activation In Partial Meniscectomy Patients

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Context: Quadriceps weakness and volitional activation deficits have been reported following meniscectomy. Sling exercise therapy (SET) and SET in conjunction with vibration (SET_v) have been hypothesized to increase muscle function via Ia afferent neural pathways, yet no research has determined if SET and SET_v will increase quadriceps activation in patients following meniscectomy. **Objective:** Determine the effect of a single intervention of SET and SET_v on quadriceps central activation ratio (CAR) in post meniscectomy patients. **Design:** Single blind, randomized controlled trial. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-five participants, SET n= 7M/1F (38.13±17.39yrs, 174.56± 11.31cm, 90.66±20.3kg, 51.66± 54.89weeks post-op), SET_v n= 5M/3F (40.00± 19.03yrs, 174.00±7.12cm, 86.43±17.79kg, 29.27±20.14weeks post-op), Control n= 5M/4F (37.33±14.27yrs, 172.93±12.03cm, 77.46±19.97kg, 42.96± 38.54weeks post-op) with a baseline CAR less than 85% were included in this study or each group. **Interventions:** Independent variables included exercise group (SET, SET_v or control) and time (baseline 0, 10 and 30-minutes post intervention). SET and SET_v participants performed 4 sets of 4 knee extensions in a prone position while suspended in slings.

Exercise intensity was manipulated using standardized sling positions, by an experienced clinician, allowing participants to perform pain free but challenging exercise. Vibration of the supporting ropes during SET_v was performed at 30Hz. The control group lied quietly on a treatment table with the involved leg suspended in the sling for five minutes. **Main Outcome Measures:** Quadriceps activation was assessed isometrically at 70° of knee flexion using the CAR, at baseline, 0, 10, and 30 minutes post intervention. A 3x4 analysis of variance with repeated measures on time was used to assess group differences over time. Appropriate *post hoc* analyses were used and an *a priori* level of significance was set at $P \leq 0.05$. **Results:** Significant differences in CAR ($F_{3,66} = 26.526, P < .001$) were detected over time, but there was no significant interaction or differences between groups. Planned comparisons showed higher SET CARs at posttest 0 (78.6%±17%, $t_7 = -5.654, P = .001$), 10 (78.15±16.4%, $t_7 = -5.677, P = .001$), and 30-minutes (80.1%±15.6%, $t_7 = -5.457, P = .001$) compared to baseline scores (70.3%± 18%). SET_v CARs were significantly higher at posttest 0 (83.29%±8.01%, $t_7 = -3.123, P = .017$), 10 (78.1%±17%, $t_7 = -6.202, P < .001$), and 30-minutes (80.1%±16.6%, $t_7 = -3.883, P = .006$) compared to baseline scores (78.9%±7.2%). Control CARs were significantly elevated at 30-minutes (79.3%±11.5%, $t_8 = -2.658, P = .029$) compared to baseline (71.5%±13.6%). **Conclusions:** Quadriceps CAR increased at all posttests compared to baseline following both SET and SET_v, while control CAR was only increased at 30-minutes following the intervention. Although, there was no difference in posttest CARs between the groups, SET and SET_v CAR increased from baseline immediately following the intervention, while the control CAR did not increase until the 30-minute posttest.

Tibiofemoral Osteoarthritis After Surgical And Non-Surgical Treatment Of The Anterior Cruciate Ligament Rupture: A Systematic Review

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Context: Surgical and non-surgical treatment options exist for anterior cruciate ligament (ACL) rupture the efficacy of which to prevent post-traumatic tibiofemoral osteoarthritis remains unclear. **Objective:** Conduct a systematic review to assess the prevalence of osteoarthritis in ACL rupture patients who either had reconstructive surgery or were treated non-surgically. **Data Sources:** A comprehensive literature search was conducted in October 2009. Databases searched: Academic Search Premier, CAB abstracts, CINAHL, Education Research Complete, Education Resources Information Center, MEDLINE, SPORTDiscus with full text, Research Starters-Education, Cochrane Database of Systematic Reviews, ACP Journal Club, Database of Abstracts of Reviews of Effects, Cochrane Library Central Register of Controlled Trials, Cochrane Library Methodology Register, Cochrane Library Health Technology Assessment, Cochrane Library Economic Evaluation Database, Journals@Ovid, Global Health, and Ovid MEDLINE. Keywords were (ACL or anterior cruciate ligament) and (osteoarthritis or osteoarthrosis or degenerative joint disease or arthritis or coxarthrosis or gonarthrosis) and

(reconstructi* or repair or surgery or replacement) and (meniscus or menisci or tear or torn or injury or injuries or injured). **Study Selection:** Studies were included if: a) treatment outcomes focused on a direct comparison of surgical versus non-surgical treatment of ACL ruptures, b) prospective or retrospective cohort study design, c) reported tibiofemoral osteoarthritis prevalence, and d) written in English. Of 799 articles identified through the literature search, 5 met the inclusion criteria. **Data Extraction:** Two independent investigators assessed the quality of the studies using the Newcastle-Ottawa Scale (NOS). Data on surgical procedure, non-surgical treatments, subject characteristics, frequency, odds ratios (OR), etc were then extracted and summarized. **Data Synthesis:** Prevalence 95% confidence intervals (CI) were calculated for treatment groups (surgical, non-surgical). Non-overlapping CIs for prevalence were statistically significant ($p < .05$). CIs excluding the null value (1.0) were considered significant ($p < .05$). Four retrospective and 1 prospective cohort studies were identified ($n=252$ surgical; $n=178$ non-surgical). The mean NOS score was 4.4 out of 10 points (range: 2 to 6 points). Osteoarthritis prevalence for surgically treated patients ranged from 29.7 to 51.2% (overall=38.9%; CI=32.9-44.9) and for non-surgical patients ranged from 24.5 to 46.22% (overall=32.0%; CI=25.2-38.9). Unadjusted ORs ranged from 0.49 to 2.37 (overall OR=1.35; CI=0.90-2.02) **Conclusions:** Osteoarthritis prevalence was slightly higher in surgically-treated than in non-surgically treated ACL patients at 11 years follow-up, but the difference was not statistically significant. There is no definitive evidence to support surgical or non-surgical treatment after ACL injury to prevent post-traumatic osteoarthritis. Current studies are limited by small numbers, low study quality, and lack of data on confounders.

Relationship Between Spinal Reflexive And Cortical Excitability Of The Quadriceps In Individuals With Unilateral Anterior Cruciate Ligament Reconstructions

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Context: Alterations in lower extremity neuromuscular control are common following anterior cruciate ligament reconstruction (ACLR). These neuromuscular alterations may be influenced by spinal reflexive and cortical level neural pathways. Understanding how spinal and cortical pathways interact with the quadriceps following ACLr may provide important information regarding the genesis of these altered neuromuscular control strategies that may influence disability following ACLr. **Objective:** Investigate the relationship between spinal and cortical quadriceps excitability in both legs of individuals with unilateral ACLr and healthy matched controls. **Design:** Case-control. **Setting:** A controlled research laboratory. **Patients or Other Participants:** Nine unilateral ACLr (3 males/6 females, 24.3 ± 5.27 years; 173.9 ± 10.8 cm, 70.45 ± 14.8 kg, 67.5 ± 42.6 months post surgery) and nine healthy matched control (3 males/6 females, 25.0 ± 5.20 years; 171.9 ± 10.4 cm, 68.1 ± 11.9 kg) participants were included in this study. **Interventions:** Measures of spinal reflex excitability and cortical excitability were tested in the vastus medialis bilaterally in ACLr and control participants. The order of both measures, as well as leg tested, was randomized. The legs in the healthy group were matched to an ACLr counterpart using leg dominance. Four separate Pearson product moment correlations were performed to assess the relationship between spinal and cortical excitability in the injured and uninjured quadriceps of the ACLr and matched control group. Alpha level was set *a priori* at $P \leq .05$. **Main Outcome Measures:** Bilateral quadriceps spinal reflex excitability was assessed using maximal Hoffmann Reflexes normalized

to maximal Muscle Responses (H:M ratio). Bilateral quadriceps cortical excitability was evaluated with active motor thresholds (AMT), derived using Transcranial Magnetic Stimulation (TMS), while participants performed knee extension at 5% of their maximal capabilities. AMTs were defined as the lowest TMS intensity that elicited a measurable ($> 100\mu V$) motor evoked potential in five out of ten consecutive trials. Higher H:M ratios denote increases in spinal excitability, while higher AMTs indicate decreased cortical excitability. **Results:** Significant, positive moderate relationships were found between H:M ratio and AMT in both the injured ($r=0.606$, $P=0.04$) and uninjured leg ($r=0.619$, $P=0.038$) in the ACLr group, while no significant relationships were found in the matched injured ($r=0.148$, $P=0.35$) and uninjured leg ($r=0.470$, $P=0.10$) of healthy controls. **Conclusions:** The moderate positive correlations between AMT and H:M ratio in the ACLr group indicate that those with low H:M ratio (low spinal reflex excitability) have lower AMT (which denotes higher cortical excitability), while no systematic relationship between these neural pathways was found in healthy controls. This suggests that if spinal quadriceps excitability is inadequate, an ACLr individual may compensate by up-regulating cortical quadriceps capabilities, or may up-regulate spinal excitability in the presence of cortical insufficiency. This provides evidence that spinal and cortical neural pathways may interact in injured populations, which may influence neuromuscular control following ACLr.

A Method To Analyze Synovial Fluid Biomarker Concentrations In Non-Effused Knees

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Context: Post-traumatic osteoarthritis is an increasing concern among athletes requiring more research exploring its onset and progression. Aspirated synovial fluid may be a source of biomarkers, but there are limited methods to analyze synovial fluid from non-effused knees, which are needed for longitudinal studies of post-traumatic joints.

Objective: To evaluate the relationship between raw biomarker concentrations (pg/ml synovial fluid) and normalized biomarker concentrations (raw biomarkers divided by total protein content) in effused osteoarthritis (requiring no saline to aspirate) and non-effused (requiring saline lavage) knees. These analyses will test the validity of a method to assess synovial fluid from non-effused knees. **Design:** A retrospective analysis of two cross-sectional studies. **Setting:** Outpatient orthopaedic clinic. **Patients:** Volunteers (age=63.1±8.4 years; 16 females, 14 males; body mass index=32.9±6.8 kg/m²) were recruited to evaluate synovial fluid biomarkers in knees with moderate-severe radiographic evidence of osteo-arthritis with (*n*=15) or without effusion (*n*=11), and normal knees (*n*=4; no osteoarthritis or effusion). **Inter-**

ventions: Knee effusion was defined based on a physical knee examination and a successful synovial fluid aspiration without injecting saline by a board-certified orthopaedic surgeon. Aspiration of effused knees was performed with a standard protocol by inserting a needle into the lateral suprapatellar region. For participants with non-effused knees, similar procedures were followed but the needle was inserted with a prefilled-saline syringe (2 or 15 mL). After saline was injected, the physician attempted to aspirate synovial fluid. If the aspiration was not successful then another syringe of saline was injected and the aspiration procedures were repeated. Samples were stored at -80°C until assayed. **Main Outcome Measures:** The dependent variables were 7 raw and normalized synovial fluid biomarker concentrations: interleukin (IL)-1β, IL-10, IL-13, matrix metalloproteinase (MMP)-3, tissue inhibitor of MMPs (TIMP)-1, TIMP-2, and osteoprotegerin (OPG). Biomarkers were assayed by an independent laboratory using a multiplex enzyme-linked immunosorbent assay (SearchLight Assay Services). Spearman rank correlations were performed (*p*≤.05). **Results:** In effused knees, normalized concentrations of 6 biomarkers had strong correlations (*r*≥.80) to raw concentrations (*r*=.80 to .99, *p*<.001; IL-13: *r*=.77, *p*<.001). In non-effused knees normalized concentrations of 5 biomarkers had strong correlations to raw concentrations (*r*=.88 to .98; *p*<.001; IL-1β: *r*=.73, *p*=.025; IL-13: *r*=.58, *p*=.029). Except for IL-1β, associations between normalized and raw concentrations were consistent between effused and non-effused knees (based on 95% confidence intervals of correlation coefficients). **Conclusions:** The associations between normalized and raw biomarker concentrations were consistent between effused and non-effused knees, except for IL-1β. The saline-assisted aspiration of synovial fluid is a valid technique for assessing

non-effused knees but investigators should evaluate correlations between normalized and raw concentrations to ensure the data are representative of raw concentrations. This technique may be valuable for examining post-traumatic osteoarthritis onset and progression.

Free Communications, Thematic Poster: Ankle Taping & Bracing

Wednesday, June 22, 2011, 3:00PM-4:30PM, Room 219; Moderator: Thomas Kaminski, PhD, ATC

Effects Of Ankle Stabilizers On Vertical Jump, Agility, And Dynamic Balance Performance

Ambegaonkar JP, Redmond, CJ, Winter C, Guyer SM, Thompson B, Cortes N: Sports Medicine Assessment Research and Testing Laboratory, George Mason University, VA, and Department of Exercise Science and Sport Studies, Springfield College, Springfield, MA

Context: Ankle sprains are among the most common athletic injuries. Prophylactic ankle stabilizers have been shown to reduce ankle sprain incidence and severity by reducing injurious excessive ranges of ankle motion during activity. Still, limited research has examined their effects on physical performance measures. **Objective:** To compare the effects of ankle stabilizers on vertical jump, agility, and dynamic balance performance. **Design:** Crossover **Setting:** Controlled Laboratory **Participants:** 10 recreationally active volunteers (4M, 6F; 25.6 ± 2.8 yrs, 167.8 ± 13.7 cm, 61.4 ± 10.7 kg) **Interventions:** Participants performed the Sargent Vertical jump test (height, cm), the Right-Boomerang Run Agility test (completion time, s), and the Modified Bass Test of Dynamic Balance (score) in a randomized order twice (scores averaged) when wearing three ankle stabilizers: athletic tape (TAPE), semi-soft (Swede-O Ankle Lok, SWED), rigid (Air-Cast Air-Stirrup, CAST), and a nonsupport control (CONT) bilaterally. **Main Outcome Measures:** Separate one-way ANOVAs ($p \leq 0.05$) compared the ankle stabilizer conditions across the vertical jump, dynamic balance, and agility tests. **Results:** Participants had similar vertical jump heights ($p = .27$; CONT = 41.4 ± 11.9 cm, TAPE = 37.9 ± 7.9 cm, SWED = 34.4 ± 1.4 cm, CAST = 39.3 ± 10.8 cm), and dynamic balance scores ($p = .08$; CONT = 92.5 ± 2.5, TAPE = 91.6 ± 3.5, SWED = 96 ± 5.3, CAST = 89.4 ± 6.1) across all conditions but had

differing agility run times ($p = .03$; CONT = 13.6 ± 1.4 s, TAPE = 14.1 ± 1.5 s, SWED = 14.1 ± 1.4 s, CAST = 14.1 ± 1.4 s). Bonferroni paired comparisons on agility scores did not reveal any significant differences across the four conditions. However, standardized effect sizes (d), indicated that compared to the control condition, wearing any ankle stabilizer increased agility run times (TAPE: $d = 0.33$, SWED: $d = 0.40$, CAST: $d = 0.43$) **Conclusions:** Ankle stabilizers did not affect vertical jump or dynamic balance, but negatively affected agility performance as compared to not wearing any ankle stabilizer. Since participants primarily required sagittal plane motion when jumping vertically and had relatively slow directional changes in the dynamic balance test, wearing ankle stabilizers may not have hampered performance in these tests. However, all ankle stabilizers hindered the participants' ability to perform the quick directional changes required in the agility test. Although ankle stabilizers may successfully reduce harmful ankle ranges of motion, athletes should be aware of their influences on performance during sport.

The Effect Of A Lace-Up Ankle Brace On The Severity Of Lower Extremity Injuries In High School Basketball Players

McGuine TA, Brooks MA, Hetzel SJ, Sigl J: University of Wisconsin-Madison; Madison WI

Context: External ankle support in the form of lace up ankle braces are used by many high school basketball players in the US to reduce the incidence of ankle injuries. There are limited data however on whether lace-up ankle braces reduce the severity of ankle injuries in these populations. In addition, laboratory research has shown that limiting motion through

external support at the ankle could influence the transfer of force up through the kinetic chain leading to more severe injuries throughout the lower extremity. **Objective:** Determine if a lace-up ankle brace reduced the severity of acute lower extremity injuries in high school basketball players. **Design:** Randomized (cluster) control trial. **Setting:** 46 Wisconsin high schools ($n = 21$ braced group, $n = 25$ control group) during the 2009-2010 basketball season. **Participants:** Fourteen hundred and sixty female and male (720 control group and 740 braced group) interscholastic basketball players (age: 16.0 ± 1.1 yrs, Ht: 174.2 ± 15.1 cm, Wt: 67.0 ± 12.3 kg.). **Intervention:** Each subject in the braced group wore a McDavid Ultralight 195 lace-up ankle brace on each ankle for the entire season. **Main Outcome Measures:** Athletic trainers at each school recorded all athlete exposures as well as the incidence and time lost for ankle injuries (lateral, medial, syndesmotic sprains, fractures), knee injuries (ACL tears, medial collateral ligament sprains, patellar instability, meniscus tears, hyperextensions) and other lower extremity injuries (metatarsal fractures, foot sprains, lower leg and upper leg muscle strains). Dependent variables included the days lost due to the injury. The Wilcoxon Rank Sum Test was used to compare the severity (median days lost, interquartile ranges [IQR]: 25th and 75th) of the injuries that occurred in the braced and control group. **Results:** One hundred seventy five injuries ($n = 70$ braced group, $n = 105$ control group) were recorded. There was no difference in the severity ($p = 0.223$) of ankle injuries ($n = 26$ braced, 5.0 days [3.0, 8.25]) compared to the control group ($n = 78$, 6.0 days [4.0, 11.0]). There was no difference ($p = 0.994$) in the severity of acute knee injury in the braced group ($n = 15$, 59.0 days [16.5, 180.0]) compared to the control group ($n = 13$, 60.0 days [13.0, 180.0]). There was no difference

($p = 0.696$) in the severity of the lower extremity injury between the braced group ($n = 30$, 5.0 days [3.0, 8.0]) and the control group ($n = 14$, 5.0 days [3.0, 13.7]) in the control group. **Conclusions:** Using a lace-up ankle brace did not reduce the severity of lower extremity injuries sustained by high school basketball players.

Effects Of Kinesio® Taping On Ankle Proprioception In Healthy Individuals

Burningham DS, Berry DC: Weber State University, Ogden, UT, and Saginaw Valley State University, University Center, MI

Context: Kinesio® tape has reportedly been used by healthcare providers in reducing edema, strengthening muscles, decreasing pain, and relieving abnormal muscle tension. Product manufacturers also advertise the tape's ability to increase proprioceptive awareness. However, research examining this property is limited. **Objective:** To determine the efficacy of Kinesio® tape on ankle joint proprioception. **Design:** A single blinded, randomized, counter-balanced model. **Setting:** Human performance laboratory. **Participants:** Healthy subjects (age= 23.68±4.65 years, mass=76.69±16.32 kg, height =175.43±9.73 cm) meeting the following inclusion criteria: 1) 18-45 years of age, 2) right foot dominant, 3) without foot or ankle abnormalities, and 4) without foot or ankle injury in the past 9 months. **Intervention:** Subjects were randomly allocated into tape first or no-tape first groups (independent variable). Ankle proprioception was determined by subjects' active reproduction of joint position sense (RJPS) for 26° dorsiflexion and 20° plantar flexion. Data was collected using a Kin-Com 125AP (Isokinetic International, Harrison TN). The subjects were blindfolded with the right forefoot strapped to the footplate. Subjects were instructed to move into 26°

dorsiflexion, maintaining that position for 5 seconds; and then instructed to move into 20° plantar flexion, maintaining that position for 5 seconds. This series was repeated three times, after which subjects were passively moved to neutral (0°). From neutral, subjects were instructed to reposition their foot into dorsiflexion to where they believed their foot was when the machine stopped them and signal researchers when there; this angle was recorded. Subjects were then instructed to reposition their foot into plantar flexion where they believed the machine stopped them previously, and signal researchers when there; this angle was recorded. This series of dorsiflexion to plantar flexion RJPS was repeated a second time. Subjects were allotted a 3 minute window wherein they were either taped or untaped before repeating the test sequence. Data was analyzed using a paired *t*-test. Significance was set a priori at $p < 0.05$. **Main Outcome Measures:** Pre and post RJPS angle measurements were recorded for ankle dorsiflexion and plantar flexion. Dependent variables were relative and absolute error for ankle dorsiflexion and plantar flexion joint angles using the means of the two trials. **Results:** Testing revealed a significant difference in the relative error for ankle RJPS of 26° dorsiflexion (tape $M = 6.57 \pm 5.07$, no-tape $M = 3.89 \pm 5.97$, $p = .027$). There were no significant differences for the absolute error ($p = .131$) for dorsiflexion, or in the relative ($p = .847$) or absolute error ($p = .730$) for 20° plantar flexion. **Conclusions:** The significant difference in the dorsiflexion relative error suggests Kinesio® tape hinders ankle RJPS in this movement. The lack of significant differences in all other measurements is supportive of previous work suggesting that Kinesio® tape does not likely enhance proprioceptive awareness in active ankle RJPS in healthy adults.

The Effects Of Ankle Taping On Dynamic Postural Control, Perceived Confidence And Pain In Patients With Acute Ankle Sprains

Haynes MB, Vela LI, Liu T, McCurdy K: Texas State University, San Marcos, TX

Context: Ankle sprains are the most common lower extremity injury in sports accounting for as much as 15% of all sports related injuries. Most individuals with ankle injuries (80%) in intercollegiate sports return to sports less than 10 days after injury. Often ankles are braced and/or taped in order to give additional external support during the time period when athletes return to physical activity and ligament tensile strength is compromised.

Objective: To identify the effects of injury and ankle taping on dynamic postural control (DPC) in participants with acute lateral ankle sprains. In addition, confidence using the Injury-Psychological Readiness to Return to Sport (I-PRRS) Questionnaire and pain, assessed with the Graphic Pain Rating Scale (GPRS), were assessed in both taped and non-taped conditions.

Design: Crossover controlled trial. **Setting:** All tests were completed in the university athletic training room.

Participants: Twenty-one, physically active, adult volunteers (16 males, 5 females; age= 20.43±1.54; mass=81.37kg ±20.72; height= 178.21cm ±8.6), who had sustained a unilateral, acute, mild or moderate lateral ankle sprain participated in the study within 5 days of injury. **Interventions:** Participants were tested under two conditions, taped and non-taped, on both the affected and unaffected leg. **Main Outcome**

Measures: DPC was calculated using the Star Excursion Balance Test (SEBT) in the anterior, posterior medial, and posterior lateral reach directions on both injured and un-injured limbs under both conditions. Reach distance was normalized to leg length and averaged across three trials for each condition and direction, The I-PRRS (Cronbach's = 0.78, $r = 0.82$) and GPRS were administered after the SEBT under each

condition on the affected leg. DPC scores in the three directions for each leg and condition were analyzed using a doubly multivariate MANOVA. Pain and confidence were analyzed on the injured limb under both conditions using a paired t-test. **Results:** Ankle taping (2.24 ± 1.81) was found to significantly decrease pain ($t(20)=-2.37$, $p=0.028$) when compared to the non-taped condition (2.9 ± 1.94). Taping (86.77 ± 12.05) increased confidence ($t(20)=2.83$, $p=.010$) during the SEBT when compared to no support (79.0762 ± 21.49525). Injury significantly decreased overall DPC ($F(3,18)=3.855$, $p=.027$), anterior DPC ($F(1,20)=9.721$, $p=.005$), and posterior lateral DPC ($F(1,20)=7.893$, $p=.011$). DPC was not significantly affected by the use of ankle tape while completing the SEBT. **Conclusions:** This study indicated that the use of ankle tape on an acute lateral ankle sprain has the potential to decrease pain and increase confidence while not significantly affecting DPC. Although taping did not greatly affect performance, athletic trainers should consider the psychological benefits of taping.

Comparison Of Self Adherent And Cloth Tape On Dynamic Ankle Inversion Before And After Exercise

Knight BD, Oney JR, Miller MG, Gyorkos AM: North Carolina Wesleyan College, Rocky Mount, NC; IncreMedical, Michigan City, IN; Western Michigan University; Kalamazoo, MI

Context: Ankle sprains are the most common injury sustained during athletic competition and new taping products are being manufactured that are purported to provide more support. **Objective:** To determine if self-adherent tape provides more structural support of the ankle by decreasing inversion range of motion as well as range of motion velocity when compared to the cloth tape before and after exercise. **Design:** Crossover experimental study. **Setting:** Human performance research laboratory. **Patients or Other**

Participants: Twenty-one college-age male and female students (12 males, 9 females; mean age = 21.3 ± 1.6 years, height = 170.78 ± 10.8 cm, mass = 75.81 ± 17.51 kg) participated in this study with no past surgery or acute injury to right ankle. **Interventions(s):** The independent variables were conditions (no tape, cloth tape, and self-adherent tape) and time (before and after exercise). Participants were asked to perform three drops on an inversion platform before and after exercise for three taping conditions. An exercise protocol consisting of four exercises was used to simulate athletic movement. An inversion platform rotating 36 degrees activated by a magnetic quick release was used to create an inversion motion. Data was collected using Modus Video capture system. **Main Outcome Measure(s):** A two-within (condition x time) repeated measures ANOVA was performed on the dependent variables, maximum inversion range of motion, time to maximum inversion range of motion, and maximum velocity. **Results:** The repeated measures ANOVA for maximal inversion range of motion showed a main effect for time ($F_{1,19} = 12.72$, $p < .002$) and a main effect for condition ($F_{2,39} = 53.02$, $p < .001$). Maximum inversion increased $1.2 \pm 0.6^\circ$ for the no tape condition, $1.5 \pm 0.1^\circ$ for cloth tape and $1.5 \pm 1.1^\circ$ for self-adherent tape. There was a condition by time interaction for time to maximum inversion ($F_{2,38} = 4.142$, $p < .024$). Post hoc testing showed that no tape (0.362 ± 0.045 seconds) was significantly faster than the cloth tape (0.405 ± 0.050 seconds) after exercise. There was a condition by time interaction for maximum inversion velocity for self-adherent tape ($F_{2,40} = 3.586$, $p < .037$). Post hoc testing showed that no tape ($648.674 \pm 98.478^\circ \text{ s}^{-1}$) was significantly different from cloth tape ($508.203 \pm 51.620^\circ \text{ s}^{-1}$), as well as no tape was significantly different from self-adherent tape ($565.485 \pm 118.426^\circ \text{ s}^{-1}$) after exercise. **Conclusions:** What can be gained from this study is that the self-adherent tape and cloth tape were

equally effective in providing prophylactic support to the ankle joint.

The Effect Of External Prophylactic Support On Ankle Laxity In Healthy, Unstable, And Previously Sprained Ankles Following Functional Activity

Miller HE, Needle AR, Swanik CB, Gustavsen G, Kaminski TW: University of Delaware, Newark, DE

Context: Ankle sprains account for 15 percent of athletic injuries and nearly 850,000 annual emergency room visits. To both prevent and accelerate recovery and return-to-play from ankle sprains, clinicians frequently employ the use of external prophylactic support (EPS), such as taping and bracing, in order to address insufficiencies of the passive support structures. While common practice clinically, research has been inconclusive in demonstrating the effectiveness of EPS on restricting laxity throughout athletic activity, as well as its efficacy in restricting ankle laxity in patients with complaints of functional ankle instability (FAI) and those with a history of previous ankle sprain. **Objective:** To investigate the effectiveness of EPS type (Tape, Brace, None) on ankle laxity before and after exercise in subjects with complaints of instability (FAI), subjects with a history of ankle sprain, but no instability (SPR), and a control group (CON). **Design:** Pre-test/post-test design with control group. **Setting:** Human performance laboratory. **Patients or Other Participants:** Ankles from twenty-four participants (20.6 ± 1.6 yrs, 173.6 ± 8.3 cm, 72.8 ± 12.2 kg) were placed into one of three groups; FAI, SPR, CON. **Interventions:** Ankle laxity was assessed on subjects before and after the application of one of the three EPS-types utilizing a reliable and validated ankle arthrometer (Blue Bay Research, Inc., Milton, FL). Subjects then completed a 20-minute functional exercise protocol (FEP) consisting of sprinting, cutting, and jumping

maneuvers. The FEP was designed to simulate sport-like activities and intensity. Following the FEP, ankle laxity was again assessed before and after removal of the EPS. Subjects were tested using a counterbalanced order on 3 separate days, with each day utilizing a different EPS. **Main Outcome Measures:** Ankle anterior displacement (ANT), inversion rotation (INV), and eversion rotation (EVR) measured under three conditions (Tape, Brace, None) and in three groups (FAI, SPR, CON). A 3-way repeated measures ANOVA was utilized to analyze differences between the groups and within EPS type and pre-post exercise. An alpha level of 0.05 was set *a priori*. **Results:** Taping and bracing each decreased laxity from pre-application (ANT=6.1±2.0mm; INV=25.0±6.9°; EVR= 17.5±7.0°) to pre-exercise (Tape: ANT= 2.9±.96mm, INV=11.3±3.9°, EVR= 7.6±3.1°; Brace: ANT=3.0±1.4mm, INV=12.6±5.4°, EVR=8.4±4.0°; p<.05) and post-exercise (Tape: ANT=4.1±1.1mm, INV=14.0±4.2°, EVR=9.1±3.5°; Brace: ANT= 3.8±1.6mm, INV=16.8±6.4°, EVR= 10.9±4.9°; None: ANT=6.3±2.3mm, INV=26.1±6.9°, EVR= 17.61±4.6°; p<.05). Tape provided greater restriction post exercise in inversion and eversion rotation (p<.05). Additionally, the FAI group demonstrated significantly greater ANT post-exercise after removal of the brace compared to other groups (FAI=7.3±1.6mm, SPR=5.5±2.5mm, CON=5.8±1.8mm p<.05). **Conclusions:** The use of EPS at the ankle appears to significantly decrease ankle laxity before and after physical activity as compared to a control no tape/brace condition. While neither taping nor bracing was more effective than the other, bracing appeared to cause a greater increase in post-exercise laxity in subjects with complaints of ankle instability.

The Effect of Kinesio Taping on Proprioception in Shoulder Impingement Syndrome

Takaoka A, De La Torre L, Ransone JW: Texas State University, San Marcos, TX

Context: Shoulder impingement syndrome (SIS) is most common cause of shoulder pain in young athlete with over-head activities. Theoretically, Kinesio tape may improve sensorimotor control by proprioceptive feedback and facilitate muscle activities. **Objective:** To determine if Kinesio tape increase shoulder proprioception in SIS subjects. **Design:** Randomized controlled trial. **Setting:** Controlled, laboratory setting. **Participants:** Fifteen healthy subjects (6F, 9M; F; 22.5 ±1.9 years, 157.5 ±5.5cm, 63.1 ±6.7kg, M; 22.9 ±1.4 years, 174.4 ±7.4cm, 88.5 ±14.4kg) and fifteen SIS group (7F, 8M; F; 23.3 ±3.4years, 161.8 ±7.6cm, 65.1 ±16.7kg, M; 24.9±2.9 years, 180.9±7.1cm, 84.0±9.2kg) Inclusion criteria were 1) positive Hawkins-Kennedy or Neer's test and 2) weakness or reproduction of pain during Empty Can Test. All subjects did not have surgeries within the past two years. **Interventions:** The Biodex 4 isokinetic dynamometer (Shirley, NY) measured both passive and active joint position sense. Subjects were asked to wear a blindfold and earplugs to minimize their visual and auditory senses throughout each testing session. The emergency stop button was utilized when subjects believed their shoulder reached a previously designated target angles. Target angles evaluated passive ER75°, active ER (AER) 45°, 75° and active IR30°. Neutral shoulder position was set at 90° flexion and 90° abduction with 90° elbow flexion. Subjects had three attempts on each target angle in randomized order, and investigators recorded the angles, which each subject reproduced. Average absolute angular error (AAAE) is an average of angular error (the difference between target angle and reproduced angle among three trials. **Main Outcome Measures:** AAAE was recorded at PROM ER75°

and AROM IR30°, ER 45°, 75°. **Result:** A significant interaction exists between the tape application and health status variables, F(1,27) = 9.98, p= .004. For the healthy subjects the response was higher with the KT (6.83 ± 4.85°) than without it (6.39 ± 4.86°). However, for the SIS subjects, the mean response with the KT (5.38 ± 3.26°) was lower than without it (7.45 ± 5.93°). This effect was consistent across all angles tested, since the interaction among tape, health status, and angle failed to achieve significance, F(3,81) = 0.51, p = .677. **Conclusion:** The study reported AAAE to significantly lower in SIS group after Kinesio tape application. This suggests Kinesio tape may improve shoulder proprioception in SIS population.

The Stabilizing Effect Of Soft Shell Ankle Bracing On Combined Talocrural-Subtalar Joint Motions

Gurchiek LR, Kovaleski JE, Hollis JM, Heitman RJ: Andrews Institute, Gulf Breeze, FL; Blue Bay Research, Navarre, FL; University of South Alabama, Mobile, AL

Context: External ankle support appliances are constructed of various materials depending on the design. Conventional ankle bracing may be constructed of thermoplastic polymer material (e.g., semirigid). Recent technology in ankle brace design incorporates Performathane™ soft-shell technology (Zoom, Ultra Athlete) as an alternative. **Objective:** To compare the effects of a soft-shell hinged ankle brace with those of a hinged semirigid shell ankle brace (Ultra Ankle 2) on rotary displacements of the foot. **Design:** Repeated measures study. **Setting:** Research laboratory. **Participants:** Six normal fresh-frozen cadaver ankle specimens. **Interventions:** The specimen was mounted to a jig proximally via a tibial rod cemented into the tibial medullary cavity and distally via an athletic shoe fixed to a mounting plate of the testing machine. The specimens were loaded

to 2 Nm in internal-external rotation at 0° plantar-flexion (PF), as well as 4 Nm inversion-eversion rotation at 15° PF. Exercise consisted of dorsi-plantar flexion cycling to ± 1.5 Nm for 10 minutes. Each trial involved testing the ankle before the application of a brace, pre-exercise braced, and after exercise with the brace still present on the ankle. Brace type was randomly assigned prior to testing. Data was obtained from two trials (semirigid and soft-shell) across three support conditions (no braced (NB), pre-exercise braced, and post-exercise braced) and analyzed with separate two by three repeated measures ANOVA's. Post-hoc analysis was performed with Bonferroni multiple comparisons. Significance was set a priori at $P < .05$. **Main Outcome Measurements:** The dependent variables were total internal-external rotation and inversion-eversion (I-E) rotation (° ROM) of the ankle complex. **Results:** A significant condition main effect was found for inversion-eversion rotation ($\lambda = .12$, $F_{2,4} = 14.33$, $P = .015$). Before exercise, application of either brace produced significant reductions in ROM (semirigid brace [$37.3 \pm 10.0^\circ$, $P < .001$] and soft-shell brace [$41.44 \pm 10.8^\circ$, $P = .008$]) when compared to the NB condition ($62.51 \pm 17.4^\circ$). No differences ($P > .05$) were found between pre-post exercise conditions for either the semirigid brace ($38.38 \pm 9.9^\circ$) or soft-shell brace ($43.04 \pm 13.1^\circ$), despite the semirigid brace demonstrating greater restriction ($-4.7 \pm 3.2^\circ$). A significant trial by condition interaction was found for internal-external rotation ($\lambda = .18$, $F_{2,4} = 9.02$, $P = .033$). Post-hoc analyses showed no statistical differences between brace support pre-exercise (semirigid: $31.3 \pm 14.9^\circ$, soft-shell: $35.5 \pm 12.8^\circ$, $P = .104$) or post-exercise (semirigid: $33.9 \pm 15.6^\circ$, soft-shell: $34.56 \pm 12.7^\circ$, $P = .793$). **Conclusions:** Our data indicate that both semirigid and soft-shell ankle brace supports are similarly effective in restricting motion before and after exercise. Clinicians may be assisted by objective data on the amount and

nature of passive support when using ankle braces for their athletes.

Free Communications, Poster Presentations: Undergraduate Poster Awards

Monday, June 20, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

Reliability And Validity Of Measuring Scapular Upward Rotation Using An Electrical Inclinometer

Ingram RL, Tucker WS: University of Central Arkansas, Conway, AR

Context: Numerous techniques have been proposed to qualitatively and quantitatively measure upward rotation of the scapula. These techniques are limited by expense or an inability to be synchronized with other measurements, such as muscle activity and force output. Implementing accurate and practical assessment techniques for the scapula is imperative for clinical diagnosis and treatment of shoulder dysfunction.

Objective: To assess the reliability and validity of a modified two-dimensional electrical inclinometer (Noraxon USA, Inc, Scottsdale, AZ) to measure scapular upward rotation during static humeral elevation.

Design: Test-retest. **Setting:** Controlled laboratory environment.

Patients or Other Participants: Thirty healthy male subjects, 11 athletes (21.1±1.2 yrs, 181.0±7.0 cm, 84.6±16.3 kg) and 19 non-athletes (22.4±2.7 yrs, 177.7±6.6 cm, 88.0±12.6 kg).

Interventions: For validity testing, scapular upward rotation was measured on the dominant arm with a digital protractor and electrical inclinometer while subjects were at rest and at 60°, 90 and 120 of humeral elevation in the scapular plane. Three trials were performed at each position. During each trial, separate static measurements were taken with both instruments at each position. There was a thirty second rest period between each trial. Order of position and instrument were randomized. For reliability testing, either 20 minutes before or 20 minutes after validity testing, subjects performed the testing positions while measurements were taken with the electrical inclinometer only. For each

instrument at each testing position, the upward rotation measurements were averaged. Validity and reliability were analyzed at all four arm positions. Validity of the two instruments was analyzed using Pearson Product Moment correlation coefficients.

Intraclass correlation coefficients (ICC) (3,1), 95% confidence intervals (CI) and standard errors of the mean (SEM) were used to analyze the reliability of the electrical inclinometer.

Main Outcome Measures: Mean upward rotation at rest, 60°, 90 and 120°. **Results:** Significant correlations existed between the electrical inclinometer and digital protractor at rest ($r=0.989$; $p<0.001$), 60 ($r=0.996$; $p<0.001$), 90 ($r=0.989$; $p<0.001$) and 120 ($r=0.996$; $p<0.001$).

The ICC (3,1) values for the electrical inclinometer demonstrated good to excellent reliability at rest (0.892), 60 (0.956), 90 (0.954) and 120 (0.975). The 95% CI results at rest, 60°, 90 and 120 were 0.785-0.947, 0.911-0.979, 0.906-0.978 and 0.949-0.988, respectively. The SEM values at rest, 60°, 90 and 120 were 1.8°, 1.5°, 1.6° and 1.1°, respectively.

Conclusions: The modified electrical inclinometer demonstrated good to excellent validity and intrarater reliability when measuring upward rotation of the scapula at all four positions of humeral elevation. The results of this study support the use of the electrical inclinometer to measure scapular upward rotation. These findings provide clinicians and researchers with a practical instrument that can accurately measure scapular upward rotation in synchrony with other measurements, such as electromyography and isokinetic data.

The Effects Of Ankle Kinesio Taping® On Ankle Stiffness And Dynamic Balance

Fayson SD, Needle AR, Kaminski TW: University of Delaware, Newark, DE

Context: Ankle sprains are a leading cause of time-loss in athletics. Taping and bracing are commonly used in both the treatment and prevention of ankle injuries to improve mechanical stability along with balance/proprioception. Recent interest in Kinesio Taping® has forced athletic trainers to examine its' efficacy in both providing mechanical support to a joint and improving proprioception over an extended period of time.

Objective: To examine the immediate effects of Kinesio™ tape application to the ankle joint on ankle stiffness and balance, and to compare this effect following 24 hours of use. **Design:** A single group, pre-test-post-test. **Setting:** A climate-controlled biomechanics laboratory.

Patients or Other Participants: 30 healthy female subjects (age=20.4±1.1yrs; mass=61.9±8.3kg; height =165.0 ±7.6cm) with no previous ankle pathology volunteered for this study.

Interventions: An instrumented ankle arthrometer was used to apply an anterior translational force at the ankle and record corresponding force and displacement. Dynamic balance was measured using time-to-stabilization (TTS) during a 10-second interval following a hopping task onto a force plate. Data from a total of 3 trials involving 4 different jump tasks were recorded. Data were collected and analyzed using custom LabVIEW (National Instruments Corporation, Austin, TX) software. All subjects participated in stiffness and balance testing prior to Kinesio Taping® application, immediately after the application of Kinesio Taping®, and after 24-hours of tape use. The ankle Kinesio Taping® Method was

employed using Kinesio® Tex Gold™ (Kinesio Holding Company, Albuquerque, NM). **Main Outcome Measures:** Anterior stiffness (N/mm) measurements were analyzed using a 2-way repeated measures analysis of variance (ANOVA) with 2 within-subjects factors (Force, Condition). TTS values (sec) were compared using a 3-way repeated measures ANOVA with 3 within-subjects factors (Condition, Hop Direction, GRF Component). An *a priori* significance level was set at $\alpha=0.05$. **Results:** The use of Kinesio® Tex Gold™ caused a significant increase in ankle stiffness from baseline (13.2 ± 0.9 N/mm) to immediately after initial application (16.5 ± 0.6 N/mm, $p=.006$) and following 24-hours, (15.5 ± 0.7 N/mm, $p=.01$). There was a significant effect of hopping direction on GRF component ($F_{6,108}=323.9$, $p=.001$); however, there was no significant effect of tape application on TTS ($F_{2,36}=.03$, $p=.97$). A statistical trend was observed demonstrating a potential effect of condition on GRF component and hop direction ($F_{12,216}=1.7$, $p=.08$). **Conclusions:** Kinesio Taping® caused an increase in anterior stiffness at the ankle joint immediately following initial application and following 24-hours of use. This evidence supports the use of this tape for providing additional mechanical support over an extended period of time. However, the Kinesio™ tape application did not affect dynamic balance as measured through TTS. While no effect was observed on this dynamic task, further research is warranted as to the effects Kinesio Taping® has on postural stability as well as other direct measures of proprioception.

Changes In Multi-Segment Foot Biomechanics Between Molded And Non-Molded Semi-Custom Foot Orthotic Devices

Benson BA, Ferber R: Faculty of Kinesiology, University of Calgary, Calgary, AB, Canada

Context: Semi-custom foot orthoses are thought to be a cost-effective alternative to traditional custom-made orthoses. However, the few studies that have investigated these products all involved pre-fabricated and non-moldable orthoses and only measured rearfoot biomechanics. **Objective:** To determine changes in multi-segment foot biomechanics while walking in semi-custom orthoses (SCO), direct from the packaging and non-molded (SCOn), and following a heat-molding process (SCOm), compared to a no-orthotic (NO) condition. We hypothesized the SCO would reduce peak rearfoot eversion (RFEV), medial longitudinal arch deformation (MLAD), and plantar fascia strain (PFS), in both the molded and non-molded condition, compared to NO. **Design:** Crossover, repeated measures. **Setting:** Clinical research laboratory. **Patients or Other Participants:** Twenty healthy individuals (9 males, 11 females: age= 24.6 ± 4.9 yrs, height = 176.5 ± 8.6 cm, mass= 75.9 ± 11.7 kg) volunteered through informed consent. **Interventions:** Retroreflective markers were placed on the right limb to represent forefoot, midfoot, rearfoot and shank segments. 3D kinematics were recorded using an 8-camera motion capture system (Vicon, Oxford, UK: 120Hz) placed around a treadmill while subjects walked at 1.1 m/s. Visual 3D (C-Motion Inc., USA) software calculated all variables of interest during the stance phase. Data were collected for three conditions: SCOn, SCom, and NO, using a neutral lab running shoe (New Balance, USA) and the order was randomized. **Main Outcome Measures:** 3D marker trajectories were calculated using custom-written Matlab software

(Natick, USA). RFEV (degrees) was measured as frontal plane movement of the rearfoot relative to the shank. MLAD (degrees) was modeled as a triangle from medial calcaneus, first metatarsal head, and navicular markers. PFS is a unitless measure calculated by approximating the plantar fascia as spanning between the first metatarsal head and calcaneus and determined as change in relative marker position. Between-condition differences were determined using 1 (group) x 3 (condition) repeated measures ANOVAs and a priori post-hoc testing ($P\leq 0.05$). **Results:** There were no significant differences ($P=0.34$) in peak RFEV between NO (4.44 ± 1.58 deg) and SCom (4.18 ± 1.60 deg) or between SCom and SCOn (4.63 ± 1.51 deg; $P=0.49$). There were no significant differences ($P=0.48$) for peak MLAD between NO (205.40 ± 8.07 deg) and SCom (205.30 ± 7.72 deg) or between SCom and SCOn (205.62 ± 6.87 deg; $P=0.45$). PFS was significantly ($P=0.03$) reduced for SCom (0.07 ± 0.02) compared to NO (0.08 ± 0.01) but not different ($P=0.10$) between SCom and SCOn (0.07 ± 0.02). **Conclusions:** A semi-custom molded orthotic does not control peak rearfoot eversion or medial longitudinal arch deformation, but does, however, reduce plantar fascia strain compared to walking without an orthoses. Heat-molding the orthotic device does not have an effect on any biomechanical variables compared to the non-molded condition. This study was supported, in part, by a charitable donation from SOLE Inc. and the University of Calgary PURE Award.

Reliability Of Various Methods For Assessment Of Static Lower Extremity Alignment

Hartley EM, Boling MC, Nguyen AD, Slye CA, Parisi GL: University of North Florida, Jacksonville, FL, and College of Charleston, Charleston, SC

Context: Altered static lower extremity alignment (SLEA) is thought to predispose athletes to knee injuries. In order to prospectively examine risk factors in large cohorts, accurate and efficient measurement methods are essential. **Objectives:** To determine the measurement reliability of SLEA between clinical measures (CM) and digital pictures (DP) within and between a trained and novice investigator, and also between CM, DP, and an electromagnetic motion tracking system (EMTS). **Design:** Reliability. **Setting:** Research laboratory. **Patients or Other Participants:** Seventeen individuals (10 females, 7 males: 21.3±1.8yrs, 172.2±9.2cm, 70.3±9.9kg) participated in study 1 that examined the reliability between CM and DP within (intra-tester) and between (inter-tester) a trained and novice investigator. Sixteen individuals (11 females, 5 males: 22.3±1.6yrs, 170.3±6.9cm, 72.9±16.4kg) participated in study 2 that examined the reliability between CM, DP, and an EMTS. **Interventions:** Measures of pelvic angle (PA), quadriceps angle (QA), tibiofemoral angle (TFA), genu recurvatum (GR), femur length (FL), and tibia length (TL) were evaluated. CM were assessed by a single examiner, with previously established reliability ($ICC_{2,k} > 0.87$). For the DP, reflective markers were adhered to anatomical landmarks. Frontal and sagittal plane views were taken using a digital camera on two separate occasions by two investigators (trained and novice), and ImageJ software was used to calculate SLEA. For the EMTS, anatomical landmarks were digitized to calculate SLEA. **Main Outcome Measures:** The

average of 3 measurements for CM and DP and the average measurement across a 5-second static trial for EMTS were used for analyses. Intraclass correlation coefficients ($ICC_{2,k}$) and standard error of measurements (SEM) were calculated between CM and DP for each investigator to determine the inter- and intra-tester reliability, and between CM, DP, and EMTS. **Results:** Both investigators had good to excellent test-retest reliability ($ICC_{2,k} = 0.84-0.99$) for measures of PA, QA, TFA, FL, and TL. The novice investigator had good consistency and precision in measures of GR ($ICC_{2,k} = 0.87$, $SEM = 1.1^\circ$), however, this was lower in the trained investigator ($ICC_{2,k} = 0.70$, $SEM = 1.4^\circ$). Fair to excellent agreement ($ICC_{2,k} = 0.75-0.95$) was observed between investigators in measures of QA, TFA, GR, FL, and TL, with poor agreement in the measure of PA ($ICC_{2,k} = 0.43-0.59$). Fair to excellent agreement ($ICC_{2,k} = 0.69-0.95$) was observed between CM and DP for QA, TFA, FL, and TL with lower agreement in the measure of PA ($ICC_{2,k} = 0.56-0.69$) and GR ($ICC_{2,k} = 0.56-0.89$). When comparing CM and DP to EMTS, good to excellent reliability was observed in measures of QA, TFA, FL, and TL ($ICC_{2,k} = 0.80-0.98$) while lower reliability was observed in measures of PA ($ICC_{2,k} = 0.38-0.60$) and GR ($ICC_{2,k} = 0.65-0.91$). **Conclusions:** The use of DP and an EMTS appear to be accurate, efficient, and reliable methods that can be used by minimally trained investigators to assess measures of frontal plane knee alignments and limb length measurements. (*Funded by University of North Florida Student Mentored Academic Research Team Grant*)

Does Lower Extremity Alignment Predict Hip And Knee Kinematics During A Single Leg Landing?

Slye CA, Nguyen A, Parisi GL, Boling MC, Rozzi SL: College of Charleston, Charleston, SC, and University of North Florida, Jacksonville, FL

Context: Altered static lower extremity alignment (LEA) has been theorized to contribute to dynamic malalignment, thereby increasing the risk of knee injuries. Limited research has been performed to quantify the relationship between LEA and dynamic joint motion, particularly during functional tasks, which are common in sports where lower extremity injury rates are high. In addition to this, there is a lack of research investigating the influence of LEA on dynamic joint motion in males and females separately. **Objective:** To determine the influence of static LEA on frontal and transverse plane hip and knee joint excursions during a single leg landing (SLL) task in males and females. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Forty females (21.0±1.7yrs, 167.3±6.0cm, 64.2±9.5kg) and forty males (21.9±1.8yrs, 179.7±7.0cm, 78.4±12.1kg), with no current or previous lower extremity injury that would alter LEA or detract from the ability to perform a SLL, volunteered to participate in this investigation. **Interventions:** Pelvic angle (PA), femoral anteversion (FA), hip internal rotation range of motion (HIR), hip external rotation range of motion (HER), genu recurvatum (GR), tibial torsion (TT), and navicular drop (ND) were measured during three trials on the dominant stance limb by a clinician with known reliability ($ICC_{2,k} > 0.87$). All LEA measures were recorded to the nearest degree or centimeter. The SLL task consisted of participants landing onto a force platform from a height of 45cm. A three-dimensional motion analysis system was used to assess kinematics of the hip and knee during five SLL

trials on the dominant stance limb.

Main Outcome Measures: Frontal and transverse plane hip and knee joint excursions were calculated by subtracting the initial contact joint angle from the peak angle determined during the deceleration phase, which was defined as the time period between initial contact ($\text{GRF} \geq 10\text{N}$) and peak knee flexion. LEA values were averaged over the three data collection trials and joint excursions were averaged over the five SLL trials. Stepwise linear regressions were performed to determine the extent to which the LEA measures predicted frontal and transverse plane hip and knee joint excursions in males and females. **Results:** Increased FA was a predictor of increased hip internal rotation excursion in females, explaining 21.7% of the variance ($P=0.039$). No other LEA variables were predictive of joint motion in males or females during the SLL task (all $P>0.05$). **Conclusions:** Structural deformity of the hip (FA) appears to be an important alignment factor contributing to transverse plane excursion of the hip during a SLL task in females. While the other LEA variables were not predictive of dynamic joint motion in males and females, future research should examine the influence of LEA on other variables influencing dynamic motion, such as muscle activity and joint moments.

Free Communications, Poster Presentations: Master Poster Awards

Monday, June 20, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

Quantification Of Knee Load Associated With Increased Risk For Specific Knee Injury Incidence

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Medicine, Columbus, OH

Context: Patellofemoral dysfunction and the resultant pain symptoms (PFP) affects up to 30% of people aged 13-19 years. PFP symptoms lead three-quarters of affected patients to limit recreational activities or to cease physical activity altogether. Injuries to the Anterior Cruciate Ligament (ACL) result in the greatest time lost from sport and recreational participation by young athletes. Interestingly, there is a similar sex disparity in both conditions, as adolescent females and young women are affected with PFP and ACL injury 2-10 times more often than their male counterparts. Altered or reduced motor control during physical activities result in excessive knee abduction joint load in females. This neuromuscular dysfunction appears to increase risk of acute ACL injury and chronic PFP in females.

Objectives: The purpose of this study was to compare incidence rates and threshold knee abduction load during landing associated with increased risk of PFP and ACL injury. **Design:** Prospective cohort study. **Setting:** Controlled laboratory. **Patients or Other Participants:** Middle and high school female athletes (n=145) were evaluated by a physician for PFP and for landing biomechanics prior to their basketball season and monitored by certified athletic trainers for PFP during their competitive seasons. Likewise, 205 high school female volleyball, soccer and basketball athletes were evaluated for landing biomechanics prior to their competitive season and monitored for

ACL injury during their competitive seasons. **Interventions:** Logistic regression analyses determined threshold knee abduction moment cut-scores that provided the maximal sensitivity and specificity for prediction of PFP and ACL injury risk. Incidence rates were expressed per 100 athlete competitive seasons. **Main Outcome Measure:** Positive PFP and ACL injury status. **Results:** The cumulative incidence rate for new PFP incidence was increased 2.2 (95% CI 1.11 to 4.34) relative to ACL injury when normalized per 100 athlete seasons (PFP 9.7 vs ACL 4.4). Regression analysis indicated that PFP risk increased in athletes who demonstrated >15.4 Nm of knee abduction, while ACL injury risk increased with peak landing knee abduction torque >25.3 Nm. **Conclusions:** Females who demonstrate >15 Nm of knee abduction during landing may be at increased risk for the development of PFP and those who demonstrate >25 Nm of knee abduction during landing may be at increased risk for both PFP and ACL injury. The increased incidence of PFP relative to ACL injury is likely associated with the reduced threshold of knee abduction associated with increased risk of PFP. Focused pre-season exercise intervention may be warranted for females who land with greater than 15 Nm of knee abduction, while those females who land with >25 Nm of knee abduction may benefit from increased treatment dosage gained from both pre-season and in-season neuromuscular training protocols aimed to reduce knee abduction and PFP/ACL injury incidence.

Differences In Active Range Of Motion Among Individuals With Functional Ankle Instability, Copers And Healthy Controls

Goldberg JS, Letchford EC, Wright CJ, Arnold BL, Ross SE: Virginia Commonwealth University, Richmond, VA

Context: While ankle ligamentous laxity has been studied extensively, few researchers have examined the difference in ankle active range of motion (AROM) between healthy individuals and those with functional ankle instability (FAI). To our knowledge, there is no research on AROM in individuals who have experienced a single ankle sprain but no subsequent instability (copers).

Objective: To determine if there are AROM differences in the sagittal (plantarflexion/dorsiflexion) and frontal planes (inversion/eversion) between FAI individuals, copers, and healthy individuals. **Design:** A three-group cross-sectional study. **Setting:** A controlled sports medicine research laboratory. **Participants:** Sixty-five individuals volunteered to participate. Participants included 23 healthy individuals without history of ankle sprain (age=23.17±4.01years, height=1.72±0.08m, mass=68.78±13.26kg, Cumberland Ankle Instability Tool [CAIT]=28.78±1.78), 21 copers with a history of one ankle sprain without giving-way (GW; age=23.48±3.80 years, height=1.71±0.07m, mass=69.62±14.62kg, CAIT=27.86±1.71), and 23 FAI individuals with a history of ≥1 ankle sprain and 2 or more give-ways in the past year (age=23.30±3.84years, height=1.70±0.11m, mass=68.66±14.60kg, CAIT=20.52±2.94, GW/month=5.81±8.42). **Interventions:** During a single visit, each participant completed the CAIT questionnaire to quantify functional limitations and one AROM trial captured with a 12-camera motion analysis system at 100Hz (Vicon,

Oxford, UK). For motion capture, reflective markers were placed on the subjects' foot and shank consistent with the Oxford Foot Model. A trial consisted of maximal AROM in each direction (plantarflexion, dorsiflexion, inversion, eversion) repeated two times. Trials were recorded while participants were seated with approximately 45° of knee flexion.

Main Outcome Measures: Total rearfoot AROM in sagittal plane (calculated as the difference between maximum plantarflexion and maximum dorsiflexion) and frontal plane (calculated as the difference between maximum inversion and maximum eversion) for the involved (sprained) side. For healthy individuals a sham-involved side was designated. A priori we defined 2 orthogonal contrasts, with the first comparing the healthy and coper groups, and the second comparing the FAI group to the pooled healthy and coper groups (stable). Contrasts were performed separately for sagittal and frontal planes. **Results:** In the sagittal plane, the healthy and coper groups were not different ($t = -1.349$, $df = 63$, $p = 0.182$; Healthy: $39.50 \pm 6.43^\circ$, Coper: $42.51 \pm 7.64^\circ$). However, individuals with FAI had significantly less AROM than the pooled healthy and coper group ($t = 2.322$, $df = 63$, $p = 0.023$; FAI: $36.62 \pm 7.81^\circ$, Stable: $40.97 \pm 7.13^\circ$). In the frontal plane there were no significant differences (first contrast: $t = -1.260$, $df = 63$, $p = 0.212$; Healthy: $27.70 \pm 7.18^\circ$, Coper: $30.58 \pm 7.02^\circ$; second contrast: $t = 0.392$, $df = 63$, $p = 0.696$; FAI: $28.38 \pm 8.17^\circ$, Stable: $29.11 \pm 7.17^\circ$). **Conclusions:** Although FAI and copers have both experienced an ankle sprain, only individuals with FAI displayed reduced sagittal plane AROM. It is unclear whether reduced AROM is a causative factor in FAI, or if reduced AROM is a mechanism by which individuals with instability attempt to increase stability.

Comparison Of Patient And Proxy Reporting Of Health-Related Quality Of Life In Adolescent Athletes Who Suffer A Sport-Related Injury That Requires Orthopaedic Consultation

Swank EM, Snyder AR, Hansen ML, Valovich McLeod TC: A.T. Still University, Mesa, AZ, and CORE Institute, Gilbert, AZ

Context: Increased attention has been given to the impact of sport-related injury on the health-related quality of life (HRQOL) of adolescent athletes. Traditionally, HRQOL is measured through patient self-report. However, there are instruments, including the Pediatric Quality of Life Inventory (PedsQL), that allow proxy reporting of HRQOL. Proxy reporting is defined as someone close to the patient completing the health status assessment instead of the patient. Limited information exists comparing patient and proxy reporting of HRQOL following sport-related injury in adolescent athletes. **Objective:** To compare patient ratings and parent-proxy ratings of HRQOL in adolescent athletes who suffer musculoskeletal injuries requiring orthopaedic consultation. **Design:** Retrospective study. **Setting:** Orthopaedic practice. **Patients:** Thirteen consecutive adolescent patients (age: 15.9 ± 1.2 years; height: 177.8 ± 8.9 cm; weight: 74.3 ± 20.0 kg) who suffered a sport-related musculoskeletal injury that required orthopedic consultation and one of their parents. **Intervention:** Adolescent patients with a sport-related musculoskeletal injury and presented to an orthopaedic practice were asked to complete the PedsQL and the patient's parent was asked to complete the parent-proxy version of the PedsQL. Testing occurred on the initial patient visit in the physician's office. **Main Outcome Measure:** The PedsQL is a pediatric generic outcome measure that consists of 23-items, composed of a total score and four sub-scales: physical, emotional, social, and school functioning. Items

are scored on a 5-point Likert scale, with total scores ranging from 0-100 and higher values indicative of better HRQOL. Both the patient self-report and parent-proxy versions of the PedsQL are valid and reliable (ICC=0.88 and 0.90, respectively). Means and standard deviations (SD) were calculated for all scores and comparisons between patient-self report and parent-proxy ratings of HRQOL were made for the PedsQL total score and subscales using Pearson Product Moment correlations (r). Data are reported as (mean \pm SD). Correlations were evaluated using the following scale: 00-.50=little-to-fair correlation, .50-.75=good correlation, and $>.75$ =excellent correlation. **Results:** Pearson Product Moment correlations showed little-to-fair, insignificant ($p > .05$) relationships between the patient self-report and the parent-proxy report of the PedsQL for the total score (patient: 63.6 ± 18.6 ; parent: 77.7 ± 13.8 ; $r = -.09$) and all subscales: physical (patient: 46.5 ± 31.7 ; parent: 68.0 ± 29.8 ; $r = .10$), emotional (patient: 62.7 ± 25.8 ; parent: 77.5 ± 20.6 ; $r = .40$), social (patient: 84.5 ± 16.0 ; parent: 91.1 ± 10.4 ; $r = .10$), and school functioning (patient: 68.9 ± 22.3 ; parent: 80.4 ± 17.9 ; $r = .10$). **Conclusions:** Our results indicate a lack of agreement between adolescent patient and parent-proxy ratings of HRQOL, with adolescents rating their HRQOL lower than their parent. These data suggest that patient perception of HRQOL may be most accurate and supports the use of patient-rated HRQOL in patient evaluation. Assessments of HRQOL made by proxies, even those close to the patient, may not adequately represent the patient's health status. Further investigations into clinician proxies are warranted to determine if healthcare providers better approximate patient HRQOL.

Effects Of Weight-Cutting Tactics On Sideline Clinical Concussion Measures In Division I Collegiate Wrestlers

Friedline AV, Mihalik JP, Register-Mihalik JK, Mays S, Prentice WE, Guskiewicz KM: The University of North Carolina, Chapel Hill, NC

Context: Wrestlers cut weight several times throughout a season to reach competition weight. Since the risk of concussion is high in wrestling and symptom overlap exists between concussion and dehydration, there is a need to examine the effects of cutting weight on clinical measures of concussion. **Objective:** To evaluate the effects of cutting weight on clinical concussion measures in Division I wrestlers. We hypothesize cutting weight will result in clinical deficits. **Design:** Quasi-experimental prospective cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-two Division I collegiate male wrestlers (age=20.0±1.4 years; height=175.0±7.5 cm; baseline mass=79.2±12.6 kg) participated in this study. **Interventions:** Participants completed a preseason concussion baseline (BL) battery that included 3 sideline clinical measures of concussion. Participants were instructed to begin cutting weight the day prior to a scheduled practice (38.6±3.6 days post-BL). A test battery was performed before the start of the subsequent practice (PRE), and repeated following the end of that session (POST). Separate one-way within-subjects repeated measures ANOVA were completed for each dependent variable across the three test sessions (3 in total). In the event of a significant omnibus finding, Tukey post hoc comparisons were employed. **Main Outcome Measures:** Sport Concussion Assessment Tool 2 (SCAT2) total score, Balance Error Scoring System (BESS) total error score, and Graded Symptom Checklist (GSC) symptom severity score served as our dependent variables. Our independent variable was test session

(BL, PRE, and POST). We observed high intratester reliability using a subset of 20 baseline BESS videos re-evaluated after the completion of the study ($ICC_{3,1}=0.95$; $SEM=1.22$). **Results:** A significant difference in SCAT2 total scores across test session was observed ($F_{2,62}=13.91$; $P<0.001$) such that PRE (90.2±5.0) and POST (87.9±6.4) scores were significantly worse than BL (93.1±3.9) measures. We also observed a significant difference in GSC severity score across test session ($F_{2,62}=16.54$; $P<0.001$), with wrestlers reporting higher symptom severities at PRE (5.4±9.8) and POST (12.7±13.8) compared to BL (1.0±2.9). Further, GSC symptom severities were greater at POST compared to PRE ($P=0.003$). We further observed a significant difference in BESS total error score across test session ($F_{2,62}=5.68$; $P=0.005$). The number of errors committed was higher during POST (18.8±6.7) compared to BL (15.7±5.1). **Conclusions:** Our data suggest that weight-cutting tactics affect several sideline clinical measures of concussion commonly employed by certified athletic trainers. In general, our PRE and POST measures of symptom severity and balance were lower than BL measures. The most important finding of our study is that baseline testing should be conducted while the athlete is properly hydrated, and not during a period when wrestlers are cutting weight. Since the results of clinical testing while athletes are cutting weight may be difficult to interpret, we recommend implementing sideline evaluations once athletes have been properly rehydrated.

An Examination Of Proximal Tibia Anterior Shear Force And Neuromuscular And Biomechanical Characteristics In The Lower Extremity During A Vertical Stop-Jump In Individuals With Chronic Ankle Instability

Terada M, Pietrosimone BG, Armstrong CW, Gribble PA: University of Toledo, Toledo, OH

Context: A kinetic chain relationship between anterior cruciate ligament (ACL) injury and previous ankle sprain has been proposed. There is currently little evidence that has quantitatively assessed neuromuscular and biomechanical factors associated with ACL injury risk, such as proximal tibia anterior shear force (PTASF) and kinematic and muscle activation knee stabilization strategies in individuals with chronic ankle instability (CAI) during high risk functional activities for an ACL injury. Identifying an underlying relationship of the presence of CAI to biomechanical and neuromuscular risk factors for ACL injury may help clinicians to develop a more effective intervention protocol to minimize subsequent proximal joint injury in those with CAI. **Objective:** To investigate the influence of CAI on the amount of peak PTASF as well as neuromuscular and biomechanical characteristics in the lower extremity during a stop-jump task. **Design:** Case control study. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty participants with self-reported unilateral CAI (10M, 10F; 20.15±3.59 yrs; 176.59±9.37 cm; 74.90±17.18 kg), and 20 healthy control participants (10M, 10F; 21.60±4.56 yrs; 171.22±9.34 cm; 70.53±14.68 kg) volunteered. **Interventions:** Participants performed 5 double-leg vertical stop-jump tasks on each limb in a randomized order. Biomechanical and neuromuscular variables were assessed with an electromagnetic tracking system interfaced with a non-conductive force plate and an 8-channel telemetered electro-

myography (EMG) system. **Main Outcomes:** Peak PTASF was calculated during landing of the stop-jump. Knee flexion angle was measured at peak PTASF. The integrated EMG (IEMG) was calculated for the vastus medialis oblique (VMO), vastus lateralis (VL), semitendinosus (ST), and biceps femoris (BF) muscles during 100 ms before and after the initial contact and was normalized by the peak ensemble EMG. A 2×2 (Group, Side) repeated-measures ANOVA was used for each dependent variable. 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. **Results:** A group by side interaction existed for pre-landing IEMG of VMO ($F_{1,36}=8.698$, $P=0.006$). Participants with CAI demonstrated significantly higher pre-landing IEMG of VMO in the injured limb compared to the matched limb of control participants (CAI= $52.03 \pm 11.00\%$ -ms, Control= $43.57 \pm 10.32\%$ -ms, $d=0.79$, 95% CI; 0.13, 1.42). Although statistically significant differences were not observed for knee flexion ($F_{1,36}=1.326$, $P=0.257$), we found a moderate effect size between the injured limb of CAI and matched limb of control group ($d=-0.68$, 95% CI; -1.30, -0.03), indicating CAI participants had less knee flexion at peak PTASF (CAI= $26.20 \pm 8.72^\circ$, Control= $32.47 \pm 9.67^\circ$). There were no significant results for peak PTASF or the other EMG measures. **Conclusion:** We found altered neuromuscular control patterns at the knee in the CAI group. These findings may provide insight regarding injury mechanisms and potentially correctable functional deficits that may be associated with contributions to CAI. Funded by the Master's Grant Program of the NATA Research & Education Foundation.

Free Communications, Poster Presentations: Doctoral Poster Awards

Monday, June 20, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

Sagittal Plane Ankle Motion Affects Frontal And Transverse Plane Motion At The Knee And Hip During A Jump-Landing

Begalle RL, Walsh MC, McGrath ML, Boling MC, Blackburn JT, Padua DA: Sports Medicine Research Laboratory, University of North Carolina, Chapel Hill, NC; University of Nebraska at Omaha, Omaha, NE; University of North Florida, Jacksonville, FL

Context: Ankle dorsiflexion displacement serves as an effective energy absorption mechanism when landing from a jump. Decreased dorsiflexion displacement may alter energy absorption strategies and result in compensatory knee and hip motions. **Objective:** To determine the relationship between ankle dorsiflexion displacement and knee and hip joint displacement during a jump-landing task. **Design:** Cross-sectional correlation. **Setting:** Research laboratory. **Participants:** Twenty-three recreationally active volunteers (9 males, 14 females, age 21.63 ± 2.10 years, height = 176.41 ± 11.84 cm, mass = 75.50 ± 14.82 kg) who were injury free at the time of testing and 6 months prior with no history of lower extremity surgery. **Interventions:** Kinematic data were collected during 5 jump-landing trials using an infrared motion capture system. The jump-landing task consisted of jumping from a 12" box to a forward target area placed at a distance of 50% of their standing height. Participants were instructed to land on the target and immediately jump in the air for maximal vertical height. **Main Outcome Measures:** Joint displacement (DSP) values were calculated for the ankle, knee, and hip as the difference between joint angles at the time of peak knee flexion and angles at initial contact. Pearson correlational analyses were performed to determine the relationship between

ankle dorsiflexion DSP and 3-dimensional hip and knee joint DSP values. **Results:** Lesser ankle dorsiflexion DSP (-41.60 ± 14.62) was associated with greater frontal plane knee varus DSP (5.03 ± 8.23 , $r=0.520$, $P=0.011$) and greater transverse plane hip internal rotation DSP (7.43 ± 6.45 , $r=0.482$, $P=0.020$). Ankle dorsiflexion DSP was not associated with knee flexion DSP (68.43 ± 13.53 , $r=0.326$, $P=0.077$), transverse plane knee rotation DSP (8.08 ± 8.62 , $r=0.098$, $P=0.656$), hip flexion DSP (-24.32 ± 9.94 , $r=-0.384$, $P=0.070$), or hip adduction DSP (3.59 ± 4.98 , $r=-0.234$, $P=0.283$). **Conclusions:** Results of this study indicate that limited sagittal plane ankle motion is associated with greater frontal plane motion at the knee and transverse plane motion at the hip. Sagittal plane flexion of the ankle, knee and hip joints work in synchrony to absorb forces upon landing. Restriction in one joint, such as limited ankle dorsiflexion DSP, may result in greater compensatory movement at other joints or in other planes of motion. These motions at the knee and hip are believed to increase the risk of knee injury, such as ACL injury, patellofemoral pain syndrome and osteoarthritis. Identifying ankle joint restrictions and improving sagittal plane ankle range of motion may be an important component of injury prevention programs aimed at improving knee and hip motion control. Support provided by the National Academy of Sports Medicine and National Basketball Athletic Trainers Association.

Trunk Position Is Associated With Combined Knee Loading During An Athletic Cutting Task

Frank BS, Bell DR, Norcross MF, Goerger BM, Blackburn JT, Padua DA: Sports Medicine Research Laboratory, University of North Carolina, Chapel Hill, NC; Wisconsin Injury in Sport Laboratory, University of Wisconsin, Madison, WI; Neuromuscular Research Laboratory, University of North Carolina, Chapel Hill, NC

Context: Triplanar knee loading induces high stress in the anterior cruciate ligament (ACL). Trunk position influences lower extremity biomechanics during landing tasks. However, the relationship between trunk position and triplanar knee loads during an athletic cutting task (CUT) has not been examined. **Objective:** To examine the relationship between trunk position and triplanar knee loads associated with ACL injury risk during an CUT; a mechanism of ACL injury in athletics. **Design:** Cross-sectional correlation analysis. **Setting:** Sports Medicine Research Laboratory. **Participants:** 30 healthy, physically active subjects (15 male, 15 female, age: 20.5 ± 2.5 yrs, mass: 67.50 ± 11.39 Kg, height: 173.78 ± 9.28 cm) participated in this study. **Interventions:** Triplanar trunk kinematics and knee kinetics were collected using an infrared motion capture system and force plate during the first 50% of the stance phase of the side-step CUT on the subject's dominant leg. The CUT task involved performing 3 running steps, jumping over a 17 cm high hurdle before cutting 60° in the opposite direction of the dominant plant leg (5-trials). Average peak triplanar trunk angles and knee kinetics during the CUT were used for analysis. Pearson product-moment correlation coefficients were calculated among peak trunk angles and external knee

kinetics. **Main Outcome Measures:** Peak triplanar trunk angles ($^{\circ}$) were used as predictor variables while knee kinetics served as criterion variables. Peak external knee moments (Nm) of flexion, valgus, internal rotation, and external rotation were normalized to the product of body weight and height. Anterior tibial shear force (N) was normalized to body weight. **Results:** Greater trunk rotation away from the stance limb ($6.92^{\circ} \pm 8.24$) was associated with greater knee valgus moment (0.010 ± 0.005 , $r=0.371$, $p=0.043$). Greater lateral trunk flexion toward the stance limb ($6.80^{\circ} \pm 2.82$) was associated with greater external tibial rotation moment (0.032 ± 0.013 , $r=0.562$, $p=0.001$) and internal tibial rotation moment (0.012 ± 0.010 , $r=0.387$, $p=0.034$). Greater forward trunk flexion ($36.80^{\circ} \pm 9.45$) was associated with greater external tibial rotation moment ($r=0.400$, $p=0.028$). No significant relationships were observed between trunk kinematics and sagittal plane knee kinetics. **Conclusions:** Subjects with greater trunk forward flexion, lateral flexion toward the stance limb, and rotation away from the stance limb exhibited greater transverse and frontal plane knee kinetics associated with ACL injury. The lack of association between trunk kinematics and sagittal plane knee kinetics may be attributed to the nature of the CUT versus landing tasks in previous methodology. Multiplanar loading of the knee imparts greater stress in the ACL, compared to single plane loading. Greater trunk motion during CUT is associated with combined knee loading in the frontal and transverse planes. Interventions focused on improving control of trunk position during athletic tasks may decrease ACL injury risk. Support provided by the National Academy of Sports Medicine and the National Basketball Athletic Trainers Association.

Ankle Dorsiflexion Range Of Motion Is Associated With Hip Muscle Activation

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Context: Frontal plane knee alignment is associated with increased risk of injuries such as patellofemoral pain syndrome and ACL rupture. Knee position can be influenced by the proximal and distal joints. For example, previous research demonstrates that gluteus medius (GMED) and hip adductor (ADD) activation influence lower extremity (LE) kinematics. Restricted ankle range of motion (ROM) is theorized to influence the LE kinematics by increasing frontal plane knee alignment. However, the relationship between GMED and ADD activation and ankle ROM has not been investigated. **Objective:** To determine the relationship between ankle dorsiflexion ROM with GMED and ADD activation. **Design:** Cross-sectional correlational. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-seven healthy subjects (Males=8, Females=29, Ht: 167.0 ± 8.5 cm, Mass: 65.4 ± 11.8 kg, Age: 20.8 ± 2.1 years) participated in this study. Subjects had no history of lower extremity injury within the past 3 months or history of surgery within the past 1 year. **Interventions:** Ankle dorsiflexion ROM with the knee straight (DFKS) and flexed (DFKF) were measured using a goniometer. Surface EMG amplitude of the GMED and ADD were collected during the descent phase of 5 separate double-leg squat trials. All measurements were taken from the dominant leg (leg used to kick a ball for maximal distance). **Main Outcome Measures:** DFKF and DFKS ROM values were averaged across 3-trials and used for analyses. Mean GMED and ADD amplitude

during descent phase of double leg squat was averaged across 5-trials and then normalized to each muscle's maximal voluntary isometric contraction (MVIC). Co-activation ratios between the GMED and ADD (GMED/ADD) were calculated as the mean GMED amplitude divided by the mean ADD amplitude (ratios less than 1 indicate the ADD was more active than GMED). Separate Pearson correlation analyses were performed between the each criterion (DFKF, DFKS) and each predictor variable (GMED, ADD, GMED/ADD) ($\alpha < 0.05$). **Results:** There was no significant correlation between DFKF ($17.41 \pm 6.95^{\circ}$) and GMED (10.93 ± 5.67 %MVIC) ($r=0.310$, $p=0.079$), or ADD (28.59 ± 17.28 %MVIC) ($r=-0.28$, $p=0.11$). Similarly, no significant correlation between DFKS ($9.66 \pm 5.68^{\circ}$) and GMED activation ($r=0.26$, $p=0.15$) or ADD (28.59 ± 17.28 %MVIC) activation ($r=-0.19$, $p=0.30$) was noted. However, GMED/ADD co-activation was significantly correlated with DFKF (0.50 ± 0.45) ($r=0.43$, $p=0.02$) and DFKS ($r=0.40$, $p=0.03$). **Conclusion:** Ankle dorsiflexion ROM was not related to activation of individual hip muscles. However, lower GMED/ADD co-activation ratio was associated with decreased ankle dorsiflexion ROM. Interventions to improve GMED and ADD neuromuscular control, which may alter frontal plane knee kinematics, may benefit from increasing ankle dorsiflexion ROM. The influence of increasing ankle dorsiflexion ROM and improving GMED and ADD neuromuscular control on knee valgus alignment requires further study. Supported by the National Academy of Sports Medicine and National Basketball Athletic Trainers Association.

Validation Of A Recalibrated Cumberland Ankle Instability Tool Cutoff Score For Chronic Ankle Instability

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Context: The Cumberland Ankle Instability Tool (CAIT) is a 9-question ankle function questionnaire that has been used to discriminate between individuals with and without chronic ankle instability (CAI). Recently, a recalibrated CAIT cutoff score was proposed. Using the new value, a score of $d \geq 25$ points indicates likely presence of CAI. However the recalibrated cutoff has yet to be validated on an independent data set. Additionally, it is unknown whether this cutoff score can adequately discriminate between CAI and individuals with a history of ankle sprain but without subsequent re-injury or symptoms of giving way (copers). **Objective:** To cross-validate the recalibrated cutoff score for discriminating individuals with and without CAI on an independent data set. **Design:** A 3 group observational cross-sectional design. **Setting:** University sports medicine research laboratory. **Participants:** Eighty-two individuals from a large metropolitan area volunteered to participate. Participants included 27 individuals with no history of ankle sprain or instability in their lifetime (Controls: 14 males, 13 females, age = 22.89 ± 3.78 yrs, height = 1.71 ± 0.08 m, weight = 69.33 ± 13.90 kg), 26 individuals with a history of a single ankle sprain and no subsequent episodes of instability (Copers: 12 males, 14 females, age = 23.35 ± 3.50 yrs, height = 1.71 ± 0.07 m, weight = 69.81 ± 13.65 kg), and 29 individuals with a history of ≥ 1 ankle sprain and at least 2 episodes of giving-way in the past year (CAI: 15 males, 14 females, age = 23.31 ± 3.53 yrs, height = 1.72 ± 0.10 m, weight = 75.12 ± 19.52 kg, monthly episodes of giving-way = 4.99 ± 7.75). CAIT score was not

an inclusion criteria for any group. **Interventions:** Participants completed the CAIT during a single session using a customized computer program (Access, Microsoft, Redmond, WA). CAIT scores can range from 0-30 points, with higher scores indicating greater function. **Main Outcome Measures:** CAIT score of the involved (sprained) limb was used for analysis. For controls, a sham-involved limb was designated. A receiver operating curve (ROC) was calculated using CAIT score and CAI group membership as the test variables. Area under the curve (AUC) and asymptotic significance was used to identify a significant ROC curve. Sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-), false positives and false negatives were calculated using the recalibrated cutoff score (≤ 25). **Results:** The AUC was significant (AUC = 0.988, $P < 0.001$). The recalibrated cutoff score had a sensitivity of 96.6%, specificity of 86.8%, LR+ of 7.318, LR- of 0.039. There were 7 false positives (1 control, 6 copers) and 1 false negative (1 CAI). The average CAIT score by group was: healthy = 28.93 ± 1.69 , coper = 27.31 ± 2.02 , CAI = 19.59 ± 4.15 . **Conclusions:** The recalibrated CAIT score demonstrated high sensitivity, high specificity, high LR+ and low LR-. Specifically, these characteristics are all improved from the original cutoff. Clinicians and researchers using the CAIT should utilize the recalibrated cutoff score to maximize test characteristics. Caution should be taken when using this score with copers, as these individuals had a higher rate of false positives.

Relationships Between Various Strength Measures and Energy Absorption During Landing

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Context: Decreased thigh muscle strength is thought to relate to stiffer landings and a lesser ability to perform eccentric work to safely decelerate the body. Maximal isometric contractions are often measured because they are easier to perform reliably, but are also criticized as they are not reflective of the muscular demands during landing. Little is known regarding the relationships between the various muscle contraction types or their comparative associations with eccentric work performed (i.e. energy absorption) during landing. **Objective:** Determine the relationships between various maximal muscle contraction types and which contraction type is most predictive of the eccentric work performed during landing. **Design:** Descriptive Cohort. **Setting:** Controlled Laboratory. **Patients or Other Participants:** Male (n = 15; 21.2 ± 3.6 yrs; 1.78 ± 0.1 m; 74.2 ± 11.0 kg) and female (n = 15; 22.3 ± 3.6 yrs; 1.69 ± 0.8 cm; 65.7 ± 8.0 kg) athletes. **Interventions:** Participants performed maximal isometric (MVIC), concentric (Con60, Con180) and eccentric (Ecc60, Ecc180) isokinetic ($60^\circ/\text{s}$ and $180^\circ/\text{s}$) contractions of the quadriceps (Quad) and hamstrings (Ham) on an isokinetic dynamometer and completed 5 drop jump landings from a 0.45m height while instrumented for biomechanical analysis. **Main Outcome Measures:** Normalized average peak torque (Nm/kg) over 3 trials was recorded during MVIC, Con60, Con180, Ecc60, and Ecc180 for Quad and Ham. Total T (hip + knee + ankle) normalized energy absorption (TEA) ($J \cdot N^{-1} \cdot \text{kg}^{-1}$) was calculated from the kinematic and kinetic data during the initial deceleration phase of the drop jump landing.

Pearson-product correlations examined relationships between each mode and speed of torque values. Multiple linear regressions determined the extent to which each mode and speed of Quad-Ham torques (including Ecc-Con, and Con-Ecc) predicted TEA. **Results** : In females, correlations among Quad torque values ranged from 0.589–0.750, with the strongest correlation between MVIC and Con60 ($r=0.750$, $p=.001$); correlations among Ham torques ranged from 0.692–0.873, with the strongest correlation between MVIC and Ecc180 ($r=0.873$, $p<.001$). In males, correlations among Quad and Ham torques ranged from 0.622–0.788 and 0.370–0.571, respectively, with the strongest correlations noted between MVIC and Ecc60 for Quad ($r=0.788$, $p=.001$) and Con60 for Ham ($r=0.571$, $p=.026$). The predictive ability of each combination of quadriceps and hamstring torques ranged from $R=0.392$ – 0.611 in females. Quad2Con60-Ham Con60 and Quad Con180-Ham Con180 were strong predictors of TEA ($R =0.611$, $p=.003$ and $R =0.569$, $p=.004$, respectively) as were Quad Ecc60-Ham 2 Con60 ($R =0.600$, $p=.004$) and Quad Ecc180-Ham Con180 ($R =0.580$, $p=.005$). MVIC was least predictive of TEA ($R =0.392$, $p=.051$). For males, none of the thigh torques 2 were predictors of TEA (R range= 0.163 – 0.279 , $p>.140$). **Conclusions** : Quad and Ham 2 MVIC torques were strongly correlated with Con and Ecc torques. However, Con and Ecc appear to be somewhat more reflective of the dynamic muscle actions performed during landing. The sex-dependent findings suggest that strength may be a more important determinant in deceleration ability in females vs. males. Funded by the Doctoral Research Grant Program of the NATA Research & Education Foundation.

Free Communications, Poster Presentations: Injury & Therapeutic Treatment

Monday, June 20, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

The Anesthetic Effect Of Lidocaine After Phonophoresis Treatments Of Varying Times

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Context: Phonophoresis is a treatment technique that utilizes ultrasound to enhance the penetration of medication through intact skin. Research on phonophoresis has used various parameters and medications resulting in inconclusive results. The ultrasound dosage is determined by the frequency, intensity, duty cycle and time. It is not known whether manipulating the duration and duty cycle affects the absorption of the medication with phonophoresis. A longer duration with a pulsed duty cycle was hypothesized to enhance drug delivery. **Objective:** To determine the anesthetic effect on the anterior forearm following 5 and 10 minute phonophoresis interventions of 1MHz at 1.5 W/cm² using lidocaine. The duty cycle was adjusted so that temporal average intensity was constant with both treatments. **Design:** Double-blinded, crossover. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-two healthy subjects participated (13 Female, 9 male, Age: 23.0±3.2 years, Height: 169.1±7.2 cm, Weight: 70.9±13.9 kg). **Interventions:** All subjects received four interventions on 4 different days separated by 48 hours: Short: 1MHz, 1.5 W/cm², 5 minutes, 100% duty cycle with lidocaine gel; Long: 1MHz, 1.5W/cm², 10 minutes, 50% duty cycle with lidocaine gel; Lidocaine Sham: no ultrasound for 10 minutes with lidocaine gel; and True Sham: no ultrasound for 10 minutes with ultrasound gel. Conditions were randomly assigned. Prior to each treatment, the primary tester cleaned the skin and marked the treatment area with a template. A secondary tester administered the condition, then the

primary tester returned and assessed skin sensation via Semmes Weinstein Monofilaments (SWM) at the specified times: pre-test, post-test, 20 minutes, 40 minutes, and 60 minutes. **Main Outcome Measures:** SWM scores, a unitless measure of skin sensitivity with larger values indicating a greater reduction in sensation. A 4x5 repeated measures ANOVA was used to analyze the anaesthetic effect over time. **Results:** There was a significant time main effect for SWM scores (p<.001). Baseline measurements were similar (3.00±.53) and were significantly lower than any other time point (p=.006). Immediate post measurements (3.63±.44) were significantly larger than any other time point for all conditions (p<.001). There was no difference between interventions. **Conclusion:** Although all conditions resulted in a significant anaesthetic effect immediately post treatment, no condition resulted in a greater reduction in skin sensation. Therefore, the phonophoresis treatments did not have a greater phonophoretic effect than either of the two sham conditions, nor was either treatment method superior. The treatment effect was too small to detect a change between conditions. Future studies investigating the effect of ultrasound time of phonophoresis should use a longer contact time of the drug and skin, using ultrasound parameters such as a 10% or 20% duty cycle with durations of 50 min or 20 min, respectively. Our results concur with some clinical trials that did not support phonophoresis used with short durations.

Effects Of Cold Water Immersion On Subsequent Performance: A Systematic Review

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Context: Cold-water immersion (CWI) is a recovery modality used to maintain performance over multiple exercise bouts. Currently, the effectiveness of this intervention on performance is unclear. **Objective:** To systematically review existing literature to determine the clinical effectiveness of CWI greater than 5 minutes on subsequent exercise tasks measured by physical performance outcomes. We hypothesized that CWI after an initial exercise bout would have a clinically meaningful effect on subsequent performance when treatment times were greater than five minutes. **Data Sources:** A computerized search for pertinent articles was performed using PubMed, CINAHL, and Web of Science from 1970 through 2010 using combinations of pre-defined MeSH terms: cold temperature, immersion, cryotherapy, athletic performance, recovery of function, and sports medicine. Search limits included all adult, human, English. **Study Selection:** Original research studies were included if they met pre-defined criteria including: CWI greater than or equal to five minutes, water temperature between 10°C and 15°C, trained subjects who performed an initial exercise bout with at least one subsequent exercise bout performed after intervention, and comparison to a control group. Twelve of 64 identified studies met criteria for inclusion, and 9 studies reported mean and standard deviation of dependent variables. **Data Extraction:** Three investigators independently reviewed the 9 studies meeting inclusion criteria, and study quality evaluated by the Physiotherapy Evidence Database

(PEDro) scale was 6 ± 0 . **Data Synthesis:** Separate analyses were performed for common outcome measures including cycling peak performance (PP, $n=2$), cycling total work (TW, $n=3$), heart rate (HR, $n=4$), and muscle soreness (MS, $n=2$), then compared between studies using effect size (ES) and 95% confidence intervals (CI). A positive effect size favors CWI while a negative effect size favors the passive control condition. Values are presented as a range of ES (lower 95% CI to upper 95% CI). PP ranged from -1.14 (-1.87 to -0.42) to -0.55 (-1.44 to 0.35). TW ranged from -1.20 (-1.93 to -0.47) to 0.28 (-0.53 to 1.08). HR ranged from -0.28 (-1.0 to 0.44) to 2.35 (3.28 to 1.42). MS ranged from -0.73 (-1.68 to 0.23) to 2.0 (0.98 to 3.02). **Conclusions:** CWI after an initial exercise bout appears to have little beneficial effect on subsequent exercise performance outcomes. The temperatures, duration, and depth of the CWI varied among studies, as did the timing of the subsequent exercise. PP worsened after CWI when compared to a control group, while TW, HR, and MS show inconclusive results with ES and CI crossing zero. Although some individual studies included in the review show a statistically significant benefit with CWI, the effect sizes ranged from strongly unfavorable to strongly favorable, and there is little evidence that CWI improves subsequent exercise performance when used as a recovery intervention

Deep Quadriceps Intramuscular Temperature With Active And Passive Heating Modalities

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Context: Heating deep tissue for pain/spasm relief or improvement in tissue compliance is often a goal of both active and passive heating techniques. However, the most optimal method of obtaining increases in tissue temperature is unknown. **Objective:** To examine the effect of 20-minutes

of stationary cycling, hot pack, and continuous shortwave diathermy on deep quadriceps intramuscular temperature. **Design:** Within repeated measure designs. **Setting:** Controlled laboratory setting. **Participants:** 6 males ($n=2$) and females ($n=4$) (age = 20 ± 1 years, mass = 68 ± 10 kg, height = 164 ± 11 cm, thigh skinfold = 19.1 ± 6.5 mm) volunteered for study. All had no current injury involving their thighs or knees. **Interventions:** A thermocouple was inserted into their proximal vastus medialis using a 1.88in 20g catheter needle to an absolute depth of approximately 4 cm from the skin surface (4.0 ± 0.1 cm; range 3.9-4.1cm). Therefore, the thermocouple was approximately 3cm deep in the muscle. The thermocouple was interfaced to a desktop computer through an Isothermex®. Three conditions were compared including (1) stationary cycling (CYC) at heart rates progressing from 40-50% (10 minutes) and 60-70% (10 minutes); 20 minutes hot pack (HP); (3) 20 minutes Rebound™ continuous shortwave diathermy (CSWD). HP was applied to thigh in standard terry cloth cover with 3 layers of thin towels for comfort and CSWD was delivered at 13.1 MHz using standard thigh sleeve. **Main Outcome Measures:** Baseline (T_B) and intramuscular (T_{IM}) temperatures ($^{\circ}C$). A 3 x 5 (condition x time) repeated measures ANOVA with five levels of time (Start, 5, 10, 15, 20 minutes) investigated changes in T_{IM} . Alpha set a priori at 0.05. **Results:** There was no difference ($p=0.32$) in T_B across conditions ($37.1\pm 0.2^{\circ}C$). There was a condition x time interaction for T_{IM} ($p=0.011$). CYC10 min ($38.2\pm 0.5^{\circ}C$) was significantly warmer than HP10 min ($37.4\pm 0.3^{\circ}C$) ($p<0.05$). CYC15 min ($38.7\pm 4^{\circ}C$) and CSWD15 min ($38.1\pm 0.1^{\circ}C$) were significantly warmer than HP15 min ($37.5\pm 0.2^{\circ}C$) ($p<0.05$). CYC20 min ($38.8\pm 0.4^{\circ}C$) and CSWD20 min ($38.3\pm 0.2^{\circ}C$) were significantly warmer than HP20 min ($37.6\pm 0.2^{\circ}C$) ($p<0.05$). **Conclusions:** Our preliminary investigation demonstrates that at 10 minutes, active

heating via stationary cycling is better than either passive heating technique at raising the intramuscular temperature of the deep quadriceps. However, by 15 minutes, both active heating and passive heating via CSWD were superior to the conductive heat produced by the hot pack. Therefore, clinicians who desire to raise tissue temperature to therapeutic levels are advised to use active heating or diathermy when the target tissue is deep. Further research is recommended to clarify time course and magnitude of various therapeutic warm-up protocols.

Instrument Assisted Soft Tissue Mobilization Decreases Pain As Measured By The Visual Analog Scale And Pressure Pain Threshold

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Context: Research on the use of Instrument Assisted Soft Tissue Mobilization (IASTM) for the treatment of soft tissue related pain is limited, but clinical evidence suggests it may be beneficial. **Objective:** Evaluate the effect of IASTM on soft tissue related pain. **Design:** Repeated Measures **Setting:** Research Laboratory **Participants:** Forty-five healthy subjects (16 males, 29 females, 23.0 ± 5.0 years, 78.2 ± 27.7 kg, and 174.6 ± 17.1 cm) volunteered to participate in this study. Subjects were randomly assigned to one of three groups: control, IASTM, and sham. **Interventions:** All subjects completed a series of eccentric dumbbell contractions on the non-dominant biceps brachii muscle to induce delayed onset muscle soreness. Subjects returned a minimum of 36 hours later (Day 1) to receive treatment. Subjects in the IASTM group received a six minute treatment consisting of distal to proximal sweeping and fanning strokes using the Graston Technique instruments (TherapyCare Resources, Inc.

Indianapolis, IN). Subjects in the sham group received a six minute ultrasound treatment but the intensity was never increased so no treatment was administered. Subjects in the control group simply rested for five minutes. Subjects completed two days of treatment with 24 hours between sessions. Pain was evaluated using the Visual Analog Scale (VAS) and Pressure Pain Threshold (PPT). For VAS, subjects were asked to mark their current level of pain on a 10cm line. PPT was measured using a digital pressure algometer (Wagner Force One FDIX Force Gage Greenwich, Connecticut). As the rubber tip of the algometer was pressed against the biceps brachii subjects were instructed to report when the sensation changed from "pressure" to "pain". Pain measurements were obtained on four occasions: prior to inducing muscle soreness (Baseline), Day 1 PreTest, Day 1 PostTest, and Day 2 PostTest. **Main Outcomes Measures:** The dependent variables were VAS (cm) and PPT (kg/cm²). For the VAS, a mixed factor repeated measures analysis of variance was conducted. For PPT, the percent change from baseline was calculated and then a univariate analysis of variance was conducted. Tukey Post Hoc analysis was performed on all significant findings. **Results:** For the VAS data, a significant interaction was identified ($F_{6, 126}=3.77, p=0.01$). The IASTM group demonstrated lower VAS values at Day 1 PostTest ($2.7\pm 1.9\text{cm}$) and Day 2 PostTest ($2.0\pm 1.5\text{cm}$) compared to Day 1 PreTest ($4.5\pm 2.0\text{cm}$). No differences were identified in the sham or control groups. For the PPT data, a significant difference was identified between the groups after one treatment ($F=4.17, p=0.02$). The IASTM group had a 13% reduction in pain compared to the sham (3%) and control (2%) groups. **Conclusions:** Only subjects in the IASTM group had a significant reduction in perceived pain following treatment. IASTM may provide clinicians with another

treatment option to assist in the reduction of soft tissue related pain.

Is Tennis Ball Induced Bruising A Useful Acute Injury Model?

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Context: Research conducted on injured subjects is needed to understand how therapeutic modalities physiologically mitigate the inflammatory process. A human injury model will facilitate this research.

Objective: To determine if a bruise induced by being struck with a tennis ball is a valid injury model. We hypothesized that bruise color would gradually resolve over time, with resolution being augmented by different treatments.

Design: Randomized, controlled, blinded trial.

Setting: Research laboratory.

Patients or Other Participants:

Sixty-four males (height: $180.2\pm 6.4\text{cm}$, mass: $78.0\pm 16.2\text{kg}$, age: $22.1\pm 2.8\text{yrs}$), randomly assigned to 4, 16 person treatment groups, volunteered for participation. All were free from cardiovascular ailments. Further, no anti-inflammatory medications/painkillers were taken at least 3 days prior to or during the study.

Interventions: Bilateral anterior thigh bruises were induced via a tennis ball fired from a tennis ball machine (distance: 31cm, ball speed: $30.84\pm 3.2\text{m/sec}$). Within 5 minutes of injury, subjects received 1 of 4 assigned treatments on an assigned thigh: cryotherapy and compression (ice for 30 minutes every 2hrs for 10hrs, continuous compression for 2 days), compression alone (continuous compression for 2 days), a tobacco poultice (poultice for $\geq 12\text{hrs}$, continuous compression for 2 days), or the SportsWrap® (continuous application for 2 days). The untreated leg served as the control. Digital photographs were taken of the trauma sites immediately before and on days 2, 4, 6, 8, and 10 post-trauma and were

analyzed with Photoshop. We calculated average pixel values of cyan, magenta, yellow, black, and luminosity for the treatment and control limbs. These data were used to calculate the overall color difference. Limb (2) and day (6) served as independent, within subjects variables. Treatment type (4) served as the independent, between subjects variable. A 2 x 4 x 6 mixed model ANOVA with Bonferroni post hoc comparisons was computed to determine treatment effect. Alpha level set at $P\leq 0.05$. During pilot data work, bruising was not different between legs of 10 individuals ($F_{1,6}=0.007, P=0.933$). This data served as our reliability measure for this study. **Main Outcome Measures:** Overall color difference, the difference between the treatment and control legs as calculated from the average pixel values, was the dependent variable. **Results:** All subjects bruised. No treatment ($F_{3,60}=0.47, P=0.70$) or limb ($F_{1,60}=0.04, P=0.84$) effect was observed; a significant day effect ($F_{3,9,234,5}=6.82, P<0.001$) was observed. Overall color difference values (mean \pm SE) were greater on Days 4 (16.6 ± 10.5) and 6 (16.3 ± 10.1) than 0 (12.3 ± 8.5) and 10 (14.6 ± 9.8), and Day 4 (16.6 ± 10.5) was greater than Day 2 (15.2 ± 9.5 ; Bonferroni < 0.05). No significant interactions were present. **Conclusions:** This model results in an acute injury, but its severity was insufficient to measure treatment outcomes. Future models need greater trauma and additional dependent variables in order to be considered a valid injury model.

The Effect Of Experimental Delayed Onset Muscle Soreness On Recovery And Sleep: A Preliminary Report

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Context: A reduction in normal sleep decreases performance. The effects of experimentally induced delayed onset muscle soreness (DOMS) on perceived and measured sleep quality are unknown. **Objective:** To measure the effect of DOMS on self report and quantitative sleep parameters. **Design:** A single group pre-post test study. **Setting:** DOMS testing was completed in a research laboratory, while the sleep measures occurred at the participants' homes using actigraphy. **Participants:** Thirteen healthy students (5 males and 8 females, height = 171.9±89.1cm, mass = 69.5±9.2 kg, age = 21.3±1.9 years) volunteered for the study. Participants were involved in a larger study. **Interventions:** The participants wore the *Actiwatch Score* (AS), and completed a sleep diary for three days to obtain baseline measures. For the DOMS induction, measures of right shoulder range of motion (ROM), and pain were recorded at baseline. Participants then completed an eccentric exercise protocol involving right shoulder external rotation using an isokinetic dynamometer and exercised until they could generate only 50% of their maximum voluntary isometric muscle contraction. DOMS post-test measures were recorded 48 hours after the exercise. The AS was worn during the three days of exercise testing in addition to completing the sleep diary. Paired sample t-tests and separated repeated measures ANOVAs were used to analyze shoulder ROM, pain, function, and all sleep variables ($\alpha=0.05$) **Main Outcome Measures:** A goniometer was used to measure shoulder ROM. The DASH questionnaire was used to measure function. The sleep diary included a

visual analogue scale (VAS) for present pain, night pain, sleep quality, and fatigue. Sleep efficiency based on wake-quiet activity, was computed using the AS. **Results:** A significant decrease in internal ROM (ROM pre= 61.3°±11.8; post= 52.7°±14.1; $p = .005$) and a significant increase in pain was noted after exercise (VAS(mm) pre= 0.23±0.59; post= 29.2±20.2; $p < .001$). In addition there was a significant decrease in function (DASH pre= 0.89±1.1; post= 22.3±12.9; $p < .001$). There was a trend toward less pain felt at night versus during the day (VAS night= 9.4 ±14.1; day=16.9±19.3; $p=.086$). There was a trend towards a decrease in sleep quality on day three compared to baseline (VAS 77.1±25.2; 64.7±19.6; $p =.084$). There was a trend for an increase in fatigue on day three (VAS 22.6±20.7; 38.6±20.2; $p=.079$). There was no significant difference in sleep efficiency as measured by the AS (pre%=87.8±4.1; post%=89.2±1.5; $p=.093$). **Conclusions:** DOMS was successfully induced in all subjects. All subjects reported more pain during the day and at night after exercise. While there was no significant effect on sleep efficiency, trends in self-reported measures indicate a decrease in perceived sleep quality and fatigue. These preliminary findings suggest that perceived sleep may be relevant for athletes who are injured and receiving rehabilitation.

Ice Massage Minimizes The Magnitude Of Electrical Stimulation Induced Muscle Cramping

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Context: Exercise associated muscle cramps (EAMC) are a common

condition during sports competition and athletic trainers (ATs) continue to search for a best practice treatment strategy. Ice massage produces rapid decline in muscle temperature and controls the pain-spasm-ischemia cycle. To assess potential treatment efficacy, an accepted and validated electrical stimulation muscle cramp (ESMC) model was used to quantify the effect of ice massage on ESMC. **Objective:** To determine the effects of a 5 min ice massage on the amplitude and duration of electrical stimulation induced muscle cramps. **Design:** Crossover design. **Setting:** This study was performed in a controlled research laboratory. **Patients or Other Participants:** Seven, healthy individuals (3 male, 4 female; age, 23.4 ± 1.0 years; height, 172.7 ± 10.1 cm; weight, 86.7 ± 8.2 kg) volunteered. **Intervention(s):** Surface electromyography (sEMG) median frequencies were recorded during induction of an electrical stimulated muscle cramp (ESMC) in the abductor hallucis muscle. The participants endured two treatment sessions on subsequent days, a 5-min rest and a 5-min ice massage. Following the 5-min condition, induction of an ESMC was again attempted. **Main Outcome Measure(s):** sEMG measurements were taken pre-cramp and post-cramp induction (frequency and median frequency). Elapsed time following the rest session was compared to the time that elapsed following the ice massage. Visual analog (VAS) and McGill pain scales (MPQ) were used to assess the level of discomfort associated with ESMCs. Urine specific gravity and urine color were collected to assure hydration status was comparable between treatment sessions. **Results:** Individual 2x2 repeated measures ANOVAs were computed to compare sEMG frequency and median frequency across time and treatment. No significant changes in the cramp sEMG frequency or median frequency existed ($p>.05$). The most meaningful

observation was that mean elapsed time to visible cramping following ice massage was significantly longer than following rest (ice massage = 451.3 ± 35.3 sec; rest = 126.0 ± 15.8 sec; $p < .05$). Mean VAS and MPQ scores were significantly lower following the ice massage (VAS = 4.4 ± 2.3 ; MPQ = 13.0 ± 6.2) when compared to the rest condition (VAS = 5.96 ± 1.9 ; MPQ = 19.5 ± 11.3 ; $p < .05$). **Conclusions:** sEMG readings following ice massage showed no significant decrease in magnitude, however, the longer elapsed time for ice massage relative to rest reinforces that ice massage is the clinically appropriate treatment. Cryotherapy can counteract the abnormal neuromuscular drive and break the pain-spasm-ischemia cycle associated with EAMC.

Fiber Strain Magnitudes And Exercise-Induced Muscle Damage In Synergist Muscles: The Role Of Architectural Properties

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Context: Eccentric exercise (EEX) creates high muscle tension and muscle damage. Although the relationship between exercise-induced muscle damage and severe, clinical muscle injury remains unknown, several previous studies have concluded that eccentric exercise induced muscle strain injury may begin with mechanical disruption, due to excessive sarcomere strain. Subsequently, synergist muscles of different architecture would be expected to exhibit greater damage and disruption following EEX when compared to its synergist based on mechanical design. **Objective:** Investigate the differences in fiber dynamics and muscle damage during EEX between two architecturally distinct synergist muscles: The long-fibered tibialis anterior (TA) and the short fibered extensor digitorum longus (EDL). **Design:** Cross-over to control design. **Setting:** This experiment took place within a

controlled basic science laboratory setting. **Participants:** Consisted of 4 Male New Zealand white rabbits (4.57 ± 0.12 kg). **Interventions:** The hindlimbs of anesthetized rabbits were instrumented bilaterally with nerve cuff electrodes on the peroneal nerves and sonomicrometry crystals within one fascicle of the TA and EDL muscles. A custom fabricated E-type force buckle transducer was placed on the tendon of the TA. Rabbits were placed supine in a sling with one foot strapped to the foot plate attached to a torque sensor and cam of a servomotor. A pre-exercise isometric torque-angle relationship was measured prior to subjecting the dorsiflexor muscles to EEX. Afterwards, a post-exercise torque angle relationship was determined to assess reduction in torque from fatigue and damage. **Main Outcomes:** Differences between TA and EDL muscle isometric force reduction as a measure of damage was assessed via Student's t-test. Differences in TA and EDL fiber strains during EEX sets were assessed with a 2x5 factorial ANOVA. **Results:** There was a significant main effect of muscle architecture on active strain during the exercise bout, as EDL fibers strained to a greater magnitude compared to the strain of TA fibers ($p=0.003$). This difference was exacerbated with set number ($p=0.002$), and resulted in a quantitative interaction effect of set and muscle ($p=0.001$). The reductions in peak isometric force following the exercise bouts were not significantly different between the TA ($39.6 \pm 7.1\%$) and the EDL ($43.6 \pm 4.6\%$, $p=0.729$), illustrating a similar response to the exercise bout. **Conclusions:** Although fiber strain magnitudes of the EDL are greater than the fiber strain magnitudes of the TA during EEX, there are no differences in muscle damage. We hypothesize the similarities in damage are due to the architectural and functional differences between the muscles. The short fibered EDL is strained to a greater magnitude, but from the ascending limb of the force-length relationship while

the TA is stretched to a lesser extent, but from the plateau. The final lengths to which the sarcomeres are actively strained are similar, and thus so are the indices of damage. Funded by the Doctoral Research Grant Program of the NATA Research & Education Foundation.

Effects of Premodulated Electrical Stimulation on Muscular Blood Flow in the Gastrocnemius

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Context: Electrical stimulation continues to be a popular modality that is used for multiple purposes such as increasing local muscular blood flow. **Objective:** To determine intramuscular and surface blood flow before, during, and after a premodulated electrical stimulation treatment. **Design:** Within-subjects repeated measures design. **Setting:** Human Performance Research Laboratory. **Participants:** Fourteen healthy subjects (8 males, 6 females, age = 22.9 ± 1.2 years, height = 175.0 ± 12.7 cm, mass = 81.7 ± 17.8 kg, calf skinfold = 18.9 ± 7.0 mm, calf girth = 36.9 ± 2.8 cm) with no history of trauma to the leg, recent leg injuries within the past 6 months, infection and vascular or nervous conditions. **Interventions:** MVIC of the gastrocnemius was measured by Kin-Com dynamometer (Chattanooga Group, TN). Premodulated electrical stimulation (Vectra Genisys, Chattanooga, TN) was applied for a 10 second on/20 second off ratio for 15 minutes at 10% MVIC. A 10% MVIC was based upon pain tolerance using premodulated current for the calf. Surface blood flow and intramuscular blood flow were measured in the left posterior gastrocnemius. Intramuscular blood flow was measured at a depth of 55-60 mm into the gastrocnemius using a laser-Doppler

needle probe (Moor Instruments Inc, DE) that was threaded through a 20-gauge hypodermic needle. The surface Doppler probe was attached on the surface of the gastrocnemius between the electrodes. Surface and intramuscular blood flow were measured throughout a 10 minute baseline, during treatment, and 10 minute recovery. Treatment was split into 3 different periods of 9 contractions. Blood flow was then averaged for the last minute of baseline, during contractions 1-9, contractions 10-18, and contractions 19-27. The recovery was split into 3 time intervals which consisted of the initial minute, minute 5, and minute 10. **Main Outcome Measures:** An analysis of variance (ANOVA) with repeated measures was used to analyze blood flow for the designated time periods. Statistical significance was set *a priori* at $p < 0.05$. **Results:** For surface blood flow, there was a significant main effect for time ($F_{2,45,31,90} = 8.35, p < 0.001$). Compared to baseline (26.82 ± 10.99 flux), skin blood flow was significantly greater for contractions 1-9 (36.70 ± 13.82 flux) and contractions 10-18 (35.54 ± 14.34 flux). For intramuscular blood flow, there was a significant main effect for time ($F_{1,9,25,1} = 3.99, p = 0.032$). Muscle contractions 1-9 (54.73 ± 52.98 flux), contractions 10-18 (37.27 ± 27.38 flux), and contractions 19-27 (29.54 ± 17.02 flux) were significantly higher compared to the last minute of recovery (20.06 ± 14.49). **Conclusions:** Our findings revealed that premodulated electrical stimulation was an effective treatment modality for increasing surface blood flow with minimal increases in intramuscular blood flow compared to baseline.

Free Communications, Poster Presentations: Upper Extremity Assessment & Exercise

Monday, June 20, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

Response To A Secondary Cognitive Task During Unstable Sitting Differs Between Males And Females

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Context: Deficits in neuromuscular trunk control have been previously linked with lower extremity injuries that occur more frequently in females than males. Gender-specific changes in neuromuscular trunk control under dual task conditions may indicate the importance of attention for understanding this issue. **Objective:** To compare between genders the effect of a secondary cognitive task on neuromuscular control of the trunk.

Design: Repeated measures design
Setting: Sports Medicine Research Laboratory **Patients or Other**

Participants: A volunteer sample of twenty-seven physically active individuals participated (Males: n=15, Age: 21±1.61 yrs, Height: 179.04±8.93 cm, Mass: 76.29±9.15 kg; Females: n=12, Age: 22±3.73 yrs, Height: 170.67±8.64 cm, Mass: 62.00±7.48 kg). **Interventions:** The unstable sitting task required participants to maintain their balance while sitting upon a seat secured atop a 30 cm polycarbonate resin hemisphere outfitted with a foot support. During the first trials, the participants did not receive any instruction other than to maintain their position on the unstable apparatus. After successfully completing five initial trials, the participants performed two additional trials while performing a secondary cognitive task. The cognitive task required participants to count backwards aloud by sevens. Each trial lasted 60 seconds each. This data collection was part of

a larger project and only two trials were performed to prevent any potential fatigue. **Main Outcome Measures:** Center of pressure (CoP) in the anterior-posterior (AP) and medial-lateral (ML) direction was recorded using a conductive force plate during the unstable sitting trials. Approximate entropy (ApEn) of CoP fluctuations in the AP and ML direction was calculated in anticipation of needing to detect subtle changes in unstable sitting during a secondary cognitive task. Values were calculated for each trial and averaged within subject for each condition. The dependent variables of ApEn_{AP} and ApEn_{ML} were compared using two 2x2 (test x gender) ANCOVAs with height and mass as covariates. An alpha level of 0.05 was set a priori to determine significance. **Results:** CoP in the posture-only condition (Males: ApEn_{AP}: 0.768±0.026, ApEn_{ML}: 0.801±0.042; Females: ApEn_{AP}: 0.733±0.030, ApEn_{ML}: 0.785±0.049) and dual task condition (Males: ApEn_{AP}: 0.786±0.036, ApEn_{ML}: 0.788±0.037; Females: ApEn_{AP}: 0.794±0.026, ApEn_{ML}: 0.912±0.042) indicated that COP fluctuations were relatively complex. A significant interaction effect was found for ApEn_{ML} ($p=0.037$) but not for ApEn_{AP} ($p=0.383$). **Conclusions:** Introducing a secondary cognitive task decreased the regularity of CoP_{ML} fluctuations during unstable sitting in females but not in males. This difference may influence the gender discrepancy in lower extremity injury and warrants further investigation. Support provided by the National Academy of Sports Medicine.

Scapular Kinematics And Subacromial Impingement Syndrome: A Meta-Analysis

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Context: Subacromial impingement syndrome(SAIS) is a common source of shoulder pain. Extrinsic mechanisms of SAIS have been associated with scapular kinematics. However inconsistencies are reported in scapular kinematic deficits during arm elevation in SAIS patients using three-dimensional(3D) analysis. **Objective:** Determine through meta-analysis if consistent differences in 3D scapular kinematics occur between SAIS and controls during arm elevation. **Data Source:** A published literature search was carried out in the Medline/Pubmed, Science Direct and Ovid databases up to March, 2010; key terms shoulder, human, kinematics, scapula and SAIS. **Study Selection:** Computerized search identified 65 studies; review of the abstracts of the 65 papers found 14 studies that met the criteria for full text review. The 14 papers were reviewed by 2 investigators for inclusion criteria: SAIS patients diagnosed by healthcare professionals, scapular kinematics using ISB recommendation when appropriate and open chain arm elevation. Nine papers met the criteria for inclusion into the meta-analysis. Each paper was assessed for threats to validity using a 23-point quality assessment tool. **Data Synthesis:** The sample sizes, means and standard deviations of scapular upward rotation(UR), external rotation(ER), posterior tilt(PT), clavicular

elevation(ELE) and clavicular retraction(RET) kinematic variables were extracted from each paper or from the paper's lead author by one investigator. Extracted data was verified by a second investigator. The standard difference in the mean(SDM) was calculated for each outcome. The Z statistic was used to determine if the overall group differences for each kinematic variable was different from zero. If the Q statistic was significant, indicating heterogeneity, a random-effects model was used. Moderator variables were plane of arm elevation(PLANE), level of arm elevation(ARM) and population(POP). Quality assessment results were; mean score $70.8\% \pm 14.02\%$. Compared to controls, SAIS patients had significantly less UR($z=3.08, p=0.002, ES=0.26$) and ER($z=2.33, p=0.020, ES=0.21$), greater ELE($z=3.93, p \leq 0.001, ES=0.31$) and RET($z=-3.858, p \leq 0.001, ES=-0.26$), but no differences in PT($z=1.38, p=0.17$). Moderator variable analysis showed significant differences in PLANE, ARM and POP. In the frontal PLANE SAIS subjects showed greater PT($z=-3.04, p=0.002, ES=-0.38$) and ER($z=-2.11, p=0.035, ES=-0.26$) and in the scapular PLANE SAIS patients showed less UR($z=4.12, p \leq 0.001, ES=0.47$) and ER($z=2.68, p=0.007, ES=0.39$) than controls. SAIS patients showed less UR($z=3.36, p=0.001, ES=0.50$) at low ARM, and greater ELE($z=4.03, p \leq 0.001, ES=0.46$) and RET($z=-3.853, p \leq 0.001, ES=-0.30$) at high ARM. In the SAIS group, athletes and overhead workers showed less UR($z=3.99, p \leq 0.001, ES=0.70$), athletes showed greater PT($z=-3.37, p=0.001, ES=-0.66$), and overhead workers showed less PT($z=3.51, p \leq 0.001, ES=0.83$) and ER($z=3.59, p \leq 0.001, ES=1.05$) than controls. **Conclusions:** SAIS patients displayed overall decreased UR and ER, increased ELE and RET. SAIS patients have less UR at low ARM and greater clavicular motion during sagittal PLANE while elevation in the frontal plane showed differences in scapular motion. In sagittal and scapular PLANE, there was increased

ELE and RET for SAIS patients. Athletes with SAIS showed greater PT while overhead workers with SAIS showed less PT during arm elevation.

Relationships Between Lower Extremity Postural Control And Pitching Velocity In College Baseball Players

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Context: Lower extremity postural control is believed to be an important factor in providing proximal stability for dynamic tasks such as baseball pitching. A relationship between stance leg static postural control and maximum pitching velocity has been previously reported, however, the relationship between stride leg postural control and pitching velocity has not been previously examined.

Objective: To determine the relationship between lower extremity static and dynamic postural control and baseball maximum pitching velocity.

Design: Descriptive study. **Setting:** Laboratory and field settings.

Patients or Other Participants: Fifteen NCAA Division I college baseball pitchers (Age= 19.8 ± 1.2 years, height= 191.3 ± 5.0 cm, mass= 90.1 ± 5.1 kg) participated.

Interventions: Static postural control was assessed in the laboratory with three 15-second trials of single leg balance on a force plate during both eyes opened (EO) and closed (EC) conditions. Dynamic postural control was measured with three trials of the star excursion balance test (SEBT) in the anterior, posterolateral, and posteromedial directions. All postural control measures were performed bilaterally. The average of three trials for each postural control measure was used for analysis. Pitching velocity was recorded with a radar gun during intercollegiate games. For each subject, the average velocity of their three fastest pitches during their first home game pitching participation was used for analysis. Pearson product

moment correlations assessed relationships between static and dynamic postural control measures for each extremity and pitching velocity.

Main Outcome Measures: Static postural control was quantified by measuring COP velocity (cm/sec). Dynamic postural control was expressed as a percentage by normalizing each subject's SEBT reach distances (cm) to their leg length (cm) and multiplying by 100. Maximum pitch velocity (m/s) was measured during game participation. **Results:** Mean and standard deviation for each dependent variable were: COP velocity (EO stance= 4.8 ± 0.78 cm/s, EO stride= 4.68 ± 0.88 cm/s, EC stance= 11.88 ± 1.95 cm/s, EC stride= 11.33 ± 1.75 cm/s), anterior reach (stance= $70.0 \pm 6.4\%$, stride= $70.3 \pm 6.9\%$), posteromedial reach (stance= $87.8 \pm 8.1\%$, stride= $90.2 \pm 8.2\%$), posterolateral reach (stance= $84.9 \pm 9.2\%$, stride= $84.9 \pm 9.2\%$), and maximum pitching velocity (39.6 ± 1.7 m/s). There were no significant correlations between pitch velocity and COP velocity in the stride leg (EO: $r=0.22, p=0.45$ EC: $r=0.27, p=0.34$) or the stance leg (EO: $r=0.10, p=0.73$, EC: $r=0.08, p=0.78$). There were also no significant correlations between maximum pitch velocity and anterior reach (stride: $r=-0.20, p=0.50$, stance: $r=-0.10, p=0.74$), posterolateral reach (stride: $r=-0.02, p=0.95$ stance: $r=-0.14, p=0.62$) or posteromedial reach (stride: $r=0.18, p=0.54$ stance: $r=0.01, p=0.96$). **Conclusions:** No significant relationships existed between static or dynamic postural control measures and maximum baseball pitch velocity. This is in contrast to previous literature reporting a significant correlation between static postural control on the stance leg and maximum pitching velocity. The difference between these results may be due to the pitch velocity measurements being gathered during games in our study as compared to laboratory simulations in previous research.

Comparison Of Five Clinical Measures Of Thoracic Spine Rotation Range Of Motion In Healthy Adults

Grindstaff TL, Johnson KD, Kim KM, Yu BK, Hertel J, Saliba S: Creighton University, Omaha, NE, and University of Virginia, Charlottesville, VA

Context: A variety of reliable measurement techniques exist to quantify thoracic spine rotation range of motion (ROM). It is unknown if these techniques provide related information, thus reducing the need for multiple measurement techniques.

Objective: To examine the relationship between five clinical measures of thoracic spine rotation range of motion (ROM).

Design: Descriptive laboratory study.

Setting: Laboratory.

Patients or Other Participants: Forty-six healthy adults (15 male, 31 female; age= 23.6 ± 4.3 years; height= 171.0 ± 9.6 cm; mass= 71.4 ± 16.7 kg).

Intervention(s): Thoracic spine rotation ROM was measured using five measurement techniques; seated rotation bar behind back, seated rotation bar in front, half-kneeling rotation bar behind back, half-kneeling rotation bar in front, and a lumbar-locked unilateral extension in a hands and knees position, sitting on heels. Measurements were obtained by a single examiner and testing order and side were counterbalanced using a Latin-square design. A standard 8-inch goniometer was used for both seated and half-kneeling measurements and a bubble inclinometer was used for the lumbar-locked position.

Main Outcome Measures: Each technique was performed three times per side, with the average between the right and left sides used for data analysis. Pearson product-moment correlation coefficients were calculated to examine relationship between the five measures of thoracic spine ROM.

Results: Means and standard deviations for each measurement were as follows; seated rotation bar behind back (46.2°±9.1°), seated rotation bar

in front (56.7°±9.0°), half-kneeling rotation bar behind back (52.4°±10.6°), half-kneeling rotation bar in front (62.8°±10.4°), and a lumbar-locked unilateral extension in a quadruped position (42.5°±13.2°). Correlation coefficients for measures in seated and half-kneeling positions (both bar in front and back) were all strong ($r = .75$ to $.90$, $P \leq .001$), while the lumbar-locked unilateral extension technique had weak to moderate correlations ($r = .20$ to $.32$, $P = .03$ to $.25$) when compared to all seated and half-kneeling positions (both bar in front and back). **Conclusions:** Thoracic spine rotation ROM values obtained in this study were similar to previously reported values. The strong correlations for the seated and half-kneeling techniques (both bar in front and back) suggest these positions may provide similar information, while the lumbar-locked unilateral extension technique provides information which is distinctly different from the other four methods. When measuring thoracic spine ROM clinicians and researchers should consider utilizing any one of the seated or half-kneeling techniques in conjunction with the lumbar-locked unilateral extension technique.

Transversus Abdominis Activation During Side Bridge Exercises In People With Recurrent Low Back Pain And Healthy Controls

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Context: Low back pain (LBP) is a debilitating condition with a high rate of recurrence. Dysfunction of the transversus abdominis (TrA) has been implicated as part of the cause of LBP recurrence. In people who suffer from recurrent LBP, deficiencies in the TrA have been reported, even in the absence of pain. LBP prevention programs often target the TrA using exercises such as the side bridge exercise with abdominal drawing-in

maneuver (ADIM). However, it is unknown how well individuals with recurrent LBP activate the TrA during a stabilization LBP exercise progression. **Objective:** To compare TrA activation during a side bridge exercise progression in recurrent LBP (rLBP) participants and healthy controls. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Twenty-three subjects with rLBP (M=8, F=15, Age: 24.0±5.4 years; Height: 171.1±10.6 cm; Mass: 71.6±12.8 kg; Oswestry Score: 17.6±11.9%) and 24 healthy controls (M=2, F=22, Age: 21.0±1.3 years; Height: 169.7±8.2 cm; Mass: 68.0±9.3 kg) volunteered. At the time of testing, those in the rLBP group were not experiencing current pain.

Interventions: All subjects performed the ADIM and side bridge exercises with clinician feedback using verbal cueing to ensure proper contraction techniques. Each participant performed the side bridge exercise with ADIM in a progression of 5 levels while 3 ultrasound (US) images were taken when the subject was in full contraction at the end of each exercise. Each exercise level was more challenging and subjects were only progressed if they successfully completed the previous level.

Main Outcome Measures: The thickness of the TrA was measured in the rested and contracted states at each level to find the activation ratio (TrA contracted/TrA rest). TrA thickness was measured from superior fascial border to inferior fascial border. Separate ANCOVAs were used to analyze TrA activation ratio differences between the groups at each level and within each level using the lowest level of the comparison as the covariate. **Results:** There were no differences in the TrA activation ratio between groups at each level (rLBP vs healthy); Level 1: 1.64±.52 vs 1.57±.40 ($p = .76$); level 2: 1.68±.70 vs 1.52±.63 ($p = .40$); level 3: 1.53±.55 vs 1.43±.42 ($p = .88$); level 4: 1.51±.58 vs 1.46±.49 ($p = .66$); level 5: 1.38±.68 vs 1.24±.57 ($p = .92$).

Conclusions: There were no

differences between groups at any level indicating both the rLBP and healthy participants were able to contract the TrA with verbal cueing during a side bridge exercise progression. Verbal cueing with one-on-one instruction may be enough to allow rLBP patients to perform side bridge exercises with ADIM correctly with proper contraction of the TrA. Therefore, the side bridge progression may be used to facilitate exercise of the TrA in rLBP patients as part of a stabilization program.

Reliability Of Thoracic Spine Rotation Range Of Motion Measurements In Healthy Adults

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Context: The reliability of clinical measurement techniques to quantify thoracic spine rotation range of motion (ROM) has not been previously evaluated. **Objective:** To determine the intratester and intertester reliability of five variations of thoracic rotation measurements. **Design:** Descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** Forty-six healthy adults (15 male, 31 female; age= 23.6 ± 4.3 years; height= 171.0 ± 9.6 cm; mass= 71.4 ± 16.7 kg) with no spine, rib, hip, knee, or shoulder pathology within the last 6 months. **Intervention(s):** Thoracic rotation ROM was measured using 5 techniques; seated rotation bar behind back, seated rotation bar in front, half-kneeling rotation bar behind back, half-kneeling rotation bar in front, and lumbar-locked rotation in a quadruped position while sitting on heels. Measurements for seated and half-kneeling techniques were taken using a standard 8-inch goniometer, and a bubble inclinometer was utilized for the lumbar-locked technique. All measurements were obtained bilaterally, and testing order between sides, techniques, and clinicians were

counterbalanced using a Latin-square design. Testing was conducted over two days 48-72 hours apart. During Day 1, two examiners each obtained two sets of measurements (Session 1 & 2) to determine the within session intertester reliability and the within day intratester reliability. During Day 2, one examiner obtained measurements (Session 3) to determine the intratester reliability between days. **Main Outcome Measures:** Each technique was performed three times per side, with the overall average between sides used for data analysis. Reliability was determined using an intraclass correlation coefficient (ICC) and associated confidence intervals (95% CI). Calculations were also made for the standard error of measurement (SEM) and minimal detectable change (MDC). **Results:** Mean ROMs and standard deviations for each technique were as follows; seated rotation bar behind back ($41.6^{\circ} \pm 8.7^{\circ}$), seated rotation bar in front ($55.4^{\circ} \pm 9.2^{\circ}$), half-kneeling rotation bar behind back ($48.2^{\circ} \pm 10.7^{\circ}$), half-kneeling rotation bar in front ($60.6^{\circ} \pm 10.8^{\circ}$), and lumbar-locked rotation ($40.8^{\circ} \pm 10.9^{\circ}$). The within session intertester ICC values for all techniques ranged from 0.85-0.94. The SEM ranged from 1.03° - 2.25° and the MDC ranged from 2.84° - 6.25° . The within day intratester ICC values for all techniques ranged from 0.86-0.95. The SEM ranged from 0.76° - 2.12° and the MDC ranged from 2.10° - 5.89° . The between day intratester ICC values for all techniques ranged from 0.84-0.91. The SEM ranged from 1.39° - 2.00° and the MDC ranged from 3.85° - 5.55° . **Conclusions:** Thoracic spine rotation ROM values obtained in this study were similar to previously reported values. All techniques had good intratester and intertester reliability and low measurement error. Therefore the techniques described can be used to document changes in thoracic spine rotation in a clinical setting.

Effects Of Side-Lying Sling-Based Bridging Exercise On Transverse Abdominis Activation In Individuals With And Without Recurrent Low Back Pain

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Context: Individuals with recurrent low back pain (rLBP) experience dysfunction of the local stabilizing muscles of the trunk, such as the transverse abdominis (TrA). Sling-based (SB) exercise has been shown to activate the TrA in simple bridging positions, but the effect during more complex exercises has not been examined. The SB system is a system of ropes and slings that supports the limbs and/or pelvis during exercise to provide an unstable environment with the distal extremity in a weight bearing position. **Objective:** To identify differences in TrA activation during a SB side-bridge exercise progression between individuals with and without rLBP. **Design:** Case control, descriptive laboratory study. **Setting:** Laboratory. **Patients or Other Participants:** 45 subjects [21 subjects with rLBP (age 24.0 ± 5.4 yrs, height 171.1 ± 10.6 cm, weight 71.6 ± 12.8 kg) and 24 healthy subjects (age 21.0 ± 1.3 yrs, height 162.5 ± 8.1 cm, weight 67.8 ± 9.2 kg)] participated. **Intervention(s):** Baseline measures of TrA thickness were obtained using real-time ultrasound during an abdominal drawing-in maneuver (ADIM) prior to initiating the sling-exercises. TrA thickness was measured as the distance between the superior edge of the deep fascial line and the inferior edge of the superior fascial line. Subjects performed a five-level progression of side-lying SB bridging exercises on their left side following multiple practice repetitions with elastic assistance to become proficient in the movement. Images were taken of the right TrA prior to bridging and during bridging. **Main Outcome**

Measures: The dependent variables were the activation ratio of the TrA (contracted thickness (mm)/resting thickness (mm)) at baseline and at each exercise level. Independent t-tests were used to compare TrA activation between groups at baseline and at each progression level. **Results:** TrA activation ratio was not different between groups during the ADIM (Healthy: 1.50 ± 0.42 , rLBP: 1.54 ± 0.97 , $p=0.86$), nor at any exercise level: Level 1 (Healthy: 1.49 ± 0.48 , rLBP: 1.44 ± 0.59 , $p=0.75$), Level 2 (Healthy: 1.35 ± 0.59 , rLBP: 1.67 ± 0.65 , $p=0.09$), Level 3 (Healthy: 1.44 ± 0.65 , rLBP: 1.48 ± 0.65 , $p=0.86$), Level 4 (Healthy: 1.39 ± 0.84 , rLBP: 1.21 ± 0.77 , $p=0.45$) or Level 5 (Healthy: 1.15 ± 0.84 , rLBP: 0.94 ± 0.81 , $p=0.45$). **Conclusions:** Healthy and LBP groups were able to activate the TrA during sling-based side bridging in a similar manner. Because the side-lying SB exercises resulted in TrA activation, these exercises can be used during prevention and rehabilitation programs for core stability in active individuals regardless of their LBP status.

Upper Trapezius Activation During Manual Muscle Testing: A Comparison Between The Sexes
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Context: Manual muscle testing is commonly used to assess muscle function and normalize electromyography data for the upper extremity. Numerous techniques have been proposed for optimal activation of the upper trapezius. It is unclear which manual muscle testing position elicits the greatest level of upper trapezius activation. It is also unknown if there are differences in upper trapezius activation between males and females within various testing positions. **Objective:** To compare upper trapezius muscle activation between males and females during four manual muscle testing positions

commonly used to perform a maximum voluntary isometric contraction. **Design:** One-between (sex), one-within (position) repeated measures. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Fifteen healthy, recreationally active females (20.0 ± 1.81 yrs, 163.75 ± 6.66 cm, 63.8 ± 9.65 kg) and 15 healthy, recreationally active males (21.1 ± 1.53 yrs, 178.17 ± 5.58 cm, 79.07 ± 12.38 kg). **Interventions:** Subjects performed three separate 5-second maximum voluntary isometric contractions for the upper trapezius against manual resistance during four different testing positions: Resisted shoulder elevation (EL), resisted shoulder elevation with additional resistance to the head and neck (ELHD), resisted shoulder abduction at 90° (AB), and resisted shoulder abduction at 90° with additional resistance to the head and neck (ABHD). The order of position was randomized. There was a two minute rest period between each manual muscle testing trial. For each subject, the mean electromyography data for the upper trapezius were normalized to the peak electromyography recorded during their manual muscle testing trials and expressed as a percentage. The independent variables were sex (male and female) and position (EL, ELHD, AB and ABHD). The dependent variable was the normalized muscle activation of the upper trapezius. Data were analyzed using a 2x4 between-within factors 2-way ANOVA with repeated measures. Level of significance was set at $p < 0.05$ for all comparisons. **Main Outcome Measures:** Normalized mean electromyography data for the upper trapezius during the four testing positions. **Results:** Statistically significant main effects existed for position ($F_{3,84} = 24.995$; $p < 0.001$). The EL position ($23.92 \pm 10.19\%$) elicited significantly less muscle activation compared to the AB position ($34.29 \pm 13.43\%$) and the ABHD position ($46.19 \pm 10.25\%$). There was no main effect for group ($F_{1,28} = 2.472$;

$p=0.127$). There was no group x position interaction ($F_{3,84} = 0.258$; $p=0.856$). **Conclusions:** It does not appear that sex influences the activation of the upper trapezius during manual muscle testing as males and females elicited similar levels of muscle activation. The ABHD position was found to elicit the greatest level of upper trapezius activation. The two positions involving shoulder abduction elicited greater upper trapezius activation compared to the two positions involving shoulder elevation. An increase in upper trapezius activation was evident when head and neck resistance was applied to shoulder elevation and shoulder abduction. Clinicians and researchers should consider these findings when utilizing manual muscle testing to assess upper trapezius muscle function or normalize electromyography data.

Establishing A Reliable Method Of Measuring Scapular Anterior-Posterior Tilt

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Context: Electromagnetic tracking systems have enabled investigators to examine tri-planar scapular kinematics in healthy and shoulder injured subjects. Clinically, modified digital inclinometers have been used to quantify scapular upward rotation. However, a substantial amount of information suggests that anterior-posterior (AP) tilt is an important factor to consider when working with shoulder injured patients. **Objective:** The purpose of our study was to test the hypothesis that static measurements of scapular AP tilt obtained with a newly validated digital inclinometer, at various points of shoulder elevation, would produce reliable results when measurements were made by multiple clinicians. **Design:** Single group repeated measures design. **Setting:** Study was performed in a controlled laboratory environment. **Patients or Other**

Participants: Twenty-four volunteers (20.42 ± 1.41 years; 1.70 ± 0.09 meters; 70.92 ± 13.96 kg; 12 males, 12 females), free from any diagnosed upper extremity, neck and or back injury agreed to participate. All subjects underwent an evaluation to ensure a healthy, dominant shoulder. **Intervention:** All data collection involved the dominant shoulder in the scapular plane. Subjects performed three trials of 0°, 30°, 45°, 60°, 90°, and 120° of humeral elevation in a randomized fashion. Scapular AP tilt was measured using a modified digital inclinometer ($r = 0.63 - 0.86$). Two blinded examiners obtained AP tilt measures. **Main Outcome Measures:** The dependent variable was scapular AP tilt for each humeral position. Two-way random effects model intraclass correlation coefficients ($ICC_{(2,2)}$) were used to assess inter-rater reliability. Standard error of measure (SEM) was quantified for each examiner by humeral position. To evaluate intra-rater reliability, two-way mixed model intraclass correlation coefficients ($ICC_{(3,2)}$) were used. An $\alpha = 0.05$ was set *a priori*. **Results:** Inter-rater reliability was determined to be good to excellent for each position of humeral elevation ($ICC_{(2,2) 0 \text{ degrees}} = 0.92$, 95% CI = 0.62 – 0.97; $ICC_{(2,2) 30 \text{ degrees}} = 0.92$, 95% CI = 0.82 – 0.97; $ICC_{(2,2) 45 \text{ degrees}} = 0.88$, 95% CI = 0.72 – 0.95; $ICC_{(2,2) 60 \text{ degrees}} = 0.85$, 95% CI = 0.67 – 0.94; $ICC_{(2,2) 90 \text{ degrees}} = 0.83$, 95% CI = 0.60 – 0.93; $ICC_{(2,2) 120 \text{ degrees}} = 0.85$, 95% CI = 0.64 – 0.93). SEM ranged from 1.59° to 2.67° and 1.44° to 2.59° for examiner One and Two, respectively. Intra-rater repeatability of inclinometer measures for each position were also determined to be good to excellent ($ICC_{(3,2)} = 0.86 - 0.99$, $p \leq 0.001$). **Conclusions:** Utilizing a modified digital inclinometer to quantify scapular AP tilts resulted in acceptable levels of reliability. Clinically reasonable measurement error as compared to error associated with standard goniometric measures was also noted. Use of the modified digital

inclinometer in this manner will enhance our ability to affordably quantify in-vivo scapular AP tilt in the clinical environment.

Subjective Visual Observations Are Related To Palpation Meter Measurements Of The Pelvic Alignment

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Context: Alignment characteristics of the pelvis influence biomechanics at the knee and can be etiologic factors for patellofemoral pain syndrome (PFPS). The reliability of these clinical measurements and subjective visual observations of these measurements must be determined.

Objective: To examine the relationship between measures obtained from the PALpation Meter (PALM) (Performance Attainment Associates; Lindstrom, MN) and subjective visual observations of static pelvic height difference (PHD) and anterior-poster pelvic tilt (APPT). In addition, inter-examiner and intra-examiner reliability of the PALM measures of pelvic height difference and pelvic tilt were assessed. **Design:** Descriptive cohort study

Setting: Controlled laboratory setting.

Participants: Twenty healthy, college-aged participants (6 males, 14 females; 22.75±1.59 years; 171.45±11.59 cm; 73.32±16.34 kg) free of any current or past musculo-skeletal pathologies volunteered for this study.

Intervention: Two novice examiners performed the assessment on each participant in a single session. Participants began each session by creating a foot template to standardize foot placement between examiners. Subjective visual observation of APPT was made in the sagittal plane. The examiner marked the ASIS and PSIS, placed their finger on participant and classified the individual as having anterior, neutral, or posterior pelvic tilt. Subjective visual observation of PHD was made in the frontal plane

with the examiner identifying the most central portion of the iliac crests and classified the individual as having left, neutral, or right tilt of the pelvis. Following subjective visual observations, each examiner performed three blinded trials of each assessment with the PALM. **Main Outcome Measures:** Percent agreement was obtained to determine the relationship between subjective visual observation and numeric PALM measurements for each examiner. Intraclass Correlation Coefficients (ICC) were used to determine inter-examiner (2,k) and intra-examiner (3,1) reliability for each assessment. **Results:** Good to excellent (65-95%) percent agreements were achieved for both tests. Examiner one exhibited 65% agreement for APPT and 90% agreement for PHD. Examiner two exhibited 80% agreement for APPT and 95% for PHD. ICC (2,k) results for inter-examiner reliability were .823 (APPT) and .777 (PHD). The PALM measures had good to excellent intra-examiner reliability for examiner one (APPT = .935, PHD = .832) and examiner two (APPT = .923 and PHD = .824). **Conclusions:** Clinicians' subjective visual observations for the assessment of PHD and APPT are shown to have a good to excellent agreement with objective PALM measurements. This finding allows clinicians to utilize a visual assessment with confidence when they may not have access to a PALM. For documentation that requires an objective measure, our results show that novice clinicians can use the PALM to assess pelvic alignment in a consistent manner within a test session.

Pain Intensity With Abduction Was Consistently Associated With Shoulder Disability During Recovery Of Induced Muscle Pain

Larkin KA, Borsa PA, Parr JJ, George SZ: University of Florida, Gainesville, FL

Context: Athletic trainers use measures of clinical pain and range of motion (ROM) in order to gauge the extent of recovery after musculo-skeletal injury. There is limited evidence that documents whether ROM or pain intensity measures are better able to estimate disability after muscle injury. **Objective:** To determine if there is an association of self reported shoulder disability with pain intensity, internal rotation, external rotation, abduction and flexion of the shoulder joint, and if they have a significant association with the disability experienced following muscle injury. **Design:** Prospective study. **Setting:** Controlled research laboratory. **Patients or Other Participants:** One hundred and twelve healthy, right hand dominant, participants (46 males: age=25.39 ± 7.00, height= 178.93 ± 7.01 cm, weight= 78.59 ± 14.04 kg; 66 females: age= 22.98 ± 6.11, height= 164.64 ± 6.94 cm, weight = 61.86 ± 11.67 kg). **Interventions:** Participants completed a shoulder fatigue protocol on the external rotators of their dominant shoulder that caused muscle injury. **Main Outcome Measures:** Disability was assessed daily for 96 hours following injury using the validated QuickDASH questionnaire. Range of motion in abduction, internal rotation, external rotation and flexion were also evaluated daily. Pain ratings were also reported for pain experienced upon active abduction. Pain ratings for abduction were given on a 0-100 scale. A rating of 0 indicated no pain and a rating of 100 indicated worst pain imaginable. The QuickDASH served as the dependent variable in regression models, while the other examination variables were considered as independent variables. **Results:**

Stepwise regression models explained disability at 48 ($r^2 = 0.295$) and 96 hours ($r^2 = 0.146$) following muscle injury. Pain intensity with abduction and internal rotation of the injured arm were associated with shoulder disability ($p < 0.001$) at 48 hrs following injury. Pain intensity had the strongest association with disability at this time ($r^2 = 0.217$). At 96 hours following injury, pain intensity with abduction was the only variable associated with shoulder disability ($p < 0.001$). Likewise, only pain intensity with abduction at 48 hours was predictive of shoulder disability experienced at 96 hours ($p = 0.008$, $r^2 = 0.065$). **Conclusions:** Following muscle injury internal rotation ROM and pain intensity with abduction were associated with disability at 48 hours. Only pain intensity was associated with disability at 96 hours. In addition, pain intensity during abduction was predictive of disability during recovery, while ROM measures were not. These findings suggest that shoulder disability following muscle injury is more consistently associated with pain intensity during shoulder motion, as opposed to limitation in shoulder ROM. Therefore, pain intensity should be routinely included in examination of muscle injuries and evaluated thoroughly throughout recovery.

Free Communications, Poster Presentations: Case Studies

Monday, June 20, 2011, 1:00PM - 5:00PM, Outside Hall A, authors present 4:00PM - 5:00PM

Allergic Reaction In A Female High School Softball Player

Blair DF, Michael CL, McGinness CJ: Wenatchee High School, Wenatchee, WA

Background: Our subject is a sixteen-year-old female softball player. She was taken to the emergency room on June 17, 2009 for a possible drug allergic reaction/interaction. She had been taking Lamictal for four weeks for a diagnosis of a "possible mild bipolar disorder" and Cefadroxil for two weeks for an unknown condition causing cervical adenitis. She returned to her pediatrician the following day with peeling of the lips and increasing macular rash involving the trunk. The pediatrician recommended Benadryl 50 mg t.i.d. On June 19, she returned to the ER again. Now, she had developed blisters and bullae on the chest. She also had worsening lip lesions and mouth sores so severe she was unable to drink liquids. She was admitted to a local hospital in Wenatchee, Washington that day. The rash gradually progressed and she developed a fever of 105 degrees F. **Differential Diagnosis:** Stevens-Johnson syndrome, Transdermal Epidermal Necrolysis, viral exanthems, toxic shock/toxic strep syndrome, exfoliative erythroderma, staphylococcal scalded skin syndrome, Kawasaki disease. **Treatment:** Diagnostics included a chest x-ray that was negative except for questionable perihilar infiltrate in the lungs. Urinalysis was negative. CBC was normal (WBC was on the high end of normal, 10,000/cu.mm). Based upon the patient's history of new medications and physical signs/symptoms, the diagnosis of Stevens-Johnson Syndrome (SJS), a life-threatening skin disease that causes rash, skin peeling, and sores on the mucous membranes, was made. She was started on morphine, Benadryl, Cipro Zithromax, and Ativan

intravenously. Despite this, she continued to have fevers of 104-105 degrees F. The rash gradually increased in size (>35% skin involvement) which put the subject in the advanced category of Toxic Epidermal Necrolysis (TEN). The lesions were positive for staphylococcus aureus. After consultation with specialists at a regional trauma center in Seattle, Washington, she was transferred to the center's burn unit on June 24, 2009, after six days in the local hospital in Wenatchee. Upon arrival in Seattle, she was immediately taken to the operating room where 1,000 sq/cm. of skin was debrided. Xenografts of pigskin were used to cover the scalp, face, neck, chest, and forearms. She received daily wound care with daily xeroform and bacitracin. Our subject was started on nasogastric feeds due to the lesions in the upper digestive tract. Following the debridement and xenografts, some improvement was noted. After eleven days, the feeding tube was removed and the patient was given soft fruit and juices. On July 7, 2009, she was discharged and returned home. As the patient's skin healed under the skin grafts, the pigskin dried up and eventually fell off. **Uniqueness:** Stevens-Johnson syndrome is a rare condition, with a reported incidence of about 2.6-6.1 per million people/year. There are still unanswered questions with this case including: Why was this reaction so severe to these medications? Was this a drug interaction or a single drug reaction? Why was the patient's upper body more dramatically affected than her lower body? Stevens-Johnson syndrome is an immune-complex-mediated hypersensitivity disorder that may be caused by medications, viral infections, and malignancies. Pathologically, cell death results causing separation of the epidermis from the dermis. **Conclusion:** Our subject has recovered remarkably well with only minimal scarring. However,

the SJS/TEN did trigger rheumatoid arthritis primarily in her knees and ankles that causes considerable pain and dysfunction. Her vision has also deteriorated and she now requires fluorometholone eye drops. It has also been estimated that she has a 95% chance of miscarrying due to the reproductive system damage caused by the SJS/TEN. Athletic trainers must be aware of SJS as a unique, severe condition and refer suspected athletes quickly to appropriate medical facilities.

Bilateral Laminar Fracture Of The Seventh Cervical Vertebrae In A Division One Collegiate Male Wrestler

Peltier CE: Northern Illinois University, DeKalb, IL

Background: This report outlines the identification and treatment of a bilateral laminar fracture of the seventh cervical vertebrae in a college athlete. At the time of the injury the subject was a 19 YO male participating in wrestling at the collegiate level. The mechanism of injury is unknown, though the athlete reported neck stiffness and soreness for 2 weeks prior to diagnosis. He presented with pain and stiffness in the neck and upper back from C-2 to T-5, with point tenderness over the T-4/5 and T-5/6 disc spaces. Additionally, he reported numbness, tingling and coldness of the hands, and right sided scapular winging and scapular dysrhythmia were noted. Range of motion and strength for the upper extremities were within normal limits and equal bilaterally. **Differential Diagnosis:** Possible injuries included cervical level disc herniation, compression fracture, or cervical nerve root impingement. **Treatment:** An MRI of the thoracic spine was negative for fracture or disc pathology. X-rays of the cervical spine showed a flattening of the cervical

column and mild degeneration of the C-5/6 and C-6/7 discs. The MRI of the cervical spine showed a bilateral laminal fracture at C-7. A follow-up CT scan confirmed the non-displaced bilateral laminal fracture. He was placed in a soft collar for approximately 4 weeks and prescribed Ultracet and Flexiril for his pain. Low impact aerobic exercise such as jogging in the rehabilitation pool and stationary bike were permitted. Daily treatment for his pain included heat and the use of interferential electrical stimulation. A bone-stimulator was also used in hopes of aiding the healing process. As his pain level decreased he was allowed to return to weight room activities as long as cervical extension was avoided, but he was held out of wrestling activities. A repeat CT scan was ordered at 8 weeks post diagnosis due to an improvement in his pain and an increase in his pain-free range of motion. The repeat CT scan showed no indication of bony healing. The treating physician referred him on to a spine specialist at this time. Upon examination the spine specialist took flexion/extension x-rays and determined that the most likely mechanism of injury was hyper-extension of the cervical column which caused the spinous process of C-6 to compress the spinous process of C-7 and transmit enough force to cause the fracture. He ordered a follow-up MRI to check the integrity of the C-7/T-1 disc. That MRI showed a healthy disc and confirmed the fracture. The physician decided to present this case to a panel of fellow surgeons to determine if surgery was an option and if the athlete could return safely to play. The panel concluded that return to play was not possible, as he has an atrophic non-union, and that surgery would not increase the likelihood he could return safely. The athlete is approximately one year post injury and some daily neck pain continues. To avoid damage to the C-7/T-1 disc, he is electing to have a cervical fusion done in December 2010. **Uniqueness:** There is very little published data on a laminal

fracture of this type in the cervical vertebrae, and none that indicate an unconfirmed mechanism in a collegiate athlete, or which became an atrophic non-union. The spine specialist indicated the only case like this he knew of was from a professional football player in the 1950's or 1960's. **Conclusions:** This is a highly atypical injury, especially since it did not heal. Closer examination of the presentation of the injury may be useful in future cervical and thoracic spine evaluations.

Severe GI Dysfunction in a Collegiate Volleyball Player

Dee AE, Butterfield TA: The University of Kentucky, Lexington, KY

Background: A 20 year old collegiate volleyball player experiencing severe gastrointestinal (GI) dysfunction. The athlete was initially assessed in December 2009 after trying to complete a weight-lifting session. She presented having several bouts of diarrhea, nausea, and vomiting with food consumption over the past 24 hours. Temperature was recorded at 98.7 degrees, elevated pulse was noted, and blood pressure was within normal limits for the athlete. No other signs or symptoms were noted at the initial onset of illness. Athlete was held from participation until vomiting subsided and until she was able to keep food and water down. **Differential Diagnosis:** Stomach influenza, food poisoning, irritable bowel syndrome, lactose intolerance **Treatment:** The athlete was sent to University Health Services (UHS) where she was diagnosed and treated for symptoms of stomach flu and dehydration. Symptoms of nausea, diarrhea, and occasional vomiting lasted consistently for three days after initial onset of illness and occurred several times per day with some occurrence during the night as well. After one week of illness the athlete was still having nausea and diarrhea even with the use of anti-diarrheal medication,

however no vomiting was noted. By mid-December the athlete was preparing to go home for winter break. Over this time frame the athlete had little occurrence of symptoms. When the athlete returned from break she began having regular occurrence of symptoms once again. The athlete was sent back to UHS later that week and was diagnosed with lactose intolerance due to a high dairy diet. There she was prescribed lactase to take with any meals/snacks that may contain dairy product. After four weeks of medication use, the lactase failed to relieve all accounts of nausea and diarrhea. Athlete was sent back to UHS to see her physician whom asked her to log her food intake over the course of a week. After reviewing her food logs, the physician diagnosed athlete with a poor diet due to poor food choices. The athlete was sent to a nutritionist that spring and worked on proper diet construction and vitamin intake. After several weeks of closely monitored eating habits athlete was still experiencing symptoms. Athlete was sent back to student health in April of 2010 where the final diagnosis of stress induced gastrointestinal disorder was presented. Athlete was given stress management techniques, re-educated on proper diet, and was set up with counseling appointments to find better ways to cope with stress. The athlete currently is still playing collegiate volleyball and has had no issues since April of 2010. **Uniqueness:** Gastrointestinal dysfunction is commonly induced through physical stress in endurance athletes, and affects up to 68% of runners and cyclists, with GI symptoms typically occurring right after or during extreme workouts. Although stress-induced GI dysfunction is uncommon in non-endurance athletes, this case demonstrates that psychological stress can induce similar symptoms throughout the day and night with no causal relationship to exercise. **Conclusions:** After four months and several diagnoses, the athlete is now asymptomatic and continuing her

volleyball career. Similar to this case, many athletes present with physical symptoms when coming into the training room. While it is important to attend to the physical disabilities that may be impacting the athlete, it is also important to consider psychological symptoms that may be less evident. Increased psychological stress may lead to reduced performance and somatization of the illness. Referral of high stress athletes to proper counseling to assist in understanding the psychological component of illness/injury may prevent physical symptoms from malingering and allow for a faster course of recovery.

Low Back Pain In A Female Adolescent Softball Player

Kavanaugh CK, Hosey RG, Cassidy RC, Medina McKeon JM: University of Kentucky, Lexington, KY

Background: A 16-y.o. female softball catcher (ht=1.69m; mass =68kg) reported low back pain (LBP). Her initial visit occurred 1 week after injury. She stated that the injury occurred while she was rounding bases, “mis-stepped”, and felt a pain in her low back. She was able to continue participating in softball, and symptoms had partially resolved since the initial injury. She reported no previous history of back injury. No obvious deformities or discoloration were present. She was point tender over the greater trochanter, sacroiliac (SI) joint, and erector spinae musculature on her left side. She had full range of motion of the trunk, and ipsilateral hip and knee. Manual muscle testing revealed 5/5 strength with pain for trunk flexion and extension, and 5/5 strength throughout lower extremities. The athlete denied any neural symptoms into her lower extremity, and the neural screen was WNL. **Differential Diagnosis:** Erector spinae strain, SI dysfunction, muscle spasm, or disc herniation. **Treatment:** The athlete was referred to a physician at 2 weeks post-injury. Physician

evaluation revealed point tenderness over the greater trochanter, SI joint, and erector spinae musculature at L4-5, pain at terminal trunk flexion, and (+) straight leg raise (SLR) test. Radiographs revealed reduced lordotic curve with no acute bony injury of the pelvis, hip, or lumbar spine. She was diagnosed with nonspecific musculoskeletal LBP, recommended to follow-up in 2 weeks, and began core-strengthening rehabilitation. At 4 weeks, the athlete reported persisting pain that increased with activity, no neural symptoms, a (-)SLR, and 5/5 strength of the lower extremity. Rounded shoulder posture and poor trunk control were noted. She was advised to continue rehabilitation and follow-up in 4 weeks. At 8 weeks, she was symptom free and returned to full activity for the summer. At 20 weeks post-injury, the fall season began and her LBP returned. She was referred to the physician. Upon physician evaluation, she reported “tingling” down her left leg, full trunk range of motion in all directions, (-) SLR, (+) FABRE test for pain in SI region, and 5/5 strength of all lower extremities. She was again diagnosed with LBP, prescribed rehabilitation, with a follow-up scheduled at 26 weeks. Upon 26-week follow-up, symptoms had not improved. Consequently, she was referred to a spine orthopaedic surgeon. MR imaging of the lumbosacral region revealed significant L4-L5 disc herniation. After failure of 26 weeks of nonsurgical treatment, a surgical discectomy and left hemilaminotomy were performed. Six weeks after surgery (32 weeks post-injury), the athlete had 5/5 strength in all lower extremities, and was allowed to begin training in softball, with no batting. At nine weeks post-op (41 weeks post-injury), she returned to full activity, and was pain-free. **Uniqueness:** The literature indicates that discectomies in adolescents are extremely rare, accounting for only 0.5-6.8% of discectomies performed in patients of all ages. Disc herniations often present with low back pain at L4-L5

region. Initially, this athlete had no symptoms of disc disease, except LBP. Nonsurgical treatment can lead to successful outcomes, and should be attempted before surgery is considered. In previous literature, both nonsurgical and surgical treatments have yielded positive return-to-play results. **Conclusions:** Although disc herniations are rare in adolescents, those affected often continue participating based on pain tolerance. Any adolescent patient, who presents with low back or leg pain, poor posture, or motor and sensory deficits, must be thoroughly evaluated in order to appropriately determine course of treatment. The key initial steps are radiological evaluation and nonsurgical rehabilitation, but surgical treatment may be essential. When chronic LPB is present, acute disc herniation must be included in the differential diagnosis even when the patient is an unlikely candidate.

Acute Elbow Pain In An Adolescent Football Player

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Background: A fourteen year-old male high school football player threw a football during pre-game warm-ups and immediately heard a loud pop. The athlete reported to the athletic trainer complaining of left elbow pain. Upon evaluation, he described a sharp pain on the medial aspect of his left elbow and reported an 8/10 on a pain scale. The athlete reported a previous history of growth plate fracture in the ipsilateral elbow 4 years prior to the injury. In addition, he admitted to an insidious onset of left elbow pain beginning 6 weeks prior to injury that had gone unreported. Clinical evaluation presented extreme point tenderness over the medial epicondyle, immediate swelling, and a loss of active and passive elbow extension. Percussion and Compression tests were positive and valgus stress test was positive for pain, but not instability.

No obvious deformity or ecchymosis was present and no neurological symptoms existed. Initial treatment consisted of cryotherapy over the injured area in combination with immobilization. The athlete was then referred to a physician for further evaluation. **Differential Diagnosis:** Humeral Bone Contusion, Ulnar Collateral Ligament Sprain, Medial Epicondyle Avulsion Fracture. **Treatment:** Upon physician evaluation, radiographs of the athlete's left elbow were ordered. The radiographs revealed an avulsion fracture of the medial epicondyle of the humerus with a 2mm displacement. The athlete's elbow was immobilized in a soft splint to avoid further displacement of the fragment. Radiographs were taken each week for the first 4 weeks to evaluate the integrity of the avulsion fracture, check for displacement, and determine course of healing. Following the initial 4 weeks the athlete's arm was removed from the splint but remained in the sling for 2 additional weeks. Once out of the sling, the athlete was prescribed physical therapy, which began 6 weeks post-injury. The initial 4 weeks of physical therapy consisted of cryotherapy for pain control and active and passive extension to correct a 55 degree elbow extension deficit. In addition, augmented soft tissue mobilization techniques and passive stretching accompanied with moist heat were utilized to stimulate the breakdown of dysfunctional tissue associated with the extension lag. Strengthening exercises were added to the protocol at week 5 of physical therapy and a functional throwing progression began 12 weeks post injury. The athlete is expected to return to full football participation upon completion of the throwing program and has reported no new issues of elbow pain. **Uniqueness:** Medial epicondyle avulsion fractures are dramatic acute injuries that typically occur as a result of acute valgus stress and aggressive flexor muscle contraction. Although acute rupture of the ulnar collateral ligament

must be considered, overload failure of the growth plate during the late cocking or early acceleration phases of throwing will likely occur before an actual ligament or tendon rupture in adolescents. Also, this case is unique because the athlete had been experiencing ipsilateral elbow pain that had gone unreported for 6 weeks. Athletic Trainers often evaluate idiopathic pain that could possibly be linked to previous injury or chronic symptoms. If any and all symptoms are reported in a timely manner, appropriate activity modifications can be made to possibly avoid further injury. **Conclusions:** Avulsion fractures of the medial epicondyle are unique injuries that must be kept in mind when dealing with adolescent athletes between the age of 9 and 14 years. It is crucial for Athletic Trainers to stress to young athletes and coaches the importance of reporting injuries, idiopathic pain, or potential injuries as soon as possible in order to initiate appropriate assessment, treatment, and follow-up that can potentially prevent a more complex injury.

**Bilateral Positive Ulnar Variance
And Chronic Wrist Pain In A
Collegiate Softball Athlete**
Quigg AS, Vesci BJ, Foster TE:
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Background: This case involves a 20 year old, female collegiate softball player. Pertinent past medical history includes bilateral shoulder subluxations with associated Bankart lesions, both requiring surgical intervention, and chronic wrist pain that was previously unreported to the athletic training staff. The patient first reported left wrist pain in September of 2009 during rehabilitation of her left shoulder subluxation. She stated that the pain had been persistent for the past 6 months and was continuous throughout her activities of daily living. Pain was located on the dorsal aspect of her left wrist proximal to the base of her fifth metacarpal and was exacerbated by wrist extension and

ulnar deviation. **Differential Diagnosis:** Extensor carpi radialis tendinopathy, extensor carpi ulnaris tendinopathy, ulnar styloid process fracture, ulnar collateral ligament sprain, scapholunate dissociation, TFCC tear. **Treatment:** Patient was initially treated with rest and ice and instructed to begin taking NSAIDs for pain and inflammation. Patient was referred to a sports medicine physician when pain was not relieved by conventional treatments; she was instructed to continue treatment and given a wrist splint to wear at night and during any activities that elicited pain. When patient followed up with the physician she reported a decrease in symptoms; shortly after she underwent a Bankart repair of her left shoulder. She did not report recurrence of symptoms until she began a return to sport specific activities 3 months later. In February of 2010 radiographs and a magnetic resonance arthrogram (MR-arthrogram) were ordered by an orthopedic surgeon. MR-arthrogram revealed a TFCC tear and partial tear of the scapholunate ligament and the patient was referred to a hand surgeon for further evaluation. Bilateral radiographs were ordered by the surgeon and revealed a +4mm ulnar variance bilaterally. An ulnar shortening osteotomy procedure was recommended. Patient completed the softball season and an ulnar shortening osteotomy with TFCC debridement was performed in June of 2010. Prior to the surgery she suffered a right shoulder subluxation with associated Bankart lesion; surgery to repair the labrum was performed six weeks after her wrist surgery to ensure that the patient was able to remain functional throughout her activities of daily living. During rehabilitation for her right shoulder, the patient reported chronic wrist pain similar to that of her contralateral wrist. With the knowledge of bilateral positive ulnar variance, an MR-arthrogram was ordered and revealed a TFCC tear and partial tear of the scapholunate ligament. The patient opted to continue with shoulder rehabilitation and plans

on competing in the 2011 softball season with the possibility of undergoing another ulnar shortening osteotomy after the conclusion of the season. Currently, she is continuing with rehabilitation of her right shoulder Bankart repair and left wrist ulnar osteotomy; both of which are showing promising signs of a full recovery and return to sport. **Uniqueness:** The uniqueness of this case stems from the patient having congenital +4mm ulnar variance bilaterally that elicited TFCC and scapholunate ligament tears due to the demands of her sport; specifically wrist hyperextension and rotation during hitting. Also, the MR-arthrogram radiology report noted normal ulnar variance which the orthopedic hand surgeon concluded to be incorrect after examining bilateral radiographs of her forearm and hand. The discovery of positive ulnar variance led to the recommendation of an ulnar shortening osteotomy as opposed to TFCC repair. **Conclusions:** This case highlights the importance of understanding the functional demands placed on a patient and how the understanding of those demands can aid in evaluation and treatment of athletic injuries. Furthermore, this case underlines the importance of immediate reporting of symptoms to facilitate appropriate and timely referral and improved outcomes.

**Alveolar Mandibular Fracture
In A Semi-Professional Hockey
Player: A Case Report**

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Background: An 18 year-old hockey player was struck in the mouth by a slap-shot (estimated speed 85 miles per hour) from a teammate while defending against a power play in practice. Upon initial inspection, there was no apparent dental fracture or loss of teeth. However, the lateral and

central incisors of the mandible were noticeably loose when palpated individually. The patient had full mandibular range of motion with moderate pain. There was an approximately 1.5-inch, star-shaped laceration at the location the puck impacted the patient's jaw, just inferior to his lower lip and above his chin. Mandibular special testing was not performed due to the urgent nature of the situation. The patient was referred immediately to the emergency room for closure of the wound and additional diagnostic testing. The wound was closed with 21 sutures (8 cutaneous, 10 subcutaneous, 3 intraoral). **Differential Diagnosis:** Alveolar fracture, laceration, dental trauma, mandibular fracture, maxilla fracture, concussion. **Treatment:** A two-inch fracture of the dentomandibular joint was diagnosed via x-ray. This diagnosis was further differentiated by the maxillofacial surgeon as an alveolar fracture. The patient was referred to a maxillofacial surgeon for further treatment and fixation of the mandibular fracture. The patient was treated by fixing the fracture in place with wiring. He also received root canals on the mandibular lateral and central incisors affected by the impact of the puck and alveolar fracture. He was prescribed a soft diet and meal recommendations were made to ensure caloric intake of 3000-3500 kcal/day. Meals included soups, well-cooked pasta, protein shakes, and meal replacement shakes. Care was taken to examine the ingredients of any nutritional supplement shakes so as to prevent accidentally ingesting a banned substance, per league rules. The patient was allowed to participate in low-impact exercise including light biking, walking, and light resisted exercises. Running and heavy resistance training were restricted to prevent jaw-clenching that would potentially compromise the repair. Eating foods that would require tearing (sandwiches, pizza, etc) was also disallowed. Upon the patient's clearance to return to play, the patient

was fitted with a fixed jaw protector to his helmet to prevent additional trauma to the fracture site during sport participation. No specific jaw rehabilitation was performed as the patient had full range of motion and no temporomandibular joint dysfunction 6 weeks after the injury when the wiring was removed and again at 10 weeks post injury for his final physician follow-up. **Uniqueness:** Alveolar fractures account for less than 5% of all mandibular fractures. With limited rehabilitation options, the focus of patient care must be on nutritional considerations. The athletic trainer in conjunction with the physician and available nutritionist or dietician must develop a nutritional plan to promote appropriate caloric intake. **Conclusions:** With the NCAA currently considering a switch to half-shield protection in men's ice hockey, this injury may become increasingly more common in competition. The patient may resume participation when the attending physician has determined that appropriate bony healing has occurred to limit the chance of further injury. Equipment considerations must be made to provide appropriate protection to the area upon return to play. While athletes wearing helmets and face-masks will be more easily protected, an athlete who cannot wear a helmet (soccer, basketball, field hockey) will likely miss more time due to an inability to protect the fracture site. In such cases, creative thinking or equipment modifications may be necessary to adequately protect the athlete during participation.

Radial Collateral Ligament Ruptures Of The 4th And 5th Metacarpophalangeal Joints In A Collegiate Male Cheerleader: A Case Report

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Background: The purpose of this case report is to document the treatment and outcome of a complete rupture of the 5th metacarpophalangeal joint (MCPJ) radial collateral ligament (RCL) and partial rupture of the 4th MCPJ RCL of the left hand in a 23-year-old male collegiate cheerleader. During stunting practice a female cheerleader performed a stunt where she was tossed too high in the air, causing her to over rotate in a back flip. Trying to compensate for the over rotation, she came out of the tuck early and subsequently landed on the 4th and 5th phalanges of the left hand of a male cheerleader as he attempted to catch her. The 4th and 5th phalanges hyperextended and abducted beyond normal joint limitations. A popping sensation, pain, and immediate swelling were noted by the athlete. Upon examination by the athletic trainer the following day, the athlete was placed in a Plastalume® finger splint and referred to the team physician for further evaluation for a 4th and 5th MCPJ sprain. **Differential Diagnosis:** Metacarpophalangeal RCL sprain, metacarpophalangeal joint dislocation/subluxation, metacarpal/phalangeal fracture, strain, and contusion. **Treatment:** Upon examination by the team physician, pain and swelling along the medial hand were noted, along with decreased flexion of the 4th and 5th phalanges. Varus stress tests revealed an empty end-feel of the 5th MCPJ and a firm end-feel with moderate laxity of the 4th MCPJ. The physician's diagnosis was a complete rupture of the 5th MCPJ RCL, and a partial rupture of the 4th MCPJ RCL. The athlete was fitted with a Velcro buddy tape device to

secure the 4th and 5th phalanges to the 3rd phalange to allow for MCPJ flexion and extension while limiting abduction. The athlete was cleared for continued participation while splinted, using pain as his guide. Upon follow-up examination, ten weeks post-injury, the 4th and 5th MCPJ RCLs were intact and the athlete no longer complained of pain. The athlete's range of motion in MCP flexion, PIP flexion, and DIP extension of the 5th phalange; and, MCP extension, PIP extension, PIP flexion, and DIP flexion of the 4th phalange were severely limited (>10°), as compared bilaterally. There was also a significant decrease in grip strength of the left hand (M=11 kg) in comparison to the right (M=38.67 kg). A rehabilitation protocol was developed to restore flexibility and strength. The protocol consisted of targeting the extrinsic and intrinsic muscles of the hand by: 1) passively flexing the IP while extending the MCP, 2) passively extending the IP while flexing the MCP, 3) individualized active flexion of the IP while maintaining MCP extension, 4) individualized active flexion of the MCP while maintaining IP extension, 5) MCP extensions off a flat surface, 6) hook grip to fist grip exercises, and 7) tennis ball gripping exercises. The rehabilitation protocol was followed for four weeks, and produced a grip strength increase to 78%. All joint movements were restored within 8° or better as compared bilaterally, except for DIP extension of the 5th digit which remained 25° less than the right hand. The athlete continues to participate in competitive cheerleading without restriction. **Uniqueness:** Metacarpophalangeal RCL sprains are rare in athletics with no known reported cases in cheerleading. In professional football the incidence of any finger MCPJ sprain occurring is approximately 2% of all hand injuries. The athlete maintained his practice routine while wearing the Velcro buddy tape device as the only means of support. **Conclusion:** The nature of this injury is highly uncommon in athletics, and

while treatment is conservative it was effective and allowed the athlete to continue to competitively compete.

Lower Right Quadrant Pain In A D1 Basketball Player

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Background: An 18 year old female basketball athlete reported to the ATR with lower right abdominal pain. History revealed no apparent mechanism or previous abdominal injuries. The athlete stated she began noticing a throbbing pain (3/10) that morning and the pain had become progressively sharper and stronger (8/10) in the passing three hours. She stated she had no appetite that morning with some nausea, but no occurrence of vomiting. Observation revealed no ecchymosis or significant swelling. Mild abdominal rigidity was noted in the lower right quadrant along with rebound tenderness. Palpation was painful distal to the umbilicus in the lower right quadrant. The pain was diffuse, and athlete stated "it felt like a deep pain." Gross trunk movements were painful with the athlete feeling most relief from pain in a fetal position. Further questioning revealed no behaviors out of the ordinary for this athlete or increased duration or intensity of workouts. Due to the severity of the pain and other associated signs and symptoms, athlete was withheld from practice and referred to the team physician. **Differential Diagnosis:** Appendicitis, Ovarian Cyst, Ectopic (Tubular) Pregnancy, Internal Oblique Muscle Strain. **Treatment:** Upon evaluation, the team physician ordered diagnostic imaging including a CT scan with oral and intravenous contrast, a CBC, and a urinalysis. Both the CBC and the urinalysis came back negative. After reviewing the CT images, the MD was able to rule out appendicitis, but identified an abnormal growth on the athlete's right ovary (7.4 x 6.1 x 5.4

cm). Following further medical inquiry of the images by adjusting contrast, the growth showed presence of two calcifications, one 7 mm across and the other 2 mm across, as well as fatty and non-fatty components. The mass was identified as a benign ovarian teratoma of the dermal cyst variety with a Gonzalez-Crussi grading of 0, indicating no malignant growths present. Despite the low malignancy risk of the cyst, a high risk of ovarian torsion existed; therefore the MD recommended immediate surgery. One day S/P, athlete was asymptomatic and opted to continue play. She agreed that if significant signs and symptoms returned, surgery would be reconsidered. She completed the season without incident. The athlete returned home where she underwent laparoscopic surgery for removal of the mass. Two weeks post-surgery, the athlete reported no signs or symptoms with appropriate healing of the portal insertion sites. She has returned for her sophomore season with no anticipated complications. **Uniqueness:** Germ cell derived-teratomas always occur on the ovaries in females and the testes in males, while teratomas derived from embryonal cells occur anywhere throughout the body, with the most common being in the sacrococcygeal region. Overall, a teratoma constitutes a rare disease with approximately 10,000 new diagnoses per year worldwide; while ovarian dermoid cysts have an incidence of approximately 8.9 in every 100,000 women. Although this disease presented closely to appendicitis, a much more common disease, it is important to expand one's differential diagnosis to be inclusive of any condition that may be indicated by common pain patterns. **Conclusion:** Many conditions can present in the body similarly with repetitive pain patterns. It is important for athletic trainers to continually educate ourselves in general medical conditions which are often overlooked due to the abundance of musculoskeletal injuries. Knowing the appropriate times to refer for further

medical inquires becomes an integral part in the identification of such diseases that are a rarity.

Hematic Anomaly In A College Baseball Participant

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Background: We present a unique clinical case report involving the seemingly benign signs and symptoms of a rare and potentially life threatening general medical condition to an intercollegiate baseball participant. A 19 year old male collegiate baseball pitcher (weight = 68 kg, height = 172.7 cm) presented to the athletic trainer with shortness of breath, unexplained weight loss (4.5 kg), loss of appetite, systemic joint rib pain, and palor. After the initial evaluation by the athletic trainer, the patient was immediately referred to a primary care physician for further evaluation. The patient's pre-participation screening questionnaire indicated that he maintained a healthy lifestyle and his previous medical history was not significant for injuries to thorax or abdomen and illnesses to the cardiovascular, endocrine, respiratory, and nervous system. **Differential Diagnosis:** Lower respiratory infection, meningitis, mononucleosis, acute anemia, neuroblastoma, non-Hodgkin lymphoma, and acute lymphoblastic leukemia. **Treatment:** Based on the initial physician examination, a battery of blood tests was obtained which included an evaluation for the presence and morphology of lymphoblasts. The CBC results demonstrated an elevated leukocyte count of more than $10 \times 10^9/L$. Several metabolic abnormalities were also present including increased serum levels of uric acid, potassium, phosphorus, calcium, and lactate dehydrogenase. Complete morphologic, immunologic, and genetic examination of the leukemia cells were positive and the patient was referred to an oncologist. A second battery of

blood tests were ordered by the oncologist and established the diagnosis of acute lymphoblastic leukemia. After consulting with the oncologist, the patient decided to begin chemotherapy immediately. The patient completed bi-phasic treatment for acute lymphoblastic leukemia, including induction therapy and post-induction therapy. The aim of therapy is to destroy as many acute lymphoblastic leukemia cells as possible, improve the overall blood count, and eliminate the signs of the disease for an extended period of time. **Uniqueness:** Only 5,400 people in the United States were diagnosed with acute lymphoblastic leukemia in 2009. It is the most common type of leukemia in children under age 15 and has a peak incidence at three to four years of age. The risk of developing acute lymphoblastic leukemia significantly decreases after age 15 and considerably increases after age 45. This case is unique because this patient developed acute lymphoblastic leukemia despite his age, the absence of other non-modifiable and modifiable risk factors, and lack of previous personal or family medical history of cancer. This case is also unique because most patients with acute lymphoblastic leukemia remain confined to bed rest and this patient actively participated in an NCAA Division II collegiate baseball season despite suffering from the adverse effects of chemotherapy which included nausea, headaches, shortness of breath, acid reflux, constipation, insomnia, and joint pain. Due to frequent trips to the patient's hometown in New York for chemotherapy, transferring schools closer to home was necessary for logistical concerns. The patient reports he is currently healthy, no longer receiving chemotherapy treatments, and continues to remain physically active. **Conclusions:** The patient's white blood cells were malignant and immature and continuously multiplied and over-produced in his bone marrow. Without immediate recognition, referral, and

continuous treatment, these cells would have spread to vital organs, eventually leading to death. The patient, athletic trainer, coaches, family, and the oncologist closely monitored the patient's condition and symptoms in order to make appropriate athletic participation changes when necessary. This case also serves as a professional reminder that not all issues in the athletic setting are orthopedic in nature and the importance of early detection, treatment, and management of a range of general medical conditions is paramount.

Posterolateral Knee Pain In A Collegiate Football Player

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Background: An 18 year-old wide receiver was tackled and immediately reported right posterolateral knee pain, paresthesia, and loss of function in the lower extremity. Initial examination revealed posterolateral instability with an empty end feel with varus stress testing. His medical history was not significant for injuries to the involved knee or surrounding area. **Differential Diagnosis:** Fibular fracture, PCL tear, LCL tear, peroneal neuritis, lateral meniscal tear, and biceps femoris strain. **Treatment:** After the initial evaluation, he was iced, placed in a straight leg knee immobilizer, instructed to ambulate utilizing NWB crutch gait pattern, and referred to the team orthopedic surgeon for further evaluation. The physician diagnosed him with an LCL and a posterolateral corner knee injury, with normal peroneal nerve functioning and ordered an MRI. MRI results indicated marked medial and lateral soft tissue edema. The LCL and biceps femoris tendon were torn at the attachment from the fibular head and retracted 15 mm. Discernible edema was present within the fibular head of the soleus, representing a partial tear. A small knee joint effusion and mild contusions were seen along the medial

aspect of the tibial plateau and anterioromedial femoral condyle. The semimembranosus tendon was completely torn and retracted 5 cm from the tibial plateau. Edema deep and anteriorly to the MCL, representing low grade tearing of the deep fibers, was present. An LCL, biceps femoris, semimembranosus, and posterolateral corner reconstruction was performed six days after incident. A post-operative rehabilitation program was initiated along with wound management of the surgical incision. Four weeks s/p, he presented with increased soreness secondary to rejection of the subcutaneous sutures by the body. Rehabilitation was reduced to the use of a stationary bike and sutures were removed as they surfaced. Six weeks s/p, the patient underwent an I+D for subcutaneous suture removal. Post I+D, re-evaluation examination revealed sutures in place, AROM 0-90° of knee flexion, and normal neurovascular function. He was instructed to cover the wound until suture removal in two weeks. Eight weeks s/p, I+D incision was healed and he was able to complete 0-135° of knee AROM. 12 weeks s/p, he complained of increased swelling, pain, and decreased ROM resulting from an infection. An additional I+D was performed and he was seen by an infectious disease specialist. The patient was placed on a second round of Keflex® and was cleared to continue with rehabilitation. 24 weeks s/p, he was fitted for a custom functional hinged knee brace and progressed to performing sport specific activities. The patient was cleared by the team physician and fully returned to athletic activities approximately 11 months post surgery. His return to activity did not elicit any pain or apprehension. Uniqueness: Posterolateral corner injuries are infrequent in athletics. Specifically, in this case, the combination of a grade III LCL sprain and avulsion fractures of the fibula and tibia from the biceps femoris and semimembranosus tendons is rare. This injury was difficult to diagnose

on evaluation because the reported symptoms were diffuse and the pathology and subsequent surgical interventions forced the rehabilitation program to follow a strict progressive protocol to reduce the pulls of the biceps femoris and semimembranosus tendons. Also, it is uncommon for the vicryl used during the surgery to be rejected. Finally, the two additional surgeries did not substantially hinder the rehabilitation, as the patient was able to progress well throughout the remainder of the program. **Conclusion:** Prompt recognition and treatment of posterolateral reconstruction is critical to reduce the incident of graft failure. The literature reports that reconstruction occurring within 2 weeks demonstrates better outcomes than when surgery is performed after two weeks.

Treatment Of A Female Division I Collegiate Soccer Goalkeeper With Chronic Chest Pain

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Background: In June 2008, while working at a summer camp a 21 year old female division I soccer goalkeeper began to experience intermittent chest pain after exercise. She had no previous history of chest pain or cardiac pathologies. The athlete was sent by the nursing staff to the Emergency Department. EKG, echocardiogram and chest radiographs were negative for abnormalities. The physician suggested a follow up with her primary care physician. After meeting with her primary physician she was advised to play as tolerated. The athlete reported to pre-season and while participating in soccer in late August the athlete continued to experience intermittent chest pain. Upon evaluation by the staff ATC it was noted the athlete was experiencing difficulty with deep breaths primarily during exhalation, and was tender to palpation along the lateral borders of

the sternum over the articulations of the 6th, 7th, and 8th ribs. At this time the athlete was referred to the team physician. **Differential Diagnosis:** Cardiac pathology, exercise induced asthma, intercostal muscle strain, rib dislocation/subluxation, stress fracture, costochondritis. **Treatment:** Previous radiographs were reviewed and no abnormalities were identified. The athlete was cleared to play as tolerated, however due to the level of discomfort experienced, a second opinion was sought. A cardiologist re-reviewed the EKG which had no abnormal findings. A rheumatologist ordered blood tests to identify any inflammatory diseases, and all blood work was normal. She was then referred to a pulmonologist who eliminated the possibility of asthma but did identify Pectus Excavatum and costochondritis. The athlete was then referred to a pain management clinic to discuss cortisone injections. The athlete rejected this option. She was once again cleared to play as tolerated. Throughout the spring and summer she chose not to play soccer, however did participate in swimming and cycling, despite chest discomfort. She returned to competitive soccer during the fall of 2009 but was still experiencing intermittent pain, and followed up with a local physician who ordered a chest MRI. The MRI showed no structural damage and confirmed the diagnosis of costochondritis. The athlete was prescribed Indocin for inflammation. A cortisone injection was discussed again with a therapeutic exercise program for posture and scapular stability. In the summer of 2010 the athlete saw another physician for upper thoracic pain and was diagnosed with mild scoliosis. Continued therapy for posture and scapular stability was recommended. **Uniqueness:** This case is particularly unique with the athlete's predisposition to costochondritis due to pectus excavatum and mild scoliosis. Both pectus excavatum and costochondritis are not commonly studied or researched in the athletic training community. Pectus Excavatum is thought to be caused by an

overgrowth of the rib cartilage and is the most common chest wall birth defect. It affects one in 300 births and is more common in males than females. Costochondritis is often an overuse injury in athletes and can last a few weeks to years before completely healed. This case is also unique given that there is no known specific mechanism and instead the sport and position as goalkeeper are the irritants for the athlete. **Conclusion:** The athlete is still participating in soccer while tolerating the intermittent chest pain. Her position as a goalkeeper combined with the chest wall deformity constantly puts pressure on the rib cage more frequently irritating the costochondral joints. As athletic trainers it's important to note that some cases may not have an immediate or rehabilitative solution. Chronic injuries and conditions, especially when the athlete has been predisposed can be frustrating and limiting. Managing the athlete's pain becomes a day to day task, especially when the athletes sport is the irritant.

Manual Therapy And Therapeutic Exercise For Treating Radiating Neck Pain In A Woman

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Background: We are presenting the case of a 41 year old woman who had a history of multiple disc herniations along her spine. This office worker has suffered from two lumbar disc herniations and multiple surgeries nine years earlier. The patient first experienced pain and stiffness in her neck in January 2010, after moving heavy boxes. Over the next four months, she noted an increase in pain in her left arm and elbow. She started physical therapy treatments consisting of cervical traction, and stretching of the neck muscles. The patient started to feel better around June 2010 but a month later, she still experienced neck stiffness but the pain transferred to the right elbow and spread down the right

arm. Her chief complaint was pain in the right elbow during movement (9/10), stiffness and pain in the neck, and pain and burning sensation down the right shoulder and arm. She indicated lifting small objects, doing her hair, driving, showering, and answering the phone was very painful. The pain and dysfunction was significant from July 2010 to September 2010. **Differential diagnosis:** A cervical disc herniation, tennis elbow, facet joint irritation, or scalene muscle spasm. **Treatment:** The MRI results indicated a C5-C6 disc herniation. The first assessment in October 2010 by an ATC identified that the patient had limited cervical range of motion with right and left side bending, flexion, and left rotation. Her strength in neck extension (4+/5) and left (4/5) and right side bending (4+/5) were weak. Myotomes for C5, C6, and T1 were positive as well as ULTT1, ULTT3, and distraction tests were positive. She had diminished bicep brachii and tricep reflexes. Atrophy in the common extensor origin of the right lateral epicondyle was noted. Treatment was comprised of a mix of manual therapy and exercise. The manual therapy consisted of occipital release, neck traction, and myofascial release of the upper trapezius muscle. The occipital release procedure decreases tension in the suboccipital muscles by applying pressure in suboccipital recess bilaterally to induce regional extension at the OA, C1, and C2 articulations. The myofascial release treatment involved applying deep pressure to the upper trapezius muscle while stretching. Initial cervical stretching included static stretching then after two treatments PNF stretching was incorporated. Strengthening exercises started with isometric contractions using a blood pressure cuff and advanced to isotonic strengthening while on her hands and knees. In addition, extremity strengthening using tubing was performed standing while maintaining proper cervical lordosis. Superficial heat and TENS was applied at the end of treatment sessions. Intensity was

increased by increasing reps, resistance, or decreasing stability. Within 3 weeks of treatment (2 sessions per week) the patient reported being able to perform activities of daily life and work without pain. Moreover, she had also stopped taking her pain medication. **Uniqueness:** There are few clinical trials measuring the efficacy of treatments for radiating neck pain. Some studies have suggested that a combination of manual therapy and therapeutic exercise would be effective in treating general neck pain. This case is an example of how manual therapy techniques in combination with regular therapy can be effective in treating an injury that could otherwise be regarded as a surgical case, especially in this patient who has received multiple surgeries for disc herniations in the past. **Conclusion:** Clinical trials are needed in the future to evaluate the use of manual therapy and therapeutic exercise for treating radiating neck pain in women. There is increasing peer reviewed evidence to support the use of manual therapy in treatment of several conditions and therefore may become an important tool in athletic training.

Idiopathic Sixth Cranial Nerve Palsy In A Female Collegiate Softball Player: A Case Report

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Background: We present the case of sixth cranial nerve palsy in a collegiate softball player. A 20-year-old healthy National Collegiate Athletic Association Division II female softball player (body mass = 66.3 kg, height = 172.7 cm) reported to the athletic trainer complaining of migraine headaches, diplopia, and blurred vision of the right eye. The athlete also complained of periodic dizziness with no reported mechanism of injury or other known medical history. After an initial assessment by a staff athletic trainer was completed, the athlete was transported to a local hospital for

further evaluation. At the hospital the athlete was provided a saline lock and underwent a complete physical examination that revealed right eye sixth nerve palsy. **Differential Diagnosis:** Brain tumor, sinus lesion, intracranial hemorrhage and/or aneurysm, internal carotid artery stenosis, dural venous sinus thrombosis, Bell's palsy, and multiple sclerosis (MS). **Treatment:** The hospital examination consisted of a complete neurological panel (unremarkable), stroke screen (unremarkable), glycosylated hemoglobin (criterion for the diagnosis of diabetes) (WNL), and a complete blood count (WNL). The athlete was placed on ketorolac tromethamine (Toradol®), 30 mg intravenous (IV) to manage the pain associated with the migraine. A series of diagnostic and neuro-imaging tests were conducted, including: radio-graphs, magnetic resonance imaging (MRI) without contrast, and computed tomography (CT) scans without contrast of the brain; as well as a computed tomography angiography (CTA) of the head and neck. All of the diagnostic and neuro-imaging results were unremarkable. The athlete was diagnosed with idiopathic sixth cranial nerve palsy and was instructed to follow a conservative treatment plan. The athlete was given a prescription for ibuprofen (Motrin®), 600 mg t.i.d. and was instructed to follow-up with her primary care physician and a neurologist within a week. The athlete was removed from athletic participation until symptoms resolved and received clearance from the family physician. One week following the initial diagnosis, a second MRI (following a (MS) protocol) was conducted of the brain, and was unremarkable. Two months following the initial onset of symptoms, the migraine headaches subsided. Diplopia and nerve palsy remained for an additional month before being resolved. Once all symptoms had resolved the athlete was cleared for participation in softball by her physician, and has remained

asymptomatic for 6 months. **Uniqueness:** Documented cases of idiopathic sixth cranial nerve palsy in collegiate athletes appears lacking. Traumatic or ischemic sixth cranial nerve palsy in young adults is more common; however, these cases are the result of sustained head trauma, increased intracranial pressure, and/or another underlying pathology affecting blood flow. In the older adult population (> 50 years of age), medical conditions or diseases such as stroke, diabetes mellitus, and MS increase the risk of developing sixth cranial nerve palsy. In this case, neither trauma to the head nor any other underlying pathology was evidenced. **Conclusions:** Sixth cranial nerve palsy affects the lateral rectus muscle, impairing eye abduction, as well as causing diplopia and severe headaches when the cranial nerve is compressed. While sixth cranial nerve palsy is usually obvious (inability abduct the eye), early recognition and appropriate referral by an athletic trainer is necessary to limit complications when the palsy is the result of an underlying pathology. In most cases, idiopathic sixth cranial nerve palsy usually resolves within two months. This case demonstrates that while many of the conditions suffered by athletes have a specific mechanism of injury or nature of illness, there remain rare instances where conditions arise spontaneously, or from an obscure or unknown cause that should not be ignored; as the underlying causes could have significant ramifications if left untreated.

Ulnar Impaction Syndrome In A Female Collegiate Cheerleader

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Background: A 22 year-old female presented with chronic pain over mid dorsal and ulnar aspects of the right wrist with sliding sensations, paresthesia in 4th and 5th digits, and a subluxating lunate that could be self set. Pain quotient described as 4/10 at rest, 8/10 with activity, and 7/10 after activity. Physical examination revealed palpable tenderness over the TFCC, scapholunate, and lunotriquetral joints. ROM testing was WNL; however, after activity weakness was present. She has a history of tight bilateral forearm compartments, right wrist pain beginning at age 8 accompanied by unusual snapping sensations, and tremors in the R 4th and 5th metacarpals starting at age 19. **Differential Diagnosis:** Flexor and extensor carpi ulnaris tendinopathy, TFCC tear, arthrosis, lunotriquetral sprain, and ulnar impaction syndrome. **Treatment:** The primary care physician ordered an MRI that revealed a possible TFCC tear; however, results were inconclusive. The patient was referred to an orthopedic surgeon who ordered radiographs which identified a positive ulnar variance causing compression of the TFCC and a chronic syndesmonic sprain. Translation between the distal ulna and radius compromised the joint leaving no room for the TFCC with ulnar deviation and ulnar impaction syndrome was diagnosed. A cortisone injection within the TFCC failed to produce positive results upon returning to activity and the patient elected surgical intervention. Initial surgery included distal ulnar scar tissue debridement, synovial and medial TFCC ligament resection, and carpal meniscectomy. Following surgery and rehabilitation, the patient felt a significant decrease in symptoms; however, with resumption

of training she began feeling wrist instability. The patient ended her gymnastics career but continued cheerleading and international sailing. To combat return of symptoms, an additional cortisone injection was administered into the TFCC. The second injection was also unsuccessful and an additional surgery was performed. The second surgery consisted of a 3 mm osteotomy ulnar shortening and realignment with a 7 hole plate. Five days post-op, she reported severe neurological pain and developed forearm compartment syndrome secondary to post-surgical complications. Radiographs were taken and she was placed in a long arm cast with slits for swelling for 3 weeks. The orthopedic surgeon continued to monitor complications and stated that additional surgical intervention may be necessary to decrease pressure within compartments. Additional radiographs were taken at weeks 3, 6, 9, 15. Following the second surgery, rehabilitation, and return to activity, she reported increased neurological symptoms, but decreased wrist symptoms. The second surgery did not decrease symptoms enough to handle the stress of intercollegiate cheerleading; however, she was able to continue competing in international sailing. A third surgery for hardware removal and to relieve compartment pressure is forthcoming. **Uniqueness:** Ulnar impaction syndrome can be hereditary or caused by overuse. In this case, repetitive upper-extremity loads from gymnastics and cheerleading was an underlying cause, as well as the young age at which gymnastics was started. The ulnar impaction syndrome was likely caused by excessive upper extremity weight bearing to the open physes, causing the radial physis to close before the ulnar, resulting in the positive ulnar variance and secondary changes in the wrist that included deformation of the lunate, scapholunate instability, scaring of the ulnar nerve, and syndesmonic changes. With chronic impaction of the ulnar head against the TFCC, progressive

deterioration of the TFCC, chondromalacia of the lunate and head of the ulna, and attrition of the lunotriquetral interosseous ligament occurred. **Conclusions:** Due to the rareness of this injury, clinicians must be aware of a patient's medical history, identify the mechanism of injury, and be able to recognize symptoms that may include tremors in conjunction with ulnar wrist pain.

Bilateral Knee Pain In A Division 1 Field Hockey Player

David S, Hobson S, Straub SJ: Quinnipiac University, Hamden, CT

Background: At the end of pre-season camp, a 19 year old collegiate field hockey player complained of chronic pain and soreness in both knees. She had a history of intermittent knee pain that dated back to her youth. Two years prior, the athlete started to notice her current signs and symptoms; at which time the athlete stopped figure skating, but she continued to play field hockey. In high school her pain was diagnosed as tendonitis and treated symptomatically. The athlete transferred to the current institution from another university where she had received treatment but the condition did not improve. During initial evaluation there was apparent inflammation in both knees primarily along the patella tendon and VMO attachment. There was palpable tenderness around the lateral aspect of both patellae and along the tendon. ROM was full and a decrease in both flexion and extension strength was noted. The structural integrity of the joints was intact. Conservative measures were taken to include: proper warm-up and stretching, pain and inflammation management, and a lower extremity strengthening program all while the athlete performed as tolerated at practice. The athlete was non-compliant with treatment and continued to experience pain thus she was self limited in all activity for the remainder of the season. During

winter break the athlete was to continue with her rehabilitation and sought outside treatment from a physical therapist at home. Upon arrival back to school and start of the spring season, no improvements were noted and the athlete was referred to the team physician for further examination. **Differential Diagnosis:** Chronic bilateral patella femoral syndrome; patellar tendonitis; plica quadriceps muscle atrophy. **Treatment:** Following a physical exam, the physician recommended blood work and an MRI with the suspicion of patella femoral syndrome; he also discussed cortisone injections pending results of the diagnostics. The athlete elected to receive the injections immediately; this was done and provided no relief. An MRI was then obtained which indicated Hoffa's Disease, impingement of the infrapatellar fat pad. With this diagnosis the athlete was advised to continue treatment of rehabilitation and the possibility of surgical intervention via arthroscopic resection was discussed with her. The athlete sought out a second opinion that confirmed the diagnosis but based on this opinion opted against surgery because of a concern of a re-occurrence. The athlete was prescribed treatment of phonophoresis. This method was utilized for a month at which time the athlete proclaimed it wasn't helping and stopped receiving treatment. The athlete no longer participates in field hockey and continues to experience pain even in daily living. **Uniqueness:** There are reports of Hoffa's Disease being present in less than 1% of patients undergoing knee arthroscopy. Hoffa's Disease is characterized by inflammation, swelling, hypertrophy, fibrosis, and/or calcifications of the infra-patellar fat pad. While typically thought of as a chronic injury, there are reports of acute onset fat pad irritation. The fat pad itself is highly innervated with free nerve endings leaving it a likely source of anterior patellar pain. A recent retrospective cohort study has indicated that patients

with isolated Hoffa's disease without additional concomitant pathology can expect long term improvement or resolution of symptoms following an arthroscopic resection. **Conclusions:** Persistent patellar femoral syndrome / anterior knee pain requires appropriate imaging to ensure proper diagnosis. Patellar impingement syndromes like Hoffa's syndrome can cause debilitating pain because of the large amount of sensory innervations of the fat pad. Arthroscopic resection appears to be a good long term solution permitting return to normal activity.

Bilateral Lower Extremity Exertional Compartment Syndrome Management In A Professional Cross Country Ski Racer: A Case Study Lacy DL, Hackett TR: Steadman Clinic, Vail, CO

Background: A 29-year-old male professional cross country skate ski racer with a history of bilateral lower extremity chronic exertional compartment syndrome (CECS) in the anterior and lateral compartments. The athlete experienced 2-3 years of anterior and lateral lower leg pain and tightness, mostly with cross-country skiing and running. The tightness resulted in difficulty closing races, thereby impeding the athlete's ability to perform. **Differential Diagnosis:** Medial tibial stress syndrome, stress fracture, gastrocnemius strain, popliteal artery entrapment, and chronic exertional compartment syndrome. **Treatment:** After conservative measures (contrast therapy, electrical stimulation, and soft tissue modalities) failed to relieve the athlete's symptoms he sought further guidance from a physician. In order to accurately diagnose CECS, intracompartmental pressure was obtained. Pressure readings between 25-30 mmHg or higher with activity are indicative of compartment syndrome. Pre exercise pressure intracompartmental readings ascertained in the office read 18 mmHg in the lateral

compartment and 30 mmHg in the anterior compartment. Following 30 minutes of roller skiing, post exercise readings elevated to 38 mmHg in the lateral compartment and 60 mmHg in the anterior compartment. Once the condition was diagnosed, the accepted method of treatment is fasciotomy of the involved compartments. A second surgical treatment option that is less common combines both fasciotomy and fasciectomy, thereby not only dividing the restricting envelope of fascia, but also excising some of the problematic tissue. After surgery the athlete was partial (50%) weight-bearing for 2 weeks. During the initial protection phase of rehabilitation (1-4 weeks following surgery) therapy involved knee and ankle range of motion as well as stationary biking with no resistance. Phase 2 of therapy involved ski-specific exercises. The following weeks included functional progression including strengthening (weeks 9-16) then return to sport at 16 weeks status post surgery. **Uniqueness:** CECS is an increasing problem in the realm of cross-country skiing over the last five years. One possible reason for this could be the technique utilized by skate skiers. These athletes forcefully dorsiflex the great toe when they push their skis from side to side, thereby activating muscles within the anterior compartment. Also, ski racers train with roller skis which are heavier in weight than regular skis. The widely accepted and relatively successful treatment option for CECS is surgical intervention through fasciotomy¹. In active individuals, such as cross country ski racers, decreasing the incidence of revision compartment release surgery is of importance so that the individuals can return to training with minimal setback. Fasciotomy in combination with a partial fasciectomy may be considered in order to prolong and enhance surgical success rate². **Conclusions:** A professional skate ski racer presented to the clinic with lower leg pain and tightness with activity. The orthopedic surgeon combined these

subjective symptoms with objective pressure measurements to diagnose and treat the athlete. Eight months post surgery, the athlete has returned to normal training and competition with no complications or return of symptoms. While the incidence of CECS is rare, it is important to understand and initiate proper management when the condition does present. It is important for health care providers to be aware of the signs and symptoms of this syndrome as well as available diagnostic and treatment methods.

Long Thoracic Neuropathy In A Division 1 Collegiate Wrestler

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Background: 20 year-old male collegiate wrestler (weight= 90.9 kg, height=188 cm) reported to the athletic training staff in November 2009 presenting with “dull and constant” right rib pain resulting from a direct blow. He was restricted from participation in wrestling, but was allowed to ride an Airdyne bike. After one week of bike riding, he reported that his right shoulder felt weak and painful. His pain increased with wrestling-specific movements and lying down for long periods of time, which resulted in difficulty sleeping. Test of function revealed severe right scapular winging of the superior angle, inferior angle, and entire medial border of the scapula upon initiation of elevation through abduction and flexion. He also could not perform a pushup due to weakness. Evaluation of active range of motion revealed elevation through flexion 0°-140°, elevation through abduction 0°-80°, and exacerbation of winging with extension. All other passive and active measurements were within normal limits. With his scapula manually stabilized, he was able to complete a full range of motion of elevation through flexion and elevation through abduction. There were no notable differences in glenohumeral joint play

or specific tissue testing when compared bilaterally and he did not report any radicular symptoms. **Differential Diagnosis:** Long thoracic neuropathy, brachial plexus lesions, posterior shoulder instability **Treatment:** Electromyography (EMG) studies showed decreased nerve conduction velocity, and abnormal spontaneous activity of the serratus anterior. Following a rest period of 36 weeks, the patient was cleared by an orthopedic surgeon to begin strengthening under the supervision of an athletic trainer. Initially rehabilitation focused on retraining of the muscles that support the scapula, as the patient demonstrated winging upon initiation of any shoulder movement. Rehabilitation was later progressed to focus on restoration of normal scapular kinematics once his scapular control had increased and he was able to statically stabilize his scapula. He still demonstrated medial border and inferior angle winging when functionally stressed, so rehabilitation exercises were progressed to focus on dynamic and sport-specific strengthening. Simultaneously, he developed spasm in his right upper and middle trapezius and rhomboid muscles, which was treated with combination therapy, mechanical release and stretching. He continued to demonstrate slight inferior angle winging with functional fatigue, and it was agreed upon by the athletic trainer and orthopedic surgeon that this may not improve due to the level of damage to the long thoracic nerve. At this point, 47 weeks post initial injury, a repeat EMG study was performed, which showed improvement in nerve conduction velocity and no longer showed abnormal spontaneous activity of the serratus anterior. The patient was cleared by the orthopedic surgeon to begin a progressive return to wrestling, and was later able to compete in the opening match of the season. **Uniqueness:** There is limited research on treatment for this pathology; however, the literature that does exist discusses a two or three

year recovery period. This case is unusual because the patient returned to a high functional level in just under one year. **Conclusions:** Long thoracic neuropathy can often present without a known mechanism, and the degree of impairment varies. This presents a unique challenge when working on retraining of scapular kinematics, as normal force couples are altered due to the denervation of the serratus anterior. Progression into strengthening exercises should not begin until healthy kinematics have been established in order to facilitate the scapula’s role as a stable base during glenohumeral motion. Each case is unique in the compensatory kinematics and altered firing patterns and need to be addressed individually.

Cervical Spine Fracture In A High School Football Player

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Background: While attempting to make tackle, an 18 year old high school football player (188cm tall and approximately 80kg) struck an opponent with the crown of his helmet and immediately fell to the ground. The athlete was attended to by two certified athletic trainers. One of the athletic trainers immediately applied manual cervical stabilization while the other athletic trainer began the primary assessment. Although the athlete was conscious when first attended to, he reported a brief loss of consciousness. He reported that he had full feeling and movement of both upper and lower extremities. The major complaint was pain directly over the cervical spine, specifically the C5 and C6 spinous processes. **Differential Diagnosis:** Cervical strain, cervical sprain, cervical fracture, spear tackler’s spine. **Treatment:** Based on the primary evaluation, the emergency action plan for spinal injuries was initiated and the athlete was subsequently transferred to a full-body immobilization device and

transported to a local level one trauma center for further evaluation and treatment. Upon arrival at the emergency department, the athlete received a CT scan which revealed a left side cervical fracture involving the inferior articulating process of C6 and extending into the junction of the lamina. The athlete was also diagnosed with a closed head injury. The athlete was placed into an Aspen cervical collar and admitted to the hospital for observation. The following morning the athlete received a MRI which confirmed a left C6 inferior articular process and lamina fracture with a small amount of C6-C7 joint effusion and left posterior paraspinal edema. There was no MRI evidence of ligamentous disruption. The athlete was released from the hospital on Day 3 post injury. He remained in the hard cervical collar for 4 weeks following the injury. An X-ray performed at 6 weeks post injury revealed normal flexion and extension views, leading the athlete to inquire about returning to football activities during the current season. The neurologist cleared the athlete to return to non-contact football activities and scheduled a CT scan for the following week. The CT scan at 7 weeks post injury revealed partial, but incomplete healing of the facet fracture. The athlete continued with non-contact football activities and then received a third CT scan at week 10 post injury. The CT scan revealed incomplete healing and the athlete was ruled out from returning to contact football activities for the season but was allowed to begin basketball activities. **Uniqueness:** Unilateral facet fractures with a diagnosed concussion and loss of consciousness are very rare in sports. Published epidemiology reports indicate that facet fractures and dislocations are most common in motor vehicle accidents. Caution must be utilized when releasing an athlete with a partially healed fracture for any non-contact sports activity. **Conclusions:** Proper on-field care of an athlete with a suspected spine-injury is crucial in minimizing potential catastrophic

outcomes. By following a predetermined emergency action plan along with good communication and teamwork with emergency medical personnel, the athlete was successfully transferred to the local hospital. At the present time, the athlete has been practicing with the high school basketball team and expects to compete in both basketball and track and field competitions.

Successful Management Of Bilateral Scapular Dyskinesia:

A Clinical Case Report

McClelland RI, Vesci BJ, Webster KA: Boston University, Boston, MA

Background: This case presents a 20 year old sophomore club male lacrosse player who reported in January 2009 with bilateral shoulder pain. He is a right-arm dominant player who reported worse pain in the right shoulder, frequent instances of instability, and pain with overhead activities, including playing lacrosse. The patient reported that the pain had been worsening over a period of 4-5 years. He had not sought help previously because until the time of evaluation he had been able to continue competing. The pain was reported as deep and diffuse throughout the superior and anterior aspects of the glenohumeral joint. Upon evaluation, the patient demonstrated general muscular weakness and marked scapular dyskinesia bilaterally. The dyskinesia was more pronounced in the right shoulder, and in accordance with previously published data, it demonstrated a predominantly Type I pattern. The left shoulder demonstrated a Type I/Type II pattern. Upper trapezius compensation was also evident bilaterally with glenohumeral abduction. Specific tissue testing revealed no abnormal findings. **Differential Diagnosis:** labral tear, scapular dyskinesia, rotator cuff tear, rotator cuff tendonopathy, sub-acromial impingement syndrome, internal impingement, capsular tightness **Treatment:** Magnetic

resonance angiographies (MRAs) revealed bilateral inferior and posterior labral tears and Hill-Sachs lesions. Additionally, the right shoulder MRA revealed tears of the middle and inferior glenohumeral ligaments and multiple adhesions in the anterior joint compartment. The patient was cleared by the orthopedic surgeon to participate as tolerated and scapular retraining rehabilitation was initiated by the athletic trainer. The rehabilitation goal was to decrease pain and increase function so the patient could participate throughout the season. The primary focus was on re-establishing normal kinematics of the scapula bilaterally via scapular assistance and biofeedback exercises. Once normal kinematics were restored, rehabilitation focused on strengthening the scapular stabilizers and decreasing upper trapezius activation. Picture and video were taken prior to commencing program and five weeks into the rehabilitation program. Subjective observation demonstrated a decrease in scapular winging, decrease in upper trapezius compensation, and an increase in synchronous scapulothoracic motion with dynamic glenohumeral motion bilaterally. The patient reported substantial decreases in pain with overhead activities and instances of instability. He was also able to play lacrosse for the entire season. Following the end of the season, the patient had surgery to repair the torn labrum in his right shoulder. He underwent a successful post-surgery rehabilitation protocol emphasizing his scapular kinematics and made a full return to lacrosse. He reported pain in his left shoulder when playing, but was able to continue competing, and upon graduation was contemplating surgery to repair the labral tears in his left shoulder. **Uniqueness:** This case illustrates the important role proper scapular biomechanics play in maintaining, or restoring, overall shoulder function. The exercises included in the pre-surgery protocol primarily focused on restoration of kinematics, with scapular and

glenohumeral strengthening and range of motion as a secondary focus. By focusing on restoring normal scapular kinematics, we were able to restore normal length and tension to the scapulohumeral muscles, leading to a restoration of strength and function to a pathologic shoulder. **Conclusions:** The scapular dyskinesis in this patient was likely secondary to the chronic labral tears, and was addressed as such. However, by addressing the malposition and maltracking of the patient's scapulae there was a decrease in his pain, increases in pain-free range of motion, strength of the shoulder girdle musculature, and functional activity. This case illustrates that for patients who choose to delay surgical repair for any reason, appropriate rehabilitation can serve to maintain a high level of function.

Fracture Blisters Following A Posterior Elbow Dislocation: A Case Report

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Background: A 21 year old, male collegiate football athlete (ht=187.9 cm; mass=92.9 kg), with no prior history of elbow injury, extended his right arm while being tackled. At the same time, an opposing player fell on his left shoulder causing more force on the outstretched arm. The Athletic Trainer initially observed gross deformity of the elbow joint with the ulna projecting posteriorly to the humerus. The physician on-site diagnosed the injury as a posterior elbow dislocation and immediately reduced the joint. Thirty-six hours after reduction of the dislocation, the athlete noted four clear-fluid blisters, each approximately 2.25 cm in diameter, over the medial aspect of the distal humerus. At a follow-up visit 48 hours later, the physician diagnosed the blisters as fracture blisters. **Differential Diagnosis:** Compartment syndrome, friction blister, ganglion cysts. **Treatment:** Follow-

ing reduction, the athlete was taken to the athletic training room where initial strength, neurological, and circulatory assessments revealed no abnormalities. However, significant edema, ecchymosis, and muscle guarding was observed. No fracture blisters were noted at this time. The athlete's arm was then immobilized with a SAM[®] splint, ace wrap, and sling. Crushed ice packs were applied on the anterior, posterior, medial, and lateral aspect of the elbow for 20 minutes after immobilization. At a follow-up visit with the physician two days post-injury, the splint and ace wrap were removed. Post-reduction radiographs were taken and were negative for fractures. Four fracture blisters were noted on the medial aspect of the right elbow. At this time, the physician recommended not aspirating the blisters to prevent infection and following a conservative treatment approach. This treatment consisted of immobilizing the athlete's elbow with a Bledsoe[®] elbow brace set at 90° flexion, daily use of a compression sleeve covering mid-forearm and mid-brachium, and icing for 20 minutes, three times a day. The sites of the fracture blisters were covered with antibacterial cream and sterile gauze which was changed three times a day until the fracture blisters had finished draining and the skin returned to normal (14 days post-diagnosis). The athlete underwent rehabilitation focusing on decreasing edema and pain and restoring full ROM while the fracture blisters were still present. No complications or infection occurred during or after rehabilitation as a result of the fracture blisters. The physician cleared the athlete for full athletic activity six weeks post-injury. **Uniqueness:** Fracture blisters occurring following athletic injuries and in the absence of a fracture are rare. Most fracture blisters occur concurrently with acute fractures following highly traumatic incidences such as car accidents. Some authors report that fracture blisters occur in 3% of all acute fractures requiring hospitalization. It is less clear how

often fracture blisters occur following posterior elbow dislocations in the absence of fractures. **Conclusions:** Fracture blisters are thought to occur when there is damage at the junction of the dermis and epidermis secondary to strains created in the skin during the initial high traumatic injury. The high traumatic injury typically causes edema and swelling which, in turn, causes an increase in interstitial and filtration pressures. Fluid then accumulates at the site of dermal and epidermal separation. Athletic Trainers must be aware that fracture blisters may occur in the presence or absence of a fracture, but do not pose much of a health risk to athletes or a significant complication for rehabilitation if handled conservatively.

Psychosomatic Induced Pathology in a Division I Football Athlete

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and Villanova University, Villanova,
PA

Background: A 20yo, African-American football athlete, experienced syncope a month prior to pre-season. His physician ordered a brain/neck MRA and MRI which were negative. The athlete was held from conditioning and referred to the team physician. An MRI, EEG, and blood screening were negative and the athlete was cleared. Approximately one week later, the athlete experienced gastrointestinal discomfort and was referred. The physician ordered a polypectomy and the athlete recovered without incident. Team physicals were seventeen days later; a history of head trauma and abdominal pain were reported. No abnormalities were noted and he was cleared. A week later, the athlete reported after practice complaining of bilateral parathesia of the upper extremities. Cervical hypertrophy was noted and he was treated for thoracic outlet compression. Two days later, physician examination revealed negative

Spurling compression test and radiographs. He was permitted to continue playing, and rehabilitation was initiated. After initial treatment, he complained of minor bilateral tingling. Approximately thirty minutes later, he returned with facial swelling and complaining of burning, tingling, and left vision loss. He denied drug use, dietary changes, or insect bites. Numbness and tingling spread to the left trunk and his condition quickly deteriorated. EMS was activated, he became argumentative, was sweating profusely; respiration was elevated, shallow, and labored. He stated he felt throat swelling. He also complained of chest pain and sustained a petit mal seizure. He was transported to the hospital and admitted. **Differential Diagnosis:** Sickle cell disease, celiac disease, epilepsy, head trauma, Crohn's disease, brain tumor, anaphylactic shock. **Treatment:** EEG, MRA head/neck without contrast, duplex scan, and blood labs were unremarkable. The athlete was prescribed anti-seizure medication and discharged the following day. He was removed from play, but experienced another seizure-like episode five days status-post. Follow up EEG, MRA, CT scan, cardiac evaluation, and chest x-ray, were negative. The anti-seizure medication was altered. Ten days after hospitalization, the athlete experienced another episode, was transported to the ED, and discharged. Cardiac involvement was ruled out, and in mid-September, epilepsy was ruled out. In October, he was admitted to the hospital with vertigo; diagnostic tests were WNL. Later that month, he resumed full activity. Four months after initial hospitalization, vestibular testing revealed an inner ear viral infection. However, the athlete continued to experience bilateral parathesia along the ulnar nerve distribution as well as gastrointestinal symptoms, which were treated symptomatically. In March, he was admitted to the ED for blurred vision, abnormal ocular response, vomiting, and left side facial pain. After psychiatric consultation, the athlete

was diagnosed with stress/psychosomatic induced pathology. He followed up with counseling and was prescribed anti-anxiety and ADHD medication which he chose not to take. He ceased seeing the psychiatrist but chose on-campus counseling through the university system. He was non-compliant with this but felt most comfortable with the athletic training staff. In consultation with the entire medical team, a "zero tolerance policy," was instituted in which any symptom return would disqualify the athlete from participation. He has been symptom free since spring 2010. **Uniqueness:** Somatic effects as a result of stress are unpredictable and rarely reported. Neurologic symptoms can be an indication of psychosomatic induced pathology. **Conclusions:** Athletes may experience anxiety from their athletic participation or from non-athletic related events. These influences, along with situations out of the control of the athletic trainer, may create an unpredictable somatic response. Those who present with an array of signs and symptoms without the support of diagnostic tests may need referral for psychiatric assessment. Once diagnosed, an appropriate support system and care must be provided. The athletic trainer should be prepared for creative solutions.

Inclusion Cyst In A Division 1 Women's Ice Hockey Athlete
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Background: A nineteen year old female Division I ice hockey player presented with pain in the plantar aspect of left foot/1st MTP joint during late spring 2009. Initial findings of the athletic trainer were point tenderness over the sesmoids, patient also has bilateral pes cavus and plantarflexed first ray. No swelling, ecchymosis, or erythema present. The patient is an otherwise healthy college aged athlete. The patient spent the summer of 2009 playing hockey in Canada. Cor-

respondence from the patient reported she saw a podiatrist and was diagnosed with sesmoiditis. The sesmoiditis was treated with a donut pad in the skate which allowed the patient to skate with minimal pain. The patient reported back for the fall semester with no change. After on-ice practice started in late September the patient reported a dramatic increase in pain. The patient was referred to the team physician for further evaluation. **Differential Diagnosis:** Sesmoiditis, Sesmoid stress reaction, flexor haluccis longus tendinopathy, foreign body, fat necrosis, ganglion cyst, inclusion cyst. **Treatment:** Physician evaluation revealed pain in the area of the sesmoids. The patient was referred for radiographs which were negative for fracture. After review of the radiographs and a continued increase in pain, the patient was then referred for MRI. MRI was negative for stress reaction in the sesmoids. The MRI revealed a small, 1.5cm subcutaneous cyst. Patient then underwent musculoskeletal (MSK) ultrasound to determine the nature of the cyst. Although the cyst was clearly visualized with MSK ultrasound it could not definitively be determined as to the type or cause. Aspiration of the fluid around the cyst confirmed it was not infected. The patient was referred to a podiatrist for further evaluation and to discuss treatment options. Due to increasing pain the patient chose to have the cyst surgically removed. Surgery was performed November 19, 2009 to remove the cyst. It was confirmed to be an inclusion cyst. An inclusion cyst is a closed epithelium-lined sac or capsule containing a liquid or semi-solid substance. Post surgical treatment was non-weight bearing for three weeks to allow the incision to heal. The patient then began a progression to return to play as pain and healing permitted and fully returned to hockey participation 5 weeks after surgical intervention with no complications. **Uniqueness:** The etiology of an inclusion cyst is typically hard to determine. This case

is unique since inclusion cysts are rare in this age population, occur two times more often in men, do not usually occur in the extremities and typically cause a visible “bump”. **Conclusions:** Sesmoiditis is a common pathology diagnosed in athletes particularly those with pes cavus. A differential diagnosis must be included since pain in the area of the sesmoids does not always correlate to sesmoiditis. In this case it was a rare inclusion cyst that was ultimately determined to be the source of pain.

Tethered Cord Syndrome And Myelomeningocele In A Competitive Tumbler - Collegiate Cheerleader: A Case Report

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Background: This case presents low back pain (LBP) from an undiagnosed congenital condition in an 18-year-old female competitive tumbler and collegiate cheerleader. The athlete complained of intermittent pain in her lumbosacral region along with lower extremity paresthesia. Pain aggravation and increased paresthesia were reported during postural changes that resulted in flexion and extension of the spine, including tumbling moves, jarring activities, and prolonged seated positions. The athlete’s medical history included diagnoses of mild scoliosis, incontinence since childhood, and a previous history of idiopathic LBP during competition. The athlete denied past history of low back injury. Physical findings revealed a birthmark and dimple approximately 1-inch to the right of the S1-S2 vertebrae, leg length discrepancy (R leg = 89.4 cm, L leg = 91 cm) and positive tests (i.e. Kernig/Brudzinski, Slump, Quadrant, Sitting Root). **Differential Diagnosis:** Disc herniation, nerve root entrapment, sciatic nerve impingement, spondylosis. **Treatment:** The athlete obtained her initial treatment from a Chiropractor where x-rays indicated an abnormality in the lumbosacral region,

warranting recommendation for an MRI. Preliminary MRI results showed a myelomeningocele cyst. The athlete was referred to a myelomeningocele clinic for further consult where surgical removal of the cyst was recommended. The athlete sought a second opinion where a full spinal, pelvic, and brain MRI was performed. Following the second MRI, physicians diagnosed myelomeningocele, a dermoid tumor, and Tethered Cord Syndrome (TCS). Surgery was warranted for tethered cord release and dermoid tumor removal. Pre-operatively, a Cystometrogram (CMG) demonstrated that the bladder never fully empties following urination. Manual muscle testing (MMT) of the lower extremities resulted in diminished strength (4/5). Post-op included an 8-day hospital stay with the following restrictions: no sitting (days 1-4); no food/beverages (days 1-6); 10 minute sitting increments (days 4-5); sitting as tolerated (days 5-6); standing/walking with ambulatory assistance (days 6-8); standing/walking as tolerated (day 8). Discharge on day 9 included home instructions of bed rest with walking (10 minutes x 5 times per day) and Tylenol for pain. One year post-surgery, an MRI, CMG, and MMT were performed. The CMG showed little to no difference and the MMT showed a decrease in strength of the lower extremities (3/5). At 5 months post-op, the athlete returned to cheerleading with restrictions of limited tumbling and no lifting activities. Return to full activity was permitted at two years post-op. **Uniqueness:** Tethered Cord Syndrome is usually diagnosed at birth or early infancy. The signs of TCS may include lesions, hairy patches, dimples, or fatty tumors on the lower back; foot and spinal deformities; weakness in the legs; LBP; scoliosis; and incontinence. In this case, the athlete exhibited many of these signs as a child and throughout adolescence, yet she was not diagnosed with the condition until adulthood. **Conclusions:** In this case, LBP resulted

from TCS and myelo-meningocele. The LBP and neurological defects in the lower extremities associated with this condition resulted from abnormal stretching of the spinal cord. In an adult, the signs of TCS may mimic conditions such as disc herniation or nerve injury. Therefore, the athletic trainer should consider TCS when evaluating a patient that complains of idiopathic LBP, weakness and paresthesia in the legs. A detailed history including information about current or past history of bladder incontinence must be obtained. The physical evaluation should observe for skin abnormalities directly overlying the spinal cord (i.e. dimples or birthmarks). Scoliosis and leg length discrepancy should be assessed so that early detection, immediate referral, and proper treatment can be provided.

Collegiate Volleyball Player With Primary Immune Deficiency: A Case Report

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Background: Presented is a unique case of an 18 year old female collegiate volleyball player who continues to participate in competitive athletics after being diagnosed with primary immune deficiency disease. The patient was diagnosed six years previously, and has no parent diagnosed with primary immune deficiency. She has two siblings, and her younger sister has also been diagnosed with the disease. Before being diagnosed, the patient had a history of bronchitis and ear infections. After the diagnosis, she has only had one episode of hospitalization due to bronchial spasms and pulse oximetry monitoring. **Differential Diagnosis:** Possible diagnosis includes anemia, allergic reactions, and cystic fibrosis. **Treatment:** After diagnosis of primary immune deficiency disease, the patient began taking natural supplements and natural sugars in addition to implementing dietary

changes to help aid in the proper function of the immune system. When these attempts were not successful, the patient was put on a vivaglobullen transdermal form of treatment. This treatment consists of three needle injections that are placed in the adipose tissue, typically on the patient's hypogastric region, proximal anterior leg, and in the lumbar spine region. This treatment uses a pump and tubing to help get the medication through the body, with the entire treatment taking roughly three to four hours. This treatment must be repeated every two weeks. As a result of the treatment, the patient has a variety of symptoms. After treatments the infusion sites are often point tender and swollen as the medicine is dispersing throughout the body. The patient also often develops migraines and nausea as a result of this treatment. It is also common for the patient to develop contact dermatitis at the infusion sites. **Uniqueness:** Primary immune deficiency causes a lowered capability of fighting infections and pathologies present throughout the body. The lowered immune system and transdermal treatment leads the patient to feel lethargic. This is a unique case because despite having primary immune deficiency disease, this patient is able to continue volleyball participation in the competitive collegiate atmosphere, even when having to miss competition as a result of treatment or due to its side effects. In addition, the patient often misses academic commitments due to the disease. **Conclusion:** Primary immune deficiency disease in this case causes nausea, migraines, and contact dermatitis after the transdermal treatments every two weeks. Despite the disease causing an inefficient immune system and lethargy, the patient continues to cope with the side effects and symptoms of treatment in order to compete in intercollegiate athletics. As healthcare professionals, it is important to understand the signs and symptoms associated with primary immune deficiency because this condition can present with similar attributes as other

common conditions. Because an inefficient immune system is prevalent in patients diagnosed with primary immune deficiency and there are associated side effects from the transdermal treatment, it is important to understand this condition to properly refer and treat patients accordingly.

Persistent Concussion Symptoms In A Div. I Men's Ice Hockey Player

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Background: A 23 year old male ice hockey player came into the athletic training room stating he was struck on the left side of the head by an elbow during a game in October, 2009. He declared his hearing was "foggy," he was dizzy, lightheaded and felt "slow". The athlete had a history of two incidences of mild traumatic brain injury (MTBI) in December 2008 and February 2009. He was able to communicate, aware of his surroundings, and was able to recall the event with full memory. Pupils were equal and reactive to light. Cranial nerve testing was within normal limits but he displayed a positive Romberg's sign, and also nystagmus during lateral eye movement. Cognitive tests were performed with little delay, and there were no signs of trouble with delayed recall. He was evaluated by the team physician the following day and diagnosed with a grade 1 MTBI and restricted from activity. The athlete continued post-concussion testing and was treated with pulsed ultrasound and anterior-posterior glides for a rotated C2 vertebrae suffered during the same incident. At four weeks S/P, the athlete presented asymptotically. The team physician permitted a gradual return to physical activity. During the next 2 weeks, the athlete complained of mild headaches and dizziness following longer workouts. At six weeks S/P a neurologist diagnosed the athlete with post concussive syndrome, and instructed him to refrain from physical

activity. **Differential Diagnosis:** MBTI, cerebral contusion, vestibular dysfunction, Benign Paroxysmal Positional Vertigo (BPPV). **Treatment:** An MRI revealed an ill-defined area of mildly increased flair and T2 signal present in the lateral right frontoparietal area. The athlete was referred to a chiropractor to evaluate the rotated C2-C3 region for the possibility that cervical spine pathology was causing the concussion-like symptoms including dizziness and vertigo. At ten weeks S/P a neurologist specializing in long term concussive symptoms examined the athlete, reviewed the MRI and ImPACT scores, and referred athlete to a vestibular specialist. While wearing frenzel goggles, the athlete showed no spontaneous nystagmus while sitting still; however, with the head rotated left, he showed right beating nystagmus with headshaking and hyperventilation which lead to the diagnosis of left BPPV. BPPV can be caused by an abnormal collection of calcium crystals within the semicircular canals; these crystals may be released from the saccule secondary to a concussive trauma. The athlete was referred for therapy to perform the Epley maneuver to reposition the calcium build up and appropriate night positioning to maintain the correction. Within a week, the athlete presented asymptomatic with the Epley maneuver, but remained slightly symptomatic with vertical movements. He was given vestibular home exercises to continue for 3-4 weeks, and permitted to start low level, symptom free physical activity with gradual progression to functional activity. S/P twenty-two weeks, he was cleared to return to non-contact skating; at forty-eight weeks, he was cleared to return to play for the upcoming season. **Uniqueness:** BPPV is reported as the cause of up to 20% of all dizziness, and incidence increases with age. The maneuvers to treat BPPV are reported to be approximately 80% effective; however only a reported 8% of sufferers receive this effective treatment. The most common cause of BPPV in

people under 50 is head injury, including MTBI. **Conclusions:** Following MTBI, some athletes experience symptoms longer than others, and it's important to monitor these athletes on a daily basis. If symptoms persist and athlete is no longer responsive to treatments or progressions, BPPV should be considered as a cause of vertigo or nystagmus. The athlete should be referred to a vestibular specialist for appropriate assessment and intervention.

Ocular Problems In A Female High School Soccer Athlete

Freed SD, Alvarez JL, McGinness CJ, Michael CL, Blair DF, Abbott MJ: Wenatchee High School, Wenatchee, WA

Background: Our subject is a seventeen-year-old female soccer player. She was first seen by the ATC at her high school with a complaint of black floaters and vision problems in her left eye in June 2010. She had constant floaters, which caused the blurring of vision in her left eye. The ATC referred her to an optometrist for possible retinal pathology. After an ocular examination, she was also referred to her family physician for additional diagnostic laboratory tests. **Differential Diagnosis:** Detached retina, tuberculosis, toxoplasmosis, retinitis, infectious or autoimmune retinopathy, Behcet's disease, syphilis, histoplasmosis, toxocariasis **Treatment:** The tests indicated positive toxoplasma IgG (immunoglobulin G) 4.31 mg/dl; however, the IgM (immunoglobulin M) was negative. The IgM is only positive with an active infection and gradually becomes negative while the IgG will remain positive when the infection is no longer active. Ocular physical examination and laboratory tests confirmed the diagnosis of ocular toxoplasmosis in the left eye. Toxoplasmosis is a zoonotic infection in humans caused by the protozoal intracellular parasite *Toxoplasma*

gondi. She was found to have an old toxoplasmosis scar with an adjacent area of reactivation in her right eye. Fortunately, the lesions in the left eye were located on the nasal side of the optic nerve and were not infringing on the macula or temporal arcades. If the lesions were nearer the macula or the optic nerve, a course of oral medications, pyrimethamine and sulfadiazine or clindamycin (if allergy to sulfa) in addition to steroids to suppress the inflammatory response, would have been started. In our subject's case, she was treated without oral medication and was only prescribed ocular steroid (prednisolone acetate) eye drops to reduce the eye inflammation. In July 2010, she returned to her eye doctor and was found to have minimal floaters and improved vision. **Uniqueness:** The cause of her case is still unknown, but is most likely from congenital origin. It is possible that the parasite was passed on congenitally during an acquired maternal infection where the organism simply crossed the placenta, and infected the fetus. The parasite persists in an encysted state for many years following infection. Cats are the primary hosts, while humans and other mammals serve as intermediate hosts. She did not have a cat, however, a family member had a cat for a few months when she was 8. Other possible modes of transmitting include: eating poorly washed vegetables that contained contaminated soil or eating undercooked meat. Most individuals do not show any symptoms with toxoplasmosis or only show symptoms later in life (ages 20-40). **Conclusion** There are numerous medical conditions that can mimic a more "routine" problem. On the surface, this appeared to be a common condition associated with the retina, such as a retinal detachment. However, the problem was a more obscure diagnosis of ocular toxoplasmosis. This condition is so rare, showing up in only .01% of live births. Nearly 80% of congenital toxoplasmosis will cause retinitis, compared to less than 1% of acquired toxoplasmosis. This

case underscores the importance of ruling out all the possible differential diagnoses when evaluating conditions. This remains a sight threatening condition as the subject could have 2 or 3 recurrences by the time she reaches her 40's. However, with the proper education on the signs and symptoms of recurrence, this should be avoided. Presently, the subject does experience the black floaters on an occasional basis and only on a limited basis. The symptoms of toxoplasmosis did not affect her play this past soccer season.

Free Communications, Poster Presentations: Knee & Hip Mechanics

Tuesday, June 21, 2011, 8:00AM - 11:30AM, Outside Hall A, authors present 10:30AM - 11:30AM

Anterior Tibiofemoral Intersegmental Forces During Landing Are Predicted By Passive Restraint Mechanics

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Context: Mechanical behavior of passive restraints may contribute to sagittal knee plane joint stability during functional activity. Axial loading increases anterior displacement of the tibia relative to the femur. Resultant acceleration at the proximal tibia can generate anterior intersegmental forces that load passive knee structures. It is unclear how sagittal passive restraint characteristics may contribute to high-risk landing mechanics. **Objective:** Determine if knee sagittal plane passive restraint characteristics are predictive of the high-risk landing mechanic of peak anterior knee shear force. **Design:** Descriptive cohort. **Setting:** Controlled laboratory. **Participants:** Recreationally active, college-aged students (74 females, 42males; 21.8±2.9 yr, 1.69±0.1 m, 68.9±14.1 kg). **Interventions:** All measures were performed on the dominant leg (stance leg when kicking a ball). Knee passive restraint behavior was assessed via joint arthrometry and during 40% body weight simulated weight acceptance. Electromagnetic motion sensors and an instrumented force platform assessed lower extremity landing mechanics during the initial landing phase of double leg drop jumps (0.45m). **Main Outcome Measures:** Anterior knee laxity (mm) was assessed at 133N while initial (0-20N) and terminal (100-130 N) anterior stiffnesses (N/mm) were calculated from arthrometer data. Peak anterior tibial acceleration (m/s^2) relative to the femur was assessed

via electromagnetic position sensors during 40% body weight acceptance trials at 20 knee flexion while surface EMG was collected from the medial and lateral quadriceps and hamstrings. Peak knee shear force (%Body Weight) during the initial landing phase of the drop jump was calculated via inverse dynamics. To ensure that peak tibial acceleration measures occurred prior to muscular force generation, time to peak acceleration was compared to time to muscle onset in the 40%BW trials. Sex specific linear stepwise regressions determined if passive restraint characteristics (anterior knee laxity, 0-20N anterior stiffness, 100-130N anterior stiffness, & peak anterior tibial acceleration) predicted peak anterior shear knee joint forces during landings. **Results:** Peak acceleration (91.0 ± 26.2 ms) and quadriceps muscle onset (95.2 ± 21.1 ms) times were not significantly different ($P>0.05$) while both were significantly less ($P<0.05$) than hamstring muscle onset time (120.5 ± 22.1 ms) with no sex main effect or interaction. In females, increasing peak tibial acceleration (5.1 ± 1.8 m/s^2) ($R^2\Delta=7.6\%$, $P\Delta=0.017$), increasing 0-20N anterior stiffness (31.0 ± 13.9 N/mm) ($R^2\Delta=5.5\%$, $P''=0.038$), and 100-130N anterior stiffness (43.2 ± 17.3 N/mm) ($R^2\Delta=5.3\%$, $P\Delta=0.036$) collectively greater peak knee shear forces ($70.0\pm 12.3\%$ BW) (Multiple $R^2 = 18.4\%$). No male regressions were significant ($P>0.05$). **Conclusions:** In females, sagittal plane passive restraint characteristics appear to be predictive of movement mechanics thought to be high-risk. Specifically greater magnitudes of tibial acceleration during early axial load along with greater initial and lesser terminal anterior stiffnesses predicted increasing anterior knee shear forces. To optimize injury prevention programs, future work should

investigate the combined contribution of passive and active restraints to high-risk mechanics.

The Effect Of Knee And Ankle Angles On The Plantarflexion Torque Of The Gastrocnemius

Landin D, Thompson MD: Louisiana State University, Baton Rouge, LA

Context: Muscle action descriptions have remained unchanged since the early 1900s. New technology now makes it possible to identify joint positions that allow a muscle to exert the greatest force, and add to the body of knowledge regarding musculo-skeletal dynamics. Understanding the joint positions that are most favorable to a muscles action would also aid clinicians in injury recognition and rehabilitation. **Objective:** To determine how different combinations of knee and ankle joint positions influence the plantarflexion moment of the gastrocnemius. **Design:** Descriptive cohort study design. **Setting:** Clinical anatomy laboratory. **Participants:** Twenty-six undergraduate female students (age = 19.3 ± 0.9 years, mass = 54.2 ± 4.2 kg, height 165.5 ± 5.7 cm) with no history of surgery or current injury to the right lower extremity. **Interventions:** Participants were positioned in a Biodex System 3 with the right ankle joint parallel to the rotational axis of the dynamometer. Eight knee flexion angles (0° , 15° , 30° , 45° , 60° , 75° , 90° , 105°) were combined with three ankle angles (dorsiflexion = -15° , 0° , plantarflexion = $+15^\circ$) creating 24 joint combinations in which the participants were tested in a counterbalanced fashion. Knee angles were maintained with removable casts, while ankle angles were controlled by the dynamometer. At each position the right gastrocnemius was electrically stimulated three times, at a

standardized level, via surface electrodes. **Main Outcome Measure:** The maximum plantarflexion moment was defined as the greatest torque achieved during each stimulation. Torque was recorded by the Biodex, averaged into a single score for each knee and ankle joint combination, and then used in the analysis. Data were analyzed with a 2 factor (Knee x Ankle) within subject ANOVA with repeated measures. **Results:** Significant main effects were found for the knee ($P=.001$) and ankle ($P=.001$). As knee flexion increased and the ankle was plantarflexed the maximum moment decreased. The greatest torque (25.16 ± 7.9 Nm) was obtained with the knee at 0° and the ankle dorsiflexed -15° . The lowest torque (12.37 ± 4.7 Nm) was obtained with the knee flexed to 105° and the ankle plantarflexed $+15^\circ$. **Conclusions:** A straight knee and dorsiflexed ankle create a position in which the gastrocnemius generates the greatest plantarflexion moment. Manual muscle testing of the gastrocnemius should be performed in this position. Clinicians should be aware that flexing the knee beyond 60° significantly decreases torque production. Furthermore, the ankle should be dorsiflexed during gastrocnemius testing for the plantarflexion torque drops significantly at 0° and $+15^\circ$.

Reliability Of The Modified-Sensory Star Excursion Balance Test

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Context: The Star Excursion Balance Test (SEBT) is a measure of postural control utilized in the assessment of balance in multiple pathologies. Modification of afferent sensory input is often implemented to increase the difficulty of postural control tasks as well as increase the sensitivity of the

task to specific impairments; however, current use of the SEBT involves no sensory modifications. If the addition of sensory input modifications does not alter reliability of the SEBT, inclusion of these conditions may improve the utility of the test in evaluating various pathologies. **Objective:** To establish the test-retest reliability of the Modified-Sensory Star Excursion Balance Test (MS-SEBT). **Design:** Repeated measures design. **Setting:** Research laboratory. **Participants:** Nineteen healthy, young adults (24.63 ± 4.40 yrs, 77.61 ± 18.90 kg, 169.38 ± 12.77 cm) participated in this study. Participants reported no changes in activity level or musculoskeletal injury status throughout the duration of the investigation. **Interventions:** The MS-SEBT was administered to each participant on two separate occasions with an average of 55.26 days between sessions. Following four practice trials in each direction, MS-SEBT measures in the anterior, medial, and posterior directions were recorded with the non-dominant limb (based on kicking preference) as the stance limb. Testing was completed under four conditions: stable surface-eyes open (SO), stable surface-eyes closed (SC), unstable surface-eyes open (UO), and unstable surface-eyes closed (UC). **Main Outcome Measures:** Intra-class correlation coefficients [ICC(2,1)] were calculated using mean performance for reach direction by condition to evaluate test-retest reliability. **Results:** High reliabilities were noted for the anterior reach direction: SO=0.97, SC=0.97, UO=0.95, UC=0.94; medial reach direction: SO=0.96, SC=0.95, UO=0.93, UC=0.90; and posterior reach direction: SO=0.93, SC=0.88, UO=0.95, UC=0.78. **Conclusions:** Mean reach distance during the MS-SEBT was reliable during test-retest measures separated by approximately eight weeks. All conditions and directions boasted good to excellent values, ranging between 0.78 to 0.97 with an average value of 0.93 (± 0.05). Eliminating visual input while

performing on an unstable surface produced the lowest reliability in all directions; however, values were still acceptable for clinical application. The clinical utility of the MS-SEBT is in need of further investigation; however, this investigation establishes that the measure is reliable and stable over time in a healthy population.

Serum Cartilage Oligomeric Matrix Protein And Patient Reported Outcomes In Division I Soccer Athletes Over The Course Of A Soccer Season

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Context: Serum cartilage oligomeric matrix protein (sCOMP) is a biomarker elicited during cartilage degradation. Patient reported outcomes (PRO) are used to document progress following injury and are not often employed prospectively to identify changes in the course of a season. It is unknown what affect intense, continuous physical activity has on sCOMP levels and PRO values in un-injured elite athletes. **Objective:** To document the course of sCOMP levels, and to determine if changes in PROs occur in elite, soccer athletes at three distinct time points during a season. **Design:** Prospective, longitudinal cohort study. **Setting:** Athletic training facility. **Patients or Other Participants:** Thirty-one Division-I soccer athletes (19 males, 12 females, age: 19.53 ± 1.16 years, height: 176.91 ± 7.24 cm, weight: 73.22 ± 9.73 kg) participated in three (pre-season (T_1), mid-season (T_2), and post-season (T_3)) data collection sessions. Subjects were included if they participated in the 2010 spring soccer season and were free of severe knee injury at time of data collection. **Interventions:** At each session, patients remained seated for 30 minutes and completed two PROs (Lysholm, IKDC) prior to serum collection. Following the rest period,

10cc of serum was collected from the antecubital vein, placed on ice and transported to the laboratory. Sera was separated, and placed in a -80°C freezer prior to analysis. Once all samples were collected, ELISA tests were run (Euro-Diagnostica, ALPCO, Salem, NH) for human sCOMP. Serum COMP values are expressed as ng/mL. Independent variables included time and gender. **Main Outcome Measures:** Serum COMP values and PRO scores for each time point were the dependent variables, investigated over time by using separate linear mixed models. Paired-sample t-tests were used to explain significant interactions or main effects. The alpha was set at $p \leq 0.05$. Values are presented as mean \pm SE. **Results:** There was no gender by time interaction for sCOMP ($p=0.43$), Lysholm ($p=0.76$), and IKDC ($p=0.22$). For sCOMP there was a significant effect for gender (Males: 1682.86 ± 45.86 , Females: 1502.82 ± 56.30 , $p=0.02$) and time ($p=0.001$). The significant differences occurred between time points $T_1(1462.81 \pm 35.51)$ - $T_2(1698.94 \pm 50.68)$, $p=0.001$ and $T_1(1462.81 \pm 35.51)$ - $T_3(1616.78 \pm 49.54)$, $p=0.0018$, but not for $T_2(1698.94 \pm 50.68)$ - $T_3(1616.78 \pm 49.54)$, $p=0.07$. For each of the PROs there was no significant effect for gender (Lysholm $p=0.11$, IKDC $p=0.71$), however there was a significant effect of time (Lysholm $p=0.01$, IKDC $p=0.04$). Post-hoc tests for the Lysholm indicated there were significant differences between $T_1(92.26 \pm 1.49)$ - $T_3(95.90 \pm 1.43)$, $p=0.02$ and $T_2(92.47 \pm 2.03)$ - $T_3(95.90 \pm 1.43)$, $p=0.04$. For the IKDC, there were significant differences between $T_2(91.29 \pm 1.72)$ - $T_3(94.47 \pm 1.32)$, $p=0.03$. **Conclusions:** These data indicate sCOMP values increase over the duration of an athletic season and the PROs indicate an increased level of function over time. Therefore, the effects of continuous, intense physical activity resulted in cartilage degradation identified as increased levels of sCOMP, however this

microtraumatic injury was not identifiable in PRO scores on the Lysholm and IKDC.

The Role Of Sex In Physical Self-Efficacy And Balance Among High School Basketball Players

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Context: Self-efficacy is the concept that an individual's measure of self-confidence, during a given situation influences the effort and determination put forth in order to successfully accomplish a given task. Physical self-efficacy is the measure of an individual's perceived physical capabilities. A direct relationship between self-efficacy and expectations of performance outcomes has been established in the literature. Limited evidence exists in regards to the examination of sex differences in physical self-efficacy in high school athletes. In addition, to our knowledge, there is no data as to how physical self-efficacy relates to the performance of functional postural control. **Objective:** To examine sex differences in physical self-efficacy expectations and to determine the relationship between physical self-efficacy and a clinical measure of functional postural control. **Design:** Prospective cohort study. **Setting:** Field testing. **Patients or Other Participants:** Fifty-seven high school basketball players (30 males, age=15 \pm 1.4, height=178.9 \pm 9.9 cm, mass=75.6 \pm 14.6 kg; 27 females, age=15 \pm 1.2, height=168.1 \pm 7.0 cm, mass=63.8 \pm 9.3) participating in interscholastic basketball. **Interventions:** Each participant completed the Physical Self-Efficacy scale (PSE). The PSE is a 22-item Likert scale questionnaire with possible scores ranging from 22 to 132, with higher scores indicating higher level of self-efficacy. Each participant then completed 3 20-second trials of the Balance Error

Scoring System (BESS) single-limb stance on a firm surface for each limb. The number of errors incurred during each trial were tallied and totaled for a comprehensive BESS score. **Main Outcome Measures:** The dependent variables were scores on the PSE and BESS. Data were not normally distributed; therefore, sex differences for the PSE and the BESS were analyzed using the Mann-Whitney U test. Bivariate Spearman's rho correlations were performed to examine the relationship between the PSE and the BESS error scores. **Results:** The following results are presented as a median [range]. Males had a significantly higher PSE score than females (males: 103[80 to 127]; females: 97[78 to 108]; $p=0.01$). There was no difference between the sexes for BESS and error scores (males median score = 15.5[0 to 52], females median score = 11[0 to 40], $p=0.20$). There was a weak, nonsignificant relationship ($r=-0.17$, $p=0.21$) between BESS error scores and PSE scores. **Conclusions:** Previous research has demonstrated that physical self-efficacy is directly related to physical performance in accuracy, endurance, and performance to physical tasks. In contrast, the results of this study indicate that physical self-efficacy expectations as measured by the PSE do not relate to postural control as measured by the BESS. The PSE may represent a more global perspective of physical self-efficacy, and correspond to a general level of perceived physical abilities. The postural control system may be too complex to predict through physical self-efficacy expectations alone.

Eight-Weeks Of Abdominal Training Reduces Vertical Ground Reaction Forces During A Landing Task

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Context: Peak vertical ground reaction forces (VGRF) are greater in chronic ankle instability (CAI) subjects than able-bodied subjects during landing. CAI may alter trunk control, thus forcing the body to compensate for the increased vertical loads placed on the lower extremity. Improved postural control has been observed following core training in healthy subjects, therefore abdominal training may have a positive outcome on the CAI patient population. **Objective:** To determine if abdominal training reduces VGRF in CAI and healthy subjects during a landing task. **Design:** A 3 x 2 (group x time) cohort design. **Setting:** Biomechanics laboratory. **Patients or Other Participants:** Nineteen Control (age = 22±3 yrs, mass = 74.1±13.8 kg, height = 172.6±11.3 cm, BMI = 24.8±3.1%), 21 CAI (age = 22±2yrs, mass = 77.6±14.0 kg, height = 175.4±12.3 cm, BMI = 25.1±2.6%), and 20 healthy (age = 23±3yrs, mass = 70.9 ±15.6 kg, height = 172.2±8.9 cm, BMI = 23.7±3.3%) subjects participated. CAI subjects self-reported ankle instability using the Ankle Instability Index and Functional Ankle Ability Measure. **Interventions:** The CAI and healthy groups participated in an eight week abdominal training program while the control group maintained their normal activities of daily living and current fitness level. A force plate (AMTI, Newton, MA) was used to measure VGRF during a single leg drop landing pre- and post-training. **Main Outcome Measures:** The dependent variable was VGRF. A general linear model repeated measures ANOVA was used

to analyze mean and peak VGRF over time. Post-hoc testing with a Bonferonni correction determined differences between and within groups. The p-value was set at 0.05 *a priori*. **Results:** Peak and mean VGRF (N) were measured pre- (Peak: *Control* – 2216.0 ± 418.6; *CAI* -2459.6 ± 430.8; *Healthy* -2085.9 ± 534.1; Mean: *Control* –1171.8 ± 252.6; *CAI* -1275.9 ± 257.7; *Healthy* -1122.0 ± 309.3) and post-training (Peak: *Control* – 2217.5 ± 436.0; *CAI* -2286.1 ± 583.3; *Healthy* -2039.7 ± 473.5; Mean: *Control* – 1149.6 ± 265.6; *CAI* -1197.8 ± 321.5; *Healthy* -1124.2 ± 294.1). A difference in peak VGRF was observed between the CAI and healthy groups prior to training (CAI•Healthy; *p*=0.03). The CAI group's mean (*p* = 0.006) and peak (*p*=0.002) VGRF decreased after eight weeks of abdominal training. No change in VGRF (mean: *p*=0.40, peak: *p*=0.94) was observed in the Healthy group following training. **Conclusions:** CAI subjects had greater peak VGRF during a single leg drop landing task than healthy subjects prior to training. Eight weeks of abdominal training can decrease the VGRF that act on the foot and ankle. Abdominal training reduces vertical loading forces, which may decrease the likelihood of recurrent ankle sprains. Clinicians may consider abdominal training as part of their patient's ankle rehabilitation program.

Validity And Reliability Of Wii Fit Balance Scores

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Context: A growing number of health care professionals are using a variety of interactive video games to help rehabilitate musculoskeletal pathologies. The Wii Fit is purported to improve balance and rehabilitation compliance and provides objective measures of balance ability which

could be used to monitor rehabilitation progress. Thus, the Wii Fit could be an effective and cost effective tool to assess and monitor changes in balance ability. However, the validity and reliability of Wii Fit balance scores remains unknown. **Objective:** To test the criterion and construct validity as well as the intrasession and intersession reliability of Wii Fit balance scores. **Design:** Test-retest study design. **Setting:** Controlled, laboratory setting. **Participants:** Forty-five subjects, 22 controls (26.2±9.2yrs, 154.9±21.4cm, 66.5±3.3kg) and 23 with a history of lower extremity injury (27.8±10.4yrs, 163.5±29.7cm, 68.0±3.8kg) participated. **Interventions:** Each subject completed three traditional balance tests (single-leg stance on a force plate, Star Excursion Balance Test [SEBT], and the Balance Error Scoring System [BESS]) and twelve Wii Fit balance activities (Basic Balance, Agility, Walking, Steadiness, Single Leg Stance, Deep Breathing, Tree, Standing Knee, Palm Tree, Single-leg Extension, Single-Leg Twist, and Sideways Leg Lift). Traditional balance tests and Wii Fit activities were completed during the first test session. Wii Fit activities were repeated during a second test session one-week later. **Main Outcome Measures:** Traditional balance outcomes included the resultant center-of-pressure excursion and velocity (single-leg stance), normalized reach distance in the anterior, posteriomedial, and posteriolateral direction (SEBT), and number of errors during all six BESS conditions. Wii Fit outcomes included the game generated scores for each of the twelve tested activities. Independent t-tests compared Wii Fit balance scores between control and injured subjects to quantify construct validity. Correlations between Wii Fit and traditional balance outcomes quantified criterion validity. Intraclass correlation coefficients determined the intra- and intersession reliability of Wii Fit balance scores. **Results:** Construct validity was not identified

as no Wii Fit activity identified differences between the control and injured groups ($p>0.05$). The Palm Tree activity demonstrated the greatest sensitivity ($p=0.12$) to group differences (Control: $69.1\pm 12.4\%$, Injured: $61.5\pm 16.0\%$). Overall, Wii Fit balance scores had poor criterion validity. Four significant relationships were identified: Single-leg Stance ($r=-0.43$, $p<0.01$) and Single-Leg Extension ($r=-0.32$, $p=0.03$) to Bess tandem stance on foam, Sideways Leg Lift to BESS double-limb stance on foam ($r=-0.47$, $p<0.01$), and Single-Leg Twist to SEBT anterior reach ($r=0.21$, $p=0.48$). Intrasession reliability of Wii Fit balance scores ranged from 0.39 to 0.80 while intersession reliability ranged from 0.29 to 0.61. **Conclusions:** The overall findings indicate that Wii Fit balance scores should not be used as a diagnostic tool monitor balance improvements over time. However, Wii Fit activities can still be used as a fun and innovative tool in the rehabilitation process.

Tibial Plateau Slope Geometry Predicts High-Risk Knee Joint Biomechanics During Landing

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Context: Females have greater medial (MTS) and lateral (LTS) posterior inferior tibial plateau slopes and reduced coronal tibial plateau slopes (CTS) compared to males, and greater LTS has been associated with greater risk of ACL trauma. The impact of these tibial plateau slope characteristics on high-risk knee joint biomechanics has received little attention. **Objective:** To determine the extent to which tibial plateau slope geometry predicts frontal and transverse plane knee joint kinematics during a drop jump landing. **Design:** Descriptive cohort study. **Setting:** Controlled, laboratory. **Patients or Other Participants:** Healthy, physically active females ($N=24$;

21.3 ± 3.0 yrs, 169.5 ± 7.4 cm, 64.8 ± 11.6 kg). **Interventions:** All measures were obtained on the dominant stance leg. Tibial slope characteristics were measured from MRI images (1.5 T; voxel size $0.55 \times 0.55 \times 1.0$ mm) using MIPAV software (<http://mipav.cit.nih.gov/>). MTS and LTS ($^\circ$) represented the angles between the perpendicular mid-diaphysis of the tibia and posterior inferior inclination of the medial and lateral tibial plateaus, respectively, and the ratio (MTS/LTS) was calculated. CTS represented the angle between a line joining the peak points of the medial and lateral tibial plateaus, and a line perpendicular to the longitudinal axis of the tibia (lateral superior to medial tibial plateau contact = positive slope). Test-retest reliability [ICC_{2,3} (SEM)] for MTS [0.98 (0.53°)], LTS [0.97 (0.41°)], and CTS [0.99 (0.18°)] was confirmed on 10 subjects. **Main Outcome Measures:** Subjects were instrumented for biomechanical analysis during a double leg drop jump landing (0.45 m). Knee valgus and internal rotation angles at initial contact ($KVAL_{INI}$, KIR_{INI}) and excursions ($KVAL_{EXC}$, KIR_{EXC}) during the initial landing phase (initial contact to peak center of mass displacement) were averaged across 5 trials. Backward, stepwise multiple linear regressions determined the extent to which LTS, MTS/LTS ratio, and CTS predicted $KVAL_{INI}$, KIR_{INI} , $KVAL_{EXC}$, and KIR_{EXC} . **Results:** Greater CTS ($3.9\pm 2.8^\circ$) and lower MTS/LTS (1.1 ± 0.8) predicted greater KIR_{EXC} ($-8.3 \pm 6.1^\circ$) (Multiple $R^2 = .33$, $P=.03$; $KIR_{EXC} = -7.51 - 1.02CTS + 2.99$ MTS/LTS). Conversely, reduced CTS was the sole predictor of greater $KVAL_{INI}$ ($2.1 \pm 4.0^\circ$) ($R^2=.20$, $P=.031$; $KVAL_{INI} = 4.54 -.634CTS$). Tibial slope characteristics were not significant predictors of KIR_{INI} or $KVAL_{EXC}$. **Conclusions:** The posterior inferior slope of the tibial plateau results in anterior translation of the tibia relative to the femur (ATT) during weight acceptance. These findings suggest that greater relative height and slope of the LTS vs. MTS may promote

greater anterior translation of the lateral versus medial tibia plateau relative to the femur, resulting in internal rotation of the tibia; coupled motions known to strain the ACL. Conversely, reduced CTS (reported to be more common in females vs. males) may couple with ATT to increase ACL strain during landing via greater initial knee valgus alignment. **Acknowledgement:** Funded by NIH-NIAMS #RO1-AR053172.

A Reliability Study Of The Patella Quadrant Test And Clinical Visual Measures Of Medial And Lateral Patella Glides

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Context: Patella hypermobility has been linked to patellofemoral pain syndrome. Since there are currently no inexpensive, easy to use clinical tools to assess patella mobility, clinicians often rely on visual inspection to assess patella movement. **Objective:** Establish intra-rater, inter-rater, and inter-session reliability of the patella quadrant test utilizing a newly developed patella quadrant tool (PQT) and to determine reliability of a clinical visual measure. **Design:** Descriptive cohort study. **Setting:** Controlled laboratory setting. **Participants:** Eighty-eight healthy collegiate subjects participated (36 males, 52 females, 21.83 ± 3.13 years, 171.60 ± 10.62 cm, 72.60 ± 13.79 kg). Subjects had no past medical history of knee or back surgery, direct knee trauma within the previous three months, chronic subluxing, dislocating patellae, or the presence of Ehlers-Danlos syndrome. **Intervention:** Two novice athletic trainers performed patella mobility measurements bilaterally on all subjects during two testing sessions separated five days apart. Each examiner visually divided the patella in four horizontal quadrants and took a subjective visual assessment of medial and lateral glides and labeled them according to quadrants of

movement. The examiner then categorized each subject into a hypomobile or normal category based on the number of quadrants moved. The patella width was measured and divided into four quadrants using the PQT. Medial and lateral displacement was measured by quadrant and in centimeters, through three trials using the PQT. **Main Outcome Measures:** Intraclass correlation coefficients ($ICC_{2,1}$) were used to determine intra-rater, inter-rater, and intersession reliability using the PQT for all glides (4). Cohen's kappa statistics were used to determine the intersession and inter-rater reliability of the subjective visual assessment. Percent agreement (PA) was obtained to determine whether raters agreed on the category for the subjective visual measure. **Results:** $ICC_{2,1}$ results for intra-rater reliability for session one ranged from .865 to .917 for rater one and .913 to .947 for rater two. Inter-rater reliability during session one ranged from .675 to .762. Intersession reliability ranged from .690 to .777 for rater one and .528 to .732 for rater two. Inter-rater Kappa results for session one ranged from .161 (PA=48%) to .333 (PA=66%). Intersession kappa values ranged from .482 (PA=74%) to .505 (PA=80%) for rater one and .367 (PA=72%) to .574 (PA=85%) for rater two. **Conclusions:** Clinician's subjective clinical visual assessment reliability ranged from fair to moderate. These findings may allow clinicians to utilize the subjective visual assessment when no PQT is available. For a more objective measure, the PQT can be used by clinicians for quantitatively measuring patella mobility.

Validation Of 2D Measures Of Hip And Knee Frontal Plane Biomechanics During Running

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Context: Clinicians commonly assess gait patterns using single-camera, two-dimensional (2D) systems whereas researchers commonly use three-dimensional (3D) systems, which are considered the gold standard. However, few studies have investigated whether 2D and 3D systems are comparative, and thus whether 2D measures are valid for assessing running kinematics. **Objective:** To determine whether 2D measures of hip and knee frontal plane kinematics are comparable to 3D measures during the stance phase of running. We hypothesized that 2D measures of peak frontal plane knee and hip angles would be comparable and moderately correlated (r -value=0.50-0.69) in waveform pattern to 3D measures.

Design: Descriptive laboratory study.

Setting: Clinical research laboratory.

Patients or Other Participants: Ten participants (3 male, 7 female; age=24.4±4.2 years, mass= 77.2±9.1kg, height= 164.4±9.8cm) participated. The number of subjects ($p_L=0.29$; $p^*=0.80$) needed for 80% reliability was determined based on an agreement analysis from Fleiss (1999). Subjects were recreationally active, accustomed to running on a treadmill, and free from any injury.

Interventions: Retroreflective markers were placed to represent foot, shank, thigh, and pelvis segments and anatomical markers placed to determine ankle, knee, and hip joint centers for the right limb. A Sony (60 Hz) camera was placed directly posterior to the treadmill and perpendicular to the lab frontal plane to record 2D frontal plane kinematics. 3D measures were recorded using an 8-camera motion capture system (Vicon, Oxford, UK: 120Hz) placed around the treadmill. Visual 3D (C-

Motion Inc., USA) and Peak Motus (Vicon, Oxford, UK) software calculated 3D and 2D measures, respectively, for the first 60% of the stance phase. **Main Outcome Measures:** 2D and 3D measures of peak knee abduction, peak hip adduction, and frontal plane knee and hip time-series curves, were calculated. Paired t-tests were used to determine differences, if any, in 2D and 3D peak angles ($P<0.05$) and coefficient of multiple correlation (CMC) were used to compare 2D and 3D knee and hip time-normalized waveform patterns. **Results:** For the knee, 2D measures of peak abduction angle were consistently greater by 5.52 ± 1.50 degrees ($P=0.03$) compared to 3D values and showed a strong correlation ($r = 0.82$, $P=0.05$) in waveform pattern. For the hip, 2D measures of peak adduction angle were consistently greater by 2.85 ± 1.73 degrees ($P=0.05$) compared to 3D values and also showed a strong correlation ($r = 0.83$, $P=0.05$) in waveform pattern. **Conclusions:** In contrast to the hypotheses, peak knee abduction and hip adduction angles measured using a single camera were consistently greater compared to the 3D measures. In support of the hypotheses, the 2D time series curves exhibited a strong correlation in temporal pattern compared to the 3D curves. Caution should be taken not to compare peak 2D angles to the 3D values but waveform patterns are similar.

Nintendo Wii Utilized As A Balance Rehabilitation Tool

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Context: The use of video gaming systems in the rehabilitation setting is becoming more popular and widely accepted by patients and clinicians. Intuitively, playing video games requires the patient to utilize the same neuromuscular strategies as traditional

rehabilitation exercise. **Objective:** The purpose of this study is to compare the effectiveness of a video game based protocol to traditional balance training exercises. **Design:** Randomized controlled trial. **Setting:** research laboratory. **Patients or Other Participants:** 15 (males = 6, females = 9) healthy participants (age = 22.3 ±3.0 years, mass = 65.3 ±12.5 kg, height = 167.1 ±9.7 cm) with no history of current or recent injury involving their lower extremities. **Interventions:** Independent variable was balance training protocol: traditional exercises (TE), video game (VG). Participants completed 9 training sessions over a 3 week period. Each session consisted of performing 3 sets of 4 different exercises. The order of exercises was randomized for each session. TE protocol: Single Leg Balance, Balance Board Training, Single Leg Weight Shifts, Lateral Jumps. VG protocol: participants were instructed to perform the same exercises as the TE group while simultaneously playing various video games on the Nintendo® Wii™ system: Tennis (Single Leg Balance); Archery (Balance Board Training); Wii™ Fit (Single Leg Weight Shift); Boxing (Lateral Jumps). Static balance was measured prior to starting and after completion of all training sessions. **Main Outcome Measures:** Dependent variable: total range (mm) of Center of Pressure in the frontal (COPX) and sagittal (COPY) planes (for both legs) was collected at a sample rate of 1500 Hz on a force platform (AMTI, Inc., Watertown, MA). Participants were instructed to stand on one leg on the force platform for 30 seconds while remaining as still as possible. Measurements for each leg were averaged over 3 trials. A two-way mixed factor [2 (protocol) x 2 (time)] ANOVA was used to assess differences between training protocols. **Results:** No differences between VG and TE groups (mean ± SD) were found for: COPX right leg (30.589 ±6.26 and 30.172 ±10.53, respectively, $P = .659$), left leg (29.768 ±7.75 and 28.790 ±10.93,

respectively, $P = .436$); COPY right leg (41.567±14.03 and 38.286 ±20.75, respectively, $P = .678$); left leg (44.548 ±17.68 and 34.885±18.31, respectively, $P = .161$). A significant main effect for time [COPX right leg ($P = .024$), left leg ($P = .045$) and COPY right leg ($P = .048$), left leg ($P = .033$)] indicated all subjects improved in balance. **Conclusions:** VG was shown to be an effective training tool for use in rehabilitation. While all participants demonstrated improvements in balance, VG participants appeared to be more enthusiastic during training sessions possibly leading to improved compliance with rehabilitation.

The Influence Of Hip Muscle Strength On Lower Extremity Kinematics And Kinetics During A Cutting Task

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Context: Strength of the hip musculature has been suggested to contribute to altered hip and knee biomechanics, increasing the risk of anterior cruciate ligament (ACL) injury. However, the relationship between hip strength and lower extremity biomechanics remains unclear. A limitation with previous investigations is that hip strength has been assessed isometrically. Examining isokinetic hip strength and relating this to dynamic motion during a cutting task may be more reflective of the dynamic hip muscle function during a common task associated with ACL injury. **Objective:** To examine the influence of concentric (CON) and eccentric (ECC) hip muscle torque on hip and knee joint kinematics and kinetics during a jump-cut task. **Design:** Descriptive cohort. **Setting:** Laboratory. **Patients or Other Participants:** Forty healthy individuals (20 females, 20 males: 21.6±1.9yrs, 173.3±9.0cm, 69.0±

12.3kg) volunteered for this investigation. **Interventions:** Five consecutive isokinetic trials of CON and ECC torque of the hip abductors (ABD), external rotators (ER), and extensors (EXT) were collected at 60% s^{-1} . Frontal and transverse plane kinematics and external joint moments of the hip and knee were collected during a jump-cut task using a three-dimensional motion analysis system. All measures were assessed on the dominant lower extremity. **Main Outcome Measures:** The average CON and ECC hip muscle peak torques of the middle three isokinetic trials were calculated and normalized to body mass. Frontal and transverse plane hip and knee joint excursions (peak joint angle minus initial contact angle) and external joint moments (normalized to body mass and height) were averaged across 5 jump-cut trials during the deceleration phase (initial contact to peak knee flexion). Separate stepwise linear regressions were performed to determine the influence of hip muscle torque on hip and knee frontal and transverse plane joint excursions and external joint moments. **Results:** Greater ER ECC torque predicted less hip internal rotation excursion, explaining 21.8% of the variance ($P=0.002$). Greater ER CON torque predicted less hip adduction excursion, explaining 11.3% of the variance ($P=0.034$). Greater EXT ECC torque predicted greater knee valgus excursion, explaining 11.1% of the variance ($P=0.036$). There were no significant predictors for knee external rotation excursion. Greater ABD CON torque predicted less hip adduction moment, explaining 11.4% of the variance ($P=0.033$). Greater EXT CON torque predicted less knee valgus moment, explaining 14.3% of the variance ($P=0.016$). There were no other significant predictors of hip and knee moments. **Conclusions:** Based on these findings, strength of the posterior-lateral hip muscles plays a role in dynamic motion of the lower extremity during a jump-cut task. However, due to the small amount of

variance explained by hip muscle strength ($R^2 < 0.218$), future research is warranted to determine the additional variables (i.e. muscle activity) that are influencing lower extremity biomechanics during dynamic tasks. (*Funded by the College of Charleston Summer Undergraduate Research with Faculty Grant*)

The Relationship Between Dynamic Postural Control And Physical Performance

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Context: Improving dynamic balance to enhance physical performance is one technique used by clinicians as part of return-to-play rehabilitation programs. To date however, there is limited information into the relationship between dynamic balance and level of physical performance of high school athletes. **Objective:** To determine the relationship between dynamic postural control and physical performance. **Design:** Between-subjects correlational study. **Setting:** This study was performed in a high school gymnasium. **Patients or Other Participants:** Twenty-eight high school athletes (14 male, 14 female; age= 16 ± 1.3 yrs; ht= 174.75 ± 10.84 cm; mass= 71.3 ± 17.3 kg). Inclusionary criteria included healthy individuals with no lower extremity injury within the past four months, participation in competitive sports for at least one season prior to the start of the study, and a valid pre-participation physical exam. Exclusionary criteria included participation in an in-season sport during the time of testing, a contraindication to performing any of the included tests, a Cumberland Ankle Instability Tool score of < 24 , or surgery to the lower extremity within the last two years. **Intervention:** Following an eight minute pre-

determined warm -up, subjects performed five tests in the following order: Modified Star Excursion Balance Test (SEBT), vertical jump (VJ), broad jump and hold (BJH), triple hop (TH) and T-test. Multiple Pearson product moment correlations (r) were used to determine relationships between the variables. The alpha level was set a priori at $p = 0.05$. **Main Outcome Measures:** The Modified SEBT scores (max anterior, normalized (%LL) anterior, max posteromedial, %LL posteromedial, max posterolateral, %LL posterolateral, composite) were used as the measure for dynamic balance. Normalization was calculated by distance reached (cm) / leg length of stance leg (cm) x 100 for a % leg length. Physical performance was measured by vertical jump height (cm) and work (mass (N) x distance (m)) performed in joules (J), standing broad jump distance (cm) and work performed (J), triple hop distance (cm) and work performed (J), and timed T-test in seconds (s). **Results:** Posteromedial reach correlation coefficients ranged from $r = -.420$ to $-.539$ ($p < .05$) between the measures of work for VJ, BJH and TH. Composite score correlation coefficients ranged from $r = -.382$ to $-.422$ ($p < .05$) between measures of Work for BJH and TH. No significant correlations were found for the other measures of the SEBT. As a secondary finding, correlation coefficients between VJ, BJH, TH and T-test ranged from $r = -.645$ to $.897$ ($p < .0001$). **Conclusions:** Normalized posteromedial reach may indicate the level of work produced by an athlete to perform a VJ, BJH and TH. Secondary results of this study indicate that accurate measures of physical performance may be achieved by testing vertical jump alone. Future research needs to be conducted on dynamic postural control of subjects with a history of lower extremity pathology.

Hip Flexor Tightness And Its Influence On Muscle Power And Endurance

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Context: It is suggested that clinicians should consider muscular imbalance when initiating rehabilitation for patients with tight hip flexors. **Objective:** Determine if hip flexor tightness influences muscle power or endurance in dominant and non-dominant lower extremities. **Design:** A $2 \times 2 \times 2$ factorial with repeated measures guided data collection. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** Thirty-two subjects (male: $n = 11$, age= 21.64 ± 1.80 yrs, ht= 174.80 ± 13.38 cm, mass= 74.54 ± 12.86 kg; female: $n = 21$, age= 20.86 ± 3.47 yrs, ht= 161.59 ± 11.00 cm, mass= 60.88 ± 8.89 kg) with no injuries to the spine or lower extremity were recruited to participate. **Intervention:** The Biodex System 4 (Biodex Medical System, Inc., Shirley, NY) was used to assess muscular output differences between tight and non-tight extremity groups, at 60 deg/sec (power) or 180 deg/sec (endurance). Muscle tightness was assessed using a bubble inclinometer in the modified Thomas test position as described by Starkey, Brown, and Ryan (2010). Extremities were grouped according to hip flexor tightness with measurements less than 0° considered normal (control group), and those $\geq 0^\circ$ considered tight. Isokinetic testing occurred on two subsequent days, with test speeds and the order of the extremities tested randomized. Prior to testing subjects warmed up on a stationary cycle for 5 minutes. Subjects also received a familiarization session of 5 submaximal repetitions at the test speed prior to each test. Day one consisted of either 1 set of 5 repetitions at 60 deg/sec or 1 set of 25 repetitions at 180 deg/sec on both

extremities. Day two consisted of the same test protocol at the opposite test speed. To prevent accessory movement, the pelvis, trunk, and opposite thigh were secured. **Main Outcome Measures:** Hip flexion and extension peak torque and total work. **Results:** Extremities with hip flexor tightness resulted in greater peak flexion torque ($F_{1,120}=5.85$; $P=.02$) but no significant increases in extension torque ($F_{1,120}=3.76$; $P=.055$). Flexion and extension torque was greater at 60 deg/sec than 180 deg/sec (flexion: $F_{1,120}=14.42$; $P=.001$; extension: $F_{1,120}=4.26$; $P=.04$). There was no difference in leg dominance (flexion: $F_{1,120}=0.24$; $P=.62$; extension: $F_{1,120}=0.02$; $P=.89$). When correcting for body weight, hip flexor tightness resulted in greater flexion torque ($F_{1,120}=7.09$; $P=.009$) but not extension torque ($F_{1,120}=2.60$; $P=.11$). There was also no difference in leg dominance when correcting for body weight (flexion: $F_{1,120}=0.61$; $P=.44$; extension: $F_{1,120}=0.01$; $P=.95$). Peak torque was greater at 60 deg/sec than 180 deg/sec (flexion: $F_{1,120}=29.34$; $P=.001$; extension: $F_{1,120}=6.72$; $P=.01$). Hip flexor tightness and leg dominance did not affect total work ($P>.05$). **Conclusions:** Hip flexor tightness increased torque in hip flexion but not extension. This observation also supports recent findings in the literature that muscle tightness is associated with greater muscular peak torque generation. Clinicians should be aware that tightness in the hip flexor can contribute to a potential muscular imbalance on the ipsilateral extremity.

Spinal Reflex Excitability In Males And Females During Drop Landing

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Context: Measuring spinal control mechanisms during drop landings allows assessment of neuromuscular control in a simulated sport-specific movement. **Objective:** To determine if a difference exists in how males and females modulate spinal reflex activity during a landing task. **Design:** Cohort study design. **Setting:** Sports Medicine Research Laboratory. **Patients or Other Participants:** Thirty healthy college-aged individuals volunteered to participate. Fifteen males (24.4±3.2yrs, 176.9±10.5cm, 78.6±11.9kg) and 15 females (24.3±3.2yrs, 166.7±5.8cm, 62.6±6.4kg) enrolled in the study. Two females were excluded from the analysis because their values exceeded 2 standard deviations from the group average. **Interventions:** To elicit soleus H-reflexes, a stimulating electrode was placed over the tibial nerve in the popliteal space on the right leg. A second stimulating electrode was placed over the ipsilateral common peroneal nerve at the head of the fibula, to condition the soleus H-reflex. Surface EMG (Ag/AgCl) electrodes recorded the soleus H-reflex (2000 Hz; MP100, Biopac, Inc). While lying prone, multiple stimulations were delivered at increasing intensities for the development of both an unconditioned and conditioned recruitment curve. Stimulations were administered in 15s intervals (S88 stimulator, Grass Instruments, Inc). During the conditioned trials, an 80ms delay was used between the conditioning and test reflexes. Next, similar recruitment curves (unconditioned and conditioned) were elicited during a series of drop landings. For the landings, the participant hung from a

bar with their feet 58cm above the ground. As the participant released their grip on the bar, stimulation was triggered and delivered prior to the participant's feet touching the ground. Peak-to-peak H reflex amplitude was normalized to Hmax. **Main Outcome Measures:** The independent variables were sex (male vs. female), testing position (prone vs. landing), and H-reflex conditioning (unconditioned vs. conditioned). The dependent variable was the slope of the ascending portion of the H-reflex recruitment curve, measured from motor threshold to Hmax. **Results:** A 2 [sex] x 2 [testing position] x 2 [H-reflex conditioning] mixed design ANOVA with repeated factors (testing position and H-reflex conditioning) revealed a significant main effect of position (prone = 5.2±1.6, landing = 3.8±1.6; $P=.001$). There was no main effect of sex (males = 4.9±1.7, females = 4.1±1.7, $P>.05$) or conditioning (unconditioned = 4.6±1.7, conditioned = 4.4±1.5, $P>.05$). Additionally, there were no significant interaction effects. **Conclusions:** Our results are consistent with other findings in the literature that show reflex modulation (inhibition) related to changes in body orientation. Additionally and possibly more important is the lack of a sex difference, indicating that men and women modulate spinal reflexes in similar ways during a simulated landing task.

ACL Prevention Program Produces Sustainable Effects In Jump-Landing Technique In Division I Women's Basketball Players

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Context: Neuromuscular control and plyometric training programs are commonly implemented to improve jump-landing patterns associated with anterior cruciate ligament (ACL) injury risk. However, it is unknown if

changes in landing biomechanics can be sustained following an intervention period in elite athletes. The Landing Error Scoring System (LESS) is a valid and reliable clinical tool used to assess jump-landing technique. **Objective:** To determine whether improvements in jump-landing patterns following a 6-week intervention program can be attained, and then maintained over an additional 7-week period. **Design:** Controlled Laboratory Study. **Setting:** Laboratory. **Patients or Other Participants:** Ten Division I female basketball players (19.40±1.35 yrs; 178.05±7.52 cm, 72.86±10.70 kg) participated in this study. **Intervention(s):** Participants were tested at three separate sessions: baseline; following the 6-week training session (POST1) and following a 7-week period of no training, which was 13 total weeks after baseline (POST2). During each session, participants were video-taped simultaneously from two angles while performing 3 jump-landings from a 30cm high box. The neuromuscular control and plyometric training program consisted of 18 sessions over a 6-week period, supervised and progressed by 2 Certified Athletic Trainers (ATC). The exercises focused on improving neuromuscular control and emphasizing proper landing techniques. **Main Outcome Measures:** All videos were scored by an ATC using the established LESS scoring criteria. The worst (highest) score of both legs was used for analysis of each testing session (baseline, POST1 and POST2). Additionally, participants were categorically grouped as excellent (LESS score ≤4), moderate (LESS score 5-6) and poor (LESS score >6) based on their worst score from each session. A 1x3 repeated measures analysis of variance and post-hoc dependent t-tests were performed to identify mean differences over the 3 testing sessions. A priori significance level was set at P≤0.05. **Results:** The mean LESS score was significantly different over time ($F_{2,9} = 7.75$, $P = 0.004$). Baseline LESS scores (7.30±3.4) were significantly higher

than POST1 (4.90±1.20; $t_{1,9} = 2.71$, $P = 0.024$) and POST2 scores (4.78±1.93; $t_{1,9} = 3.41$, $P = 0.008$) indicating improvements from baseline in the LESS score at both posttests. No significant differences were found between POST1 and POST2 ($t_{1,9} = .25$, $P = 0.81$). Categorical grouping indicated that at baseline 20% were considered excellent, 30% moderate and 50% poor; POST1 40% were excellent, 50% moderate and 10% poor; while at POST2 50% were excellent, 40% moderate and 10% poor. **Conclusions:** Jump-landing technique can be improved following a 6-week intervention focused on neuromuscular control and plyometric training. Interestingly, these participants were able to maintain improvements in landing errors over an additional 7 weeks after the training ended. Further research is needed to determine how long initial improvements last and if other, non-elite populations can sustain improvements following a 6-week intervention.

Inter-Rater Reliability Of The Star Excursion Balance Test

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Context: The Star Excursion Balance Test (SEBT) is widely used by clinicians in many settings to assess dynamic postural control. While inter-rater reliability of the test has been examined, the sample sizes from previous studies were small, resulting in wide confidence intervals. Furthermore, measurements were not normalized for leg length, which is now standard practice. **Objective:** The main objective was to determine inter-rater reliability of the SEBT for normalized measurements. Additionally, reliability was determined for measurements using the average and the maximum score from three test trials. **Design:** Descriptive laboratory study **Setting:** Research

laboratory. **Patients or Other Participants:** A sample of 40 participants from university populations in Toledo (USA) and Sydney (Australia) volunteered for the study (27F, 13M; 30.9±11 yrs; 170.9±9.2cm; 67.0± 14.1kg). **Interventions:** At each of the two testing locations, a sub-set of the 40 participants were tested by three raters. One of the raters was present at both sites and trained the other raters at each site prior to testing, for a total of 6 raters involved in the study. Participants reported to the laboratories for a single testing session. For normalizing, length of the stance leg was measured in supine from the ASIS to the most distal point on the ipsilateral medial malleolus. A verbal and visual demonstration of the SEBT was given to participants for three directions; anterior, posteromedial and posterolateral. Participants performed four practice trials in each direction, followed by three test trials in each direction for three separate raters. The participants' test (stance) leg, the order of test directions and the order of raters were randomized. **Main Outcome Measures:** Normalized reaching distances (maximum reach/leg length) were used. Intraclass Correlation Coefficients [ICC (1,1)] with 95% Confidence Intervals were calculated for normalized measurements from each SEBT direction. This was done using the average and maximum scores of the three trials from each direction. The reliability model [ICC(1,1)] was employed because there were always three raters measuring each participant, although the individual raters varied. **Results:** The inter-rater reliability was excellent for all directions and type of measure. For the average reach of the three trials normalised for leg length, ICC(1,1) was 0.87 (95%CI:0.79-0.93) for anterior, 0.91 (95%CI:0.85-0.95) for posteromedial and 0.87 (95% CI:0.79-0.92) for posterolateral. For the normalized maximum reach of the three trials, reliability also was excellent, with an ICC (1,1) of 0.86 (95%CI:0.77-0.92) for the anterior

direction, 0.88 (95%CI:0.81-0.93) for posteromedial and 0.81 (95%CI:0.71-0.89) for posterolateral. **Conclusions:** Raters from two different sites, trained by the same experienced individual, produced strong inter-rater reliability when using the SEBT on healthy participants. This strengthens the existing evidence that the SEBT can be used by clinicians as a reliable outcome tool for assessing dynamic postural control.

Effects Of Five-Toed Socks With Multiple Rubber Bits On The Foot Sole On Dynamic Postural Control And Subjective Parameters During Jump And Landing Among Healthy Young Adults

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Context: Previous studies have demonstrated that wearing five-toed socks with multiple rubber bits on the foot sole (FRB) improves static postural control in individuals with and without chronic ankle instability, possibly through enhanced plantar tactile feedback and foot gripping. However, it is unclear if FRB have similar effects on dynamic postural control during activities such as a jump-landing task. Additionally, self-reported feelings of comfort and stability when wearing the FRB during activity have not been considered. **Objective:** To assess the effect of FRB on dynamic postural control and self-reported comfort and stability during a jump-landing task among healthy young adults. **Design:** Crossover design. **Setting:** Research laboratory. **Patients or Other Participants:** Fourteen healthy young adults (8 males, 6 females: 25.79±3.95 yrs, 169.09±5.69 cm, 66.18±10.30 kg) volunteered to participate. **Interventions:** Participants completed a one-time testing session to quantify dynamic postural control and subjective feelings of

comfort and stability under two sock conditions: FRB and regular socks. The order of the sock condition was randomized and athletic shoes were worn for all testing. The jump-landing task consisted of a single-leg landing from 50% of the participant's maximum jump height. Participants jumped off both feet, reached up and touched the indicated marker, and landed on a force plate on the dominant limb. Three trials were performed with each sock condition. Ground reaction forces were used to calculate Time to Stabilization (TTS) in the medial/lateral (MLTTS) and anterior/posterior (APTTS) directions. After the jump-landing procedure was completed in each sock condition, three separate 10-point visual analogue scale measures were completed asking about subjective parameters concerning: 1) perceived comfort (PC), 2) feeling of stability (FS), and 3) confidence in protecting the ankle from a potential injurious situation (CON). **Main Outcome Measure(s):** The dependent variables were the dynamic postural control (APTTS and MLTTS) and the subjective parameters (PC, FS, and CON). The independent variable was the sock condition (FRB, regular socks). A separate paired t-test was performed for each of the dependent variables. Significance was set a priori at $p < 0.05$. **Results:** A significant statistical difference was observed in CON (FRB=5.36± 2.02, RS=4.79±1.53, $t_{1,13}=2.51$, $p=0.03$). No significant difference was observed in either PC (FRB=6.93±1.86, RS=7.07±1.64, $t_{1,13}=-0.32$, $p=0.75$) or FS (FRB=6.93±1.86, RS=7.07±1.64, $t_{1,13}=1.86$, $p=0.09$). No significant difference was observed for APTTS (FRB=1.15±0.04, RS=1.15±0.04, $t_{1,13}=-1.49$, $p=0.16$) or MLTTS (FRB=1.15±0.10, RS=1.16±0.08, $t_{1,13}=-0.33$, $p=0.75$) directions. **Conclusions:** These results indicate that wearing the FRB is associated with improved confidence in protecting the ankle from a potential injurious situation, compared to wearing the regular socks. However, the dynamic postural control measured by the TTS did not change

between the sock conditions. Continued research is needed to determine if the FRB could positively influence patient populations with balance deficits.

Inter-Limb Deficits Between Measures Of Quadriceps Strength And Voluntary Activation Do Not Correlate

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Context: Lower extremity neuromuscular assessment is important for detecting possible injury risk and determining return to play criteria following injury. Evaluation of isokinetic strength and voluntary activation testing are both commonly performed to detect inter-limb neuromuscular quadriceps deficits, yet it is unknown if inter-limb deficits in these two measures provide similar information regarding quadriceps function. **Objective:** Determine if inter-limb deficits differ between measures of isokinetic quadriceps strength and voluntary activation at 30°, 70° and 90° of knee flexion in healthy participants. Secondly, we sought to determine the relationship between inter-limb deficits in quadriceps strength and voluntary activation. **Design:** Crossover. **Setting:** Research laboratory. **Participants:** Twenty-five participants (11 Males, 14 Females, age=25.08 ±4.67 years, height=172.88± 7.74cm, weight= 67.04 ±10.67kg) with no history of knee injury volunteered for the study. **Interventions:** Independent variables included testing measure (isokinetic strength and voluntary activation) and joint angle (30°, 70° and 90° of knee flexion). The order in which testing measure, joint angle and leg (dominant vs. non-dominant) were performed was randomly assigned. Isokinetic strength was performed at 60°/second through the full range of motion. Voluntary activation was assessed by

administering a supramaximal electrical stimulus during a maximal voluntary isometric contraction at each target angle. **Main Outcome Measures:** Isometric quadriceps strength was determined by extracting torque measurements at each joint angle, while voluntary activation was measured via the central activation ratio. Inter-limb difference scores for each measure were expressed as an absolute value percentage of the dominant leg ((non-dominant - dominant leg)/ dominant leg). A 2x3 repeated measures analysis of variance was used to determine differences in inter-limb deficits between measures at each joint angle. A Pearson product moment correlation was used to assess the relationship between deficits at each joint angle. An a priori level of significance was set at $P \leq 0.05$. **Results:** Inter-limb isokinetic strength deficits were greater than voluntary activation deficits at all joint angles (30° , 15.26 ± 14.46 vs $10.47 \pm 7.24\%$; 70° , 13.3 ± 14.47 vs $8.86 \pm 7.4\%$ and 90° ; 12.82 ± 17.76 vs $4.97 \pm 4.87\%$, $F_{1,24} = 11.26$, $P = 0.003$). No significant correlations were found for inter-limb differences between quadriceps isokinetic strength and voluntary activation at any of the joint angles 30° ($r = -0.17$, $P = .43$), 70° ($r = 0.19$, $P = .38$) and 90° ($r = -0.06$, $P = .79$). **Conclusion:** Inter-limb deficits were higher for quadriceps isokinetic strength compared to voluntary activation at all joint angles. Interestingly, inter-limb deficits between measures were not strongly correlated, suggesting that these measurements may be evaluating completely different phenomena within the neuromuscular system. While future data is still needed to determine how deficits in each measure relate to physical function and long-term outcomes in injured populations, this may be evidence to suggest that athletic trainers should utilize information from both isokinetic strength and voluntary activation tests to compile a complete

assessment of quadriceps neuromuscular function.

Intra-Rater Reliability Of The Functional Movement Screen Among Certified Athletic Trainers And Athletic Training Students

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Context: Injury prevention often focuses on recognizing muscular strength and flexibility imbalances. One proposed method of detecting muscular strength and flexibility imbalances is the Functional Movement Screen™ (FMS). Using the FMS as a clinical outcome tool may be useful for Athletic Trainers. However, intra-rater reliability of the FMS among different levels of clinical and FMS experience has not been adequately established. **Objective:** The purpose of this study was to establish the intra-rater reliability of the FMS among athletic trainers and athletic training students (ATS). **Design:** Cohort study. **Setting:** A controlled research laboratory. **Patients or Other Participants:** A convenience sample of 37 evaluators was divided into three groups, based on level of clinical and FMS experience: senior ATS ($n = 16$; 7M, 9F; 20.94 ± 0.44 yrs; 172.72 ± 9.45 cm; 70.25 ± 9.35 kg; 0.00 ± 0.00 years of certification), certified athletic trainers with no FMS experience (ATC) ($n = 14$; 7M, 7F; 24.50 ± 2.31 yrs; 175.08 ± 8.48 cm; 69.66 ± 10.46 kg; 2.50 ± 2.56 yrs of certification); or certified athletic trainers with FMS experience (ATCExp) ($n = 7$; 2M, 5F; 27.71 ± 5.28 yrs; 177.99 ± 8.51 cm; 72.58 ± 8.78 kg; 6.28 ± 4.96 yrs of certification). **Interventions:** Evaluators watched video-taped recordings of three subjects performing three trials of all seven tasks of the FMS on two occasions separated by one week.

At the first testing session, prior to viewing the video tape segments, the primary investigator, an ATC with experience using the FMS, provided verbal and visual explanation of how the FMS is performed and scored. Then evaluators from all groups individually scored the video-taped subjects' performance, which is reported as the number of points out of 21, with a higher number indicating better function. The evaluators returned a week later and watched the same video-taped subjects again. The order of the presentation of the three video-taped subjects in each session was randomized. **Main Outcome Measures:** The intra-rater reliability ($ICC_{2,k}$) of the average FMS scores for the 3 observed video-taped subjects for all evaluators and for each group. Means and standard deviations for each evaluator's rating of all three video-taped subjects were used for analysis. Interclass coefficients were performed for all 37 evaluators as well for each group of evaluators between the scores from session 1 and 2. **Results:** For all 37 evaluators, the intra-rater reliability was moderate ($ICC_{2,37} = 0.723$). The ATCExp ($ICC_{2,7} = 0.946$) had strong intra-rater reliability, while the ATC group had moderate reliability ($ICC_{2,14} = 0.758$) the ATS group had poor reliability ($ICC_{2,16} = 0.372$) **Conclusions:** Intra-rater reliability of the FMS appears to improve with clinical experience. With previous training, the reliability among athletic trainers slightly improves. These results indicate that the FMS™ has high reliability when employed by athletic trainers with experience using the FMS.

Sex Comparison Of The Effects Of Contractile Effort On Hamstring Stiffness And Anterior Tibial Translation

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Context: Anterior tibial translation (ATT) is greater in females than in males, and excessive ATT increases anterior cruciate ligament (ACL) injury risk. Individuals with greater hamstring stiffness demonstrate less ATT, thus increasing hamstring stiffness may reduce ATT and ACL injury risk. Muscle stiffness increases with contractile effort, but it is unclear how increasing hamstring stiffness influences ATT. **Objective:** To compare the effects of contractile effort on hamstring stiffness and ATT across sex. **Design:** Cohort design with repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six healthy volunteers (18 males: age=23±4yr, mass=82±17kg, height=1.8±0.1m; 18 females: age=23±3yr, mass=65±11kg, height=1.7±0.1m). **Interventions:** Hamstring stiffness and ATT were assessed at 30 and 45 % maximal voluntary contraction (%MVC) with subjects positioned prone in 30° of knee and hip flexion. During stiffness assessments, a perturbation was applied to the shank to produce oscillatory knee flexion/extension. An accelerometer captured the damped oscillatory frequency from which stiffness was derived. ATT was assessed via a custom-built perturbation device that applied 20% body weight to the proximal posterior shank. Electromagnetic motion capture sensors were used to calculate ATT as the peak difference in anterior displacement of the shank relative to the thigh. **Main Outcome Measures:** Hamstring stiffness (N/m*kg⁻¹) and ATT (mm) were compared across sex and %MVC via 2(Sex) x 2(%MVC) repeated measures ANOVAs (d²0.05).

Significant interaction effects were evaluated post hoc using Bonferroni's correction. The extent to which increasing stiffness influenced the decrease in ATT was evaluated via the correlation between change scores (45%MVC-30%MVC). **Results:** ATT (ICC_{2,1}=0.98, SEM=1.7mm) and hamstring stiffness (ICC_{2,1}=0.75, SEM=3.1N/m*kg⁻¹) demonstrated moderate-to-excellent intra-session reliability and precision. The Sex x %MVC interaction effect (F_{1,34}=5.594, p=0.024) and %MVC main effect (F_{1,34}=6.320, p=0.017) for ATT were significant. ATT was less at 45%MVC compared to 30%MVC in females (10.3±10.9mm vs. 13.0±12.4mm), but not in males (10.1±9.3mm vs. 10.2±9.0mm). The %MVC (F_{1,34}=53.122, p<0.001) main effect was significant for hamstring stiffness, with stiffness being greater at 45%MVC compared to 30%MVC (19.8±5.5 N/m*kg⁻¹ vs. 15.5±3.6 N/m*kg⁻¹). The correlation between the increase in hamstring stiffness and the decrease in ATT was non-significant (r = -0.005, p = 0.978). **Conclusions:** Hamstring stiffness increased and ATT decreased with increasing contractile effort. Contrary to our hypotheses, however, the decrease in ATT was not correlated with the increase in stiffness. The decrease in ATT was likely attributable to the increase in tibiofemoral compressive force caused by increasing contractile effort. These data suggest that the magnitude of hamstring stiffness increase between 30 and 45%MVC (mean increase=28%) may be insufficient to influence ATT. However, though not statistically significant (t₃₄=0.989, p=0.330), females demonstrated a larger increase in hamstring stiffness compared to males (31% vs. 25%), potentially explaining the significant decrease in ATT in females but not in males.

Strength Differences Between Male And Female Soldiers Of The 101st Airborne Division (Air Assault)

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Context: In the US Army, male and female Soldiers participate in gender-neutral physical training and may have similar physical demands during occupational and operational tasks. Musculoskeletal injuries, many of which may be preventable, are the primary reason for seeking medical care among military personnel and may be related to suboptimal musculoskeletal characteristics, which may result in higher injury rates in female Soldiers. **Objective:** To determine if strength differences exist between genders in US Army Soldiers of the 101st Airborne Division (Air Assault) matched on age and years of service (YOS). **Design:** Cross-sectional study. **Setting:** Research laboratory. **Participants:** Data were collected on 65 female Soldiers (age=26.9±5.7 years, height =1.65 ±0.06 m, mass =65.7±9.8 kg) and 65 male Soldiers (age=26.9±5.8 years, height =1.76±0.07 m, mass= 82.3± 12.7 kg) matched on age (±2 years) and YOS (± 1.0 years). All subjects were free of current medical or musculoskeletal conditions that prevented full active duty. **Interventions:** Isokinetic knee flexion/extension (FLEX/EXT), shoulder internal/external rotation (IR/ER), and torso rotation (ROT) strength was assessed using an isokinetic dynamometer (5 repetitions each, 60°/sec). Isometric hip abduction/adduction (ABD/ADD) strength was assessed with three, 5 sec alternating contractions using an isokinetic dynamometer. Isometric ankle

inversion/eversion (IN/EV) and plantarflexion/dorsiflexion (PF/DF) strength was assessed using a handheld dynamometer (3 repetitions). All tests were performed on the right side. Paired *t*-tests were used to compare normally distributed variables and Wilcoxon signed rank tests were used to compare non-normally distributed variables. Statistical significance was set at $p < 0.05$ *a priori*. **Main Outcome Measures:** Peak torque was averaged normalized to body weight (%BW) for: shoulder IR/ER, knee FLEX/EXT, torso ROT, and hip ABD/ADD. Average peak force (kg) was calculated for ankle IN/EV and PF/DF. **Results:** Female Soldiers demonstrated significantly less strength in shoulder IR (F: 35.8±8.9 %BW; M: 61.3±15.1 %BW), shoulder ER (F: 29.5±5.2 %BW; M: 43.7±9.7 %BW), knee FLEX (F: 92.9±20.9 %BW; M: 116.8±30.1 %BW), knee EXT (F: 189.5±36.9 %BW; M: 241.6±55.4 %BW), torso ROT (F: 105.8±25.3 %BW; M: 150.9±29.2 %BW), ankle IN (F: 25.2±6.8 kg; M: 34.3±7.5 kg), and ankle EV (F: 22.3±6.0 kg; M: 30.7±6.3 kg), (all, $p < 0.001$). **Conclusions:** Strength differences do exist between male and female Soldiers, with female Soldiers demonstrating less shoulder, knee, ankle, and torso strength. No gender differences were noted in hip strength or ankle PF/DF; however it is unclear if this is due to adequate strength in female Soldiers or inadequate strength in male Soldiers and should be explored further. Future research should explore if these differences contribute to unintentional musculoskeletal injury and decreased physical readiness as well as if these differences can be mitigated through gender-specific physical training.

The Relationship Between Isometric Maximum Strength And Rate Of Torque Development Assessed At The Hip And Thigh
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Context: Isometric maximum strength (Smax) may not provide an adequate representation of other aspects of muscular strength (e.g., rapid force production). To date there is limited research comparing measures of rate of torque development (e.g., rapid force production) to Smax (i.e. peak torque) in the collegiate athlete setting. **Objective:** To determine the relationship between isometric peak torque (PT) and rate of torque development (RTD) **Design:** Correlational Design **Setting:** Research Laboratory **Patients and Other Participants:** 36 NCAA Division I female soccer athletes (19.4±1 years, 166.4±5.1 cm, and 62.1± 5.3 kg) were recruited. **Interventions:** Participants performed 3 maximum isometric contractions, 5 seconds in duration, separated by 60 seconds of rest at the hip abductors (AB), hip adductors (AD), knee flexors (KF), and knee extensors (KE). Isometric data were collected with a portable fixed dynamometer sampled at 1000Hz and filtered using a low pass 4th order Butterworth filter with a 50Hz cut-off frequency. Separate Pearson's Product-Moment Correlations were performed and the coefficients of determination calculated. Hopkins (2002) scale was used to interpret the correlation coefficients: trivial (0.0), small (0.1), moderate (0.3), strong (0.5), very strong (0.7), nearly perfect (0.9), and perfect (1.0). Alpha level was set at $p \leq 0.05$. **Main Outcome Measures:** Isometric AB, AD, KF, and KE PT[Nm], normalized PT (%T =PT[Nm]/(weight[N] x height[m]), and RTD[Nm/s] at 4 time intervals (0-30,0-50,0-100, and 0-200 milli-

seconds[ms]). **Results:** AB PT and %T demonstrated trivial to moderate correlations ($r=0.03-0.45$) to AB RTD, with AB RTD at 200 ms displaying significant correlations to PT ($r=0.45$, $p \leq 0.01$) and %T ($r=0.41$, $p \leq 0.01$). AD PT showed trivial correlations ($r=0.00-0.05$) to AD RTD, while AD %T displayed trivial to small negative correlations ($r= -0.07$ to -0.12) to RTD. KF PT and %T demonstrated trivial to moderate correlations ($r=0.15-0.49$) to RTD, with KF RTD at 100 ($r=0.41$, $p \leq 0.01$) and 200 ms ($r=0.49$, $p \leq 0.01$) displaying significant correlations to PT. Additionally, KF %T showed a significant moderate correlation ($r=0.36$, $p \leq 0.05$) to KF RTD at 200 ms. KE PT and %T displayed moderate to strong significant correlations ($r=0.36-0.58$, $p \leq 0.05$) to KE RTD. KE PT demonstrated strong significant correlations ($r=0.52-0.58$, $p \leq 0.01$) to all KE RTD time intervals, with the strength of the association increasing as the time interval increased. The shared variance between Smax variables and RTD at separate time intervals ranged from 0-34%. **Conclusions:** Except for AD PT, the results suggest that Smax displays its lowest association with RTD at 0-30 ms. The results demonstrate that the strength of the associations increases as the interval of time increases. The percentage of common variance between Smax and RTD suggest each parameter is measuring a different aspect of strength and may not be indicative of the other, thus highlighting the need to evaluate both parameters.

Validity Of The Single Leg Triple Hop As A Clinical Predictor Of Neuromuscular Function At The Hip

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Context: Decreased neuromuscular function of the hip has been suggested to increase the risk of acute and chronic knee injuries. While neuromuscular evaluation of hip muscles have been included in prospective risk factor studies, methods of assessment can be time consuming and have been limited to isometric strength measures. Functional hop tests have been suggested to assess neuromuscular function of the lower extremity and may be an efficient alternative to evaluate neuromuscular function of the hip in large, prospective risk factor studies. **Objective:** To determine if concentric (CON) and eccentric (ECC) hip strength and reach distance during the Star Excursion Balance Test (SEBT) are associated with distance during a Single Leg Triple Hop (SLTH). **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Forty individuals (20 males, 20 females: 21.3±1.6yrs, 173.7±9.1cm, 73.6±13.4kg) participated in the study. **Interventions:** All measures were performed on the dominant stance leg. Five continuous isokinetic trials of CON and ECC torque of the hip abductors (ABD), external rotators (ER), and extensors (EXT) were measured at 60°·s⁻¹. To assess neuromuscular control at the hip, SEBT trials were performed standing on the stance leg and maximally reaching with the contralateral leg in the anteromedial (AM), medial (MD), and postero-medial (PM) directions. SLTH distance was assessed beginning in a single leg stance followed by 3 consecutive hops for maximal distance and recorded in centimeters from the

starting line to initial heel contact on the final hop. **Main Outcome Measures:** The average CON and ECC peak torque of the middle three trials was calculated for each strength measure and normalized to body mass. The average of 3 SEBT reaches for each direction, normalized to leg length (%LL), and the max distance during 3 SLTH trials were used for analysis. A step-wise linear regression determined the extent to which hip strength and distance during the SEBT predicted SLTH distance. **Results:** Greater ER CON ($R^2=0.488$, $P<0.001$) and EXT CON ($R^2_{\text{change}}=0.085$, $P=0.010$) were positive predictors of greater SLTH distance explaining 57.4% of variance ($P=0.007$). All other hip torque measures were significantly correlated ($R=0.300-0.680$) with SLTH distance, but did not contribute significantly to the model once ER CON and EXT CON were accounted for. SEBT reach distances were not significantly correlated ($R=0.070-0.237$) with SLTH distance. **Conclusions:** Hip muscle strength, particularly the gluteus maximus serving as the primary hip external rotator and extensor, is a strong predictor of SLTH distance. These findings suggest the SLTH may be an efficient functional tool to assess gross muscular strength of the gluteus maximus, during prospective risk factor screening studies.

Influence Of Hip Strength On Lower Extremity Joint Excursions During Single And Double Leg Landings

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Context: The hip musculature plays an important role in controlling lower extremity frontal and transverse plane motion. It has been suggested that decreased strength of the hip

musculature leads to a dynamic knee valgus position during functional tasks; however, few studies have investigated the influence of concentric and eccentric hip muscle strength on lower extremity motion during single and double leg landing tasks. **Objective:** To determine the influence of concentric and eccentric hip muscle strength on hip and knee joint excursions during single and double leg landings. **Design:** Descriptive cohort. **Setting:** Research laboratory. **Patients or Other Participants:** Forty participants (20 females, 20 males: 21.6±1.9yrs, 173.3±9.0cm, 79.0±12.3kg) with no previous history of lower extremity surgery, hip or knee joint injury within the last 6 months, and no current injury to the lower extremity volunteered to participate in this study. **Interventions:** An isokinetic dynamometer was used to assess concentric and eccentric torque of the hip abductors, external rotators, and extensors across five trials at 60°·s⁻¹. A three-dimensional motion analysis system was used to collect hip and knee kinematics of the dominant stance leg during five trials of a single leg land (SLL) and double leg land (DLL). **Main Outcome Measures:** Peak concentric torque and peak eccentric torque were separately averaged across the middle three trials for each hip muscle group and were normalized to body mass. Frontal and transverse plane hip and knee joint excursions were calculated by subtracting the initial contact angle from the peak joint angle during the deceleration phase (initial contact to peak knee flexion) of the SLL and DLL. Separate stepwise linear regressions were performed to determine the influence of hip muscle torque on frontal and transverse plane joint excursions at the hip and knee. **Results:** During a SLL, greater hip extension eccentric torque predicted greater knee valgus excursion, explaining 12.1% of the variance ($P=0.028$). During a DLL, greater hip external rotation concentric torque predicted less hip adduction excursion,

explaining 11.9% of the variance ($P=0.030$). No other hip torque measures contributed significantly to hip and knee joint excursions during a SLL or DLL ($P>0.05$). **Conclusions:** Hip extension torque and external rotation torques were associated with frontal plane hip and knee excursions during a SLL and DLL. However, the relationships were weak where approximately 88% of the variance was left unexplained. These findings, along with a lack of identified relationships between other hip torque measures and joint kinematics, suggest that hip strength alone may not control lower extremity motion during landing tasks. Future research should examine the role of muscle activation along with other neuromuscular and anatomical factors that may influence kinematics of the hip during functional tasks.

Learning Effect For The Timed Cross Over Hop Test

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Context: Athletic trainers have used a variety of functional tests to access an athlete's rehabilitation progress to determine physical readiness to return to sport. Without knowledge of the learning effect of a functional test it is difficult to differentiate the effects of learning from rehabilitation. **Objective:** To determine the learning effect between days and legs on the Timed Cross Over Hop (TCOH) test. **Design:** A 5x2 (day, leg) counter-balanced repeated measures. **Setting:** Research laboratory. **Patients or Other Participants:** Twenty six (11 males, 15 females) healthy subjects (age = 23.0 ± 3.5 yrs, height = 169.6 ± 7.1 cm, mass = 70.3 ± 11.4 kg) with no history of lower extremity injury. **Interventions:** All subjects performed 2 trials of TCOH test (s) each leg for 5 different days, and the best trial for

each day was retained for analysis. A 5x2 repeated measures ANOVA was used to determine the effects of day and leg on TCOH time, $\alpha=0.05$. Non-linear regression was used to predict asymptote of learning. **Main Outcome Measures:** Learning effect and between leg differences for single leg TCOH (s) test between days. **Results:** There were no leg ($p = .267$) or leg x day interactions ($p = .425$) for single leg TCOH performance. The single leg TCOH performance significantly improved over time ($p = .000$) with a significant quadratic trend ($p = .01$): Day1 17.11 ± 5.69 s, 95% CI 14.81–19.40 s; Day2 14.92 ± 4.12 s, 95% CI 13.26–16.58 s; Day3 14.22 ± 3.66 s, 95% CI 12.74–15.70 s; Day4 13.00 ± 3.39 s, 95% CI 11.63–14.37 s; Day5 12.48 ± 3.15 s, 95% CI 11.21–13.76 s. The absolute value of the differences between legs by days was: LegDiffDay1 = 2.43 ± 3.07 s, 95% CI 1.20–3.68 s; LegDiffDay2 = 1.36 ± 1.52 s, 95% CI 0.75–1.98 s; LegDiffDay3 = 1.37 ± 1.12 s, 95% CI 0.92–1.82 s; LegDiffDay4 = 0.90 ± 0.78 s, 95% CI 0.59–1.22 s; LegDiffDay5 = 0.72 ± 0.49 s, 95% CI 0.52–0.91 s. The non-linear re-gression indicated that improvement and between leg differences reached a plateau at day 5, $R^2 = .984$, $SEE = .32$ s, $R^2 = .92$, $SEE = .27$ s, respectively. **Conclusions:** The 95% CI threshold for between leg differences in healthy subjects is 3.68 s which represents the minimum detectable difference between healthy and injured limbs for the TCOH test. The learning effect for the test is extinguished after 5 days.

The Relationship Between Performance Measures And Landing Technique In Female Youth Soccer Athletes

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Context: Poor landing technique is associated with anterior cruciate ligament (ACL) injury risk. It is unknown how injury risk factors relate

to measures of sport performance, which may be important for injury prevention program design and compliance. It is also unknown if these measures are reliable in youth athletes. **Objective:** To evaluate the within-day reliability of landing technique and performance measures and to evaluate the relationship between these measures. We hypothesized that all measures would be reliable and that landing technique would be related to performance measures. **Design:** Correlational research design. **Setting:** Soccer field. **Patients or Other Participants:** Fourteen healthy youth female soccer athletes (Age: 13 ± 2 years, Height: 154.9 ± 10.4 cm, Mass: 50.6 ± 13.2 kg) volunteered to participate. **Interventions:** Participants performed three trials of a jump landing task, an agility test (T-test), a double-leg countermovement vertical jump and a double-leg broad jump in a random order during a single test session. The jump-landing task required participants to jump forward from a 30cm high box a distance of half their body height and jump vertically for maximal height immediately upon landing. The jump-landing trials were videotaped from the sagittal and frontal planes and graded using the Landing Error Scoring System (LESS). The agility test required participants to sprint forward, side shuffle left and right, and sprint backwards. Participants jumped as high as possible for the vertical jump test and jumped as far as possible for the broad jump. Intraclass coefficients were calculated between the three trials of each dependent variable. Pearson correlation coefficients evaluated the relationship between LESS score and performance on the agility, vertical jump, and broad jump tests ($\alpha \leq 0.05$). **Main Outcome Measures:** The LESS uses a binary system to evaluate several landing characteristics. A low LESS score indicates few landing errors and proper landing technique. Performance on the agility test was measured using a digital timing system. Maximal vertical jump height was measured via

a Vertec Jump Training System. Broad jump distance was manually recorded. Intra-class coefficients and standard error of measurements were calculated for all variables. Average scores were calculated and used for analyses. **Results:** All four tests demonstrated good to excellent within-day reliability ($ICC_{(2,k)}$, SEM values= LESS: 0.76, 0.91 points; Agility: 0.96, 0.31s; Vertical jump: 1.00, 1.37cm; Broad jump: 0.96, 4.39cm). Agility test time ($r=0.69$, $P=0.007$) and broad jump distance ($r=-0.74$, $P=0.002$) were significantly related to LESS score. Vertical jump height was not significantly related to LESS score ($P>0.05$). **Conclusions:** All measures demonstrated good within-day reliability. Female youth soccer athletes who demonstrate proper landing technique also score well on sport performance measures. Future research should evaluate if there is a causal relationship between landing technique and sport performance.

A Comparison Of Transverse And Sagittal Plane Jump-Landing Tasks Using The Landing Error Scoring System

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Context: The Landing Error Scoring System (LESS) is a valid and reliable clinical movement analysis tool. Traditional uses of the LESS during a jump-landing task in the sagittal plane may have a ceiling effect that makes it difficult to see improvements in individuals with decent landing technique. It is possible that a more challenging jump-landing task may address this problem and expand the range of scores. **Objective:** To compare transverse and sagittal plane

LESS scores. **Design:** Cross Sectional. **Setting:** Field laboratory. **Patients or Other Participants:** Thirty healthy individuals ($n=25$ Males, 5 Females; age= 18 ± 1 years) volunteered to participate. **Interventions:** Participants performed two jump-landing tasks: sagittal plane task and transverse plane task. The sagittal plane task required participants to jump forward off a 30cm high box to a distance of half their body height and jump for maximum vertical height immediately upon landing. Participants performed the transverse plane task similarly but started with their body facing 90 degrees to the front camera. Participants were instructed to jump off the box, rotate 90 degrees in the air to land with their body facing forward and immediately rebound for maximum vertical height. Each type of jump was performed 2 times. Both tasks were videotaped in the frontal and sagittal plane and graded using the LESS. LESS scores on the two tasks were compared using a paired t-test. McNemar's test for marginal homogeneity evaluated the paired proportions of individual LESS items scored between the two tasks. Alpha was set a priori at 0.05. **Main Outcome Measures:** The LESS uses a binary system to identify the presence or absence of several landing characteristics including knee flexion, knee valgus, and foot position. A higher LESS score indicates a greater number of errors committed and, thus, poorer jump-landing technique. Average LESS scores for sagittal and transverse plane jump-landing tasks were computed. **Results:** There was a significant difference between the sagittal plane and transverse plane LESS scores (Transverse LESS: 5.97 ± 1.51 , Sagittal LESS: 5.10 ± 1.69 , $t_{(29)}=3.45$, $P=0.002$). McNemar's test showed non-homogeneity between tasks for Trunk Lateral Flexion at Initial Contact (IC) ($X^2_{(1)}=13.00$; $P<0.001$), and Symmetrical Foot Contact ($X^2_{(1)}=7.14$; $P=0.013$). No other proportional differences for LESS items were observed. **Conclusions:** The transverse plane jump-landing task

appears to increase average LESS scores when compared with the traditional, or sagittal plane task. Individual item analysis showed the transverse jump to be as effective as the sagittal jump at eliciting most individual LESS item errors. The proportion of errors scored with the transverse jump was significantly higher for Trunk Lateral Flexion at IC, while the sagittal jump was more effective at eliciting asymmetrical landing. A composite average for both types of jumps may best address the LESS ceiling effect.

Predictors Of Internal Knee Abduction Moment During Running In Healthy Participants

Bazett-Jones DM, Joshi M, Sanders JJ, Weinhandl JT, Cashin SE, Cobb SC, Earl JE: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Research has identified the knee abduction moment (KAM) during running as an important factor in the identification and prediction of those with patellofemoral pain syndrome (PFPS). The KAM has also been shown to decrease with hip strengthening in those with and without PFPS. However, no research has been performed to investigate clinical measures that would be predictive of KAM. **Objective:** To determine if static or dynamic measures of hip and trunk strength and endurance are better predictors of KAM during running, and which of these measure(s) are most predictive of KAM during running. **Design:** Multi-session, cross-sectional. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** 54 healthy, physically active participants (24 men, 30 women; age= 23.2 ± 4.7 yrs, mass= 75.6 ± 18.6 kg, height= 1.74 ± 0.09 m) volunteered to participate. **Interventions:** Participants attended five testing sessions during which static and dynamic measures of hip and trunk strength and endurance were taken. The tests for muscle strength was a static maximal

voluntary isometric contraction (MVIC) and dynamic one-repetition maximum (1RM), whereas the tests for muscle endurance was a static timed hold test (THT; body part held in position for maximal time) and dynamic repetitions to failure (RTF). Tests were performed on the dominant (DLTF) and non-dominant lateral trunk flexors (NLTF), hip lateral rotators (LR), abductors (ABD), and hip extensors with a bent knee (BKE). Five running trials were recorded with a 3D motion capture system and force plate, and peak KAM during stance was extracted and averaged over the five trials. **Main Outcome Measures:** The dependent variable was KAM and independent variables included THT (seconds), RTF (reps), and normalized MVIC and 1RM values for each of the 6 tests. Pearson correlations were used to investigate the relationship between strength and endurance measures, and KAM. Those variables that were significant ($p < 0.001$), as well as gender, were put into a single regression to determine the most predictive factors. Two separate regressions for static and dynamic measures were also performed with all measures to determine the most variance explained (adjusted R^2). Significance was determined with an alpha level of $p < 0.05$ for the regression analyses. **Results:** ABD MVIC ($r = -0.235$, $p = 0.088$), NLTF THT ($r = 0.247$, $p = 0.074$) and HER 1RM ($r = 0.255$, $p = 0.066$) were significantly correlated with KAM. ABD MVIC ($p = 0.015$) was predictive of KAM in the regression analysis ($R = 0.497$, $R^2 = 0.247$, $p = 0.009$). All static measures accounted for 24.1% of the variance while dynamic measures explained 5.8%. **Conclusions:** Static measures of hip and trunk strength and endurance are sufficient measures to evaluate muscle function. Less hip abductor strength was the only predictor of greater KAM; therefore, those with less ABD strength may be more prone to overuse knee injury. Predicting KAM using a clinical strength measure may be important in

knee injury and osteoarthritis prevention.

Relationships Among Hip And Trunk Strength And Endurance And The Frontal Plane Projection Angle During Single-Leg, Lateral Step-Downs

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Context: Hip strength and trunk endurance are thought to be factors in dynamic valgus and lower extremity injury. Other evidence suggests that hip endurance and trunk strength may also be factors. All of these factors have not been investigated together using clinically available measures. **Objective:** To determine the relationships among hip and trunk muscular strength and endurance measures and frontal plane projection angle (FPPA) during a single-leg, lateral step-down. **Design:** Multi-session, cross-sectional. **Setting:** Neuromechanics Laboratory. **Patients or Other Participants:** 54 healthy, physically active participants (24 men, 30 women; age= 23.2 ± 4.7 yrs, mass= 75.6 ± 18.6 kg, height= 1.74 ± 0.09 m) volunteered to participate. **Interventions:** Participants attended five testing sessions during which static measures of hip and trunk strength and endurance were taken. The test for muscle strength was a maximal voluntary isometric contraction (MVIC), whereas the test for muscle endurance was a timed hold test (THT; body part held in position for maximal time). Tests were performed on the trunk flexors (TF), trunk extensors (TE), dominant (DLTF) and non-dominant lateral trunk flexor (NLTF), hip lateral (LR) and medial rotators (MR), adductors (ADD), abductors (ABD), hip flexors lying supine (SHF), and hip with a bent knee (BKE). A single leg, lateral step-down was performed to assess FPPA, where the

participant lowered one foot down to touch the ground while standing on a 21.5cm block. Video was recorded using a standard video camera at a distance of 2.4m in front of the participant and an image was extracted when the participant's knee flexion angle was 45° . The FPPA was measured from the picture using ImageJ freeware. **Main Outcome Measures:** Independent variables included THT (seconds) and 3-trial average normalized MVIC for each of the 11 tests and the dependent variable was the FPPA (more negative=greater valgus). Pearson correlations were used for the statistical analysis to investigate the relationship between strength and endurance measures, and FPPA. Significant variables ($p < 0.10$) and gender were used in a regression model to determine the most predictive factor(s). A significance level of $p < 0.05$ was used for the regression analysis. **Results:** DLTF MVIC ($r = 0.245$, $p = 0.075$), NLTF MVIC ($r = 0.393$, $p = 0.032$), and TF THT ($r = -0.453$, $p = 0.001$) were significantly correlated with FPPA. The regression model was significant ($R = 0.629$, $R^2 = 0.395$, $p < 0.001$), and TF THT ($p = 0.010$) and gender ($p = 0.006$) were the only significant variable. The average FPPA ($-3.3 \pm 4.0^\circ$) was similar to previously reported healthy controls. **Conclusions:** Trunk strength and endurance are important factors related to a clinical assessment of dynamic valgus, though gender seems to also play a significant role in these relationships. Decreased lateral trunk flexor strength was related to greater FPPA and dynamic valgus, and higher trunk flexor endurance was predictive of greater FPPA. These factors should be evaluated when an individual displays dynamic valgus, and may be a focus of a rehabilitation program.

A Gender Comparison Of Reactive Knee Stiffening Strategies Under Cognitive Loads

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Context: There is a higher incidence of non-contact anterior cruciate ligament (NC-ACL)_injuries in females, and irregular neuromuscular control strategies have been blamed for disrupting the dynamic restraint mechanism during unanticipated joint loading. Gender differences in mental faculties have also been identified, which suggests that altered neuromuscular control may originate from differences in processing cognitive loads and potentially lead to the disproportionate number of NC-ACL injuries. **Objective:** To assess whether preparatory and reactive knee stiffening strategies are affected differently in males and females exposed to gender-biased cognitive loads. **Design:** A two group repeated measures post test only study. **Setting:** This study was performed in a controlled laboratory setting. **Patients or Other Participants:** Forty (20 males, 20 females) healthy college aged participants (20.3 ± 1.4 yrs; 71.6 ± 10.0 cm; 73.5 ± 20.0 kg) with no current injury or previous surgery to their dominant lower extremity. **Interventions:** The independent variables were the type of cognitive tasks administered, which included the Benton Judgment of Line Orientation (JOLO), Symbol Digit Modalities Test (SDMT), and a control condition. Participants were seated in the custom-made Stiffness and Proprioception Assessment Device (SPAD) with the testing leg in 30° of knee flexion. They were then instructed to perform one of the three cognitive conditions and also react to a randomly

timed knee flexion perturbation of 40°. Reactive knee stiffness was measured during the move and data was processed using customized LabVIEW software (National Instruments, Austin, Tx). Surface electromyography (EMG) assessed muscle activation in the quadriceps and hamstrings. An analysis of variance with repeated measures was used to analyze the differences in gender and reactive knee stiffening strategies between the cognitive tasks. **Main Outcome Measure(s):** Reaction time (ms) to peak torque (TTP) was assessed and knee stiffness was calculated as torque (Nm) / position (degrees), normalized to body mass (kg). **Results:** Equal performance was observed on the JOLO (Female=24.7±3.7, Male=26.400±2.761) and SDMT (Female=65.6±8.0, Male=65.3±7.9) cognitive tasks. Males were significantly faster attaining TTP (Males=338.1±57.1 ms, Females= 363.5±48.2 ms; p=0.039). All participants were 9% slower and had decreased muscle activity under cognitive loading; however, females had greater stiffness (Females=0.043±0.010 Nm/Deg/kg, Males=0.035±0.014 Nm/Deg/kg). Few EMG differences were observed but interaction effects between gender and cognitive loading (p>0.05). **Conclusion:** Cognitive loading decreased reaction times and muscle recruitment critical for joint stability, regardless of gender. The propensity for females to generate greater knee stiffness, with different muscle activation timing has also been observed during functional tasks. However, the strong effect by both cognitive load conditions appeared to exceed the influence of specific gender biased cognitive loading tasks. More research is needed investigating how cognitive faculties may alter neuromuscular control and stiffness regulation strategies in regards to injury prevention and rehabilitation.

Landing Biomechanics Differ Between High And Low Energy Absorption Groups

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Context: While greater lower extremity energy absorption (EA) during the first 100ms of a double-leg jump landing (DLJL) is associated with biomechanical factors related to non-contact ACL injury, it is currently unknown if individuals displaying high vs. low EA during landing exhibit differences in these same biomechanical factors. **Objective:** To compare landing biomechanics between high and low EA groups. **Design:** Cross-sectional, quasi-experimental. **Setting:** Research laboratory. **Patients or Other Participants:** 22 Female (Age: 21.5±3.3 years, Height: 1.66±0.07 m, Mass:63.6±9.9 kg) and 17 Male (Age:21.4±2.4 years, Height: 1.80±0.07 m, Mass:80.0±14.3 kg) volunteers. **Interventions:** Dominant leg kinematics and kinetics were assessed using an electro-magnetic motion capture system and a force plate as participants performed five DLJLs from a 30-cm box placed 50% of their height behind the plate. Hip, knee, and ankle joint angular velocities were multiplied by net internal joint moments calculated using inverse dynamics to produce net joint power curves. Eccentric muscle activity results in negative work at a joint, thus EA for each joint was calculated by integrating the negative portions of the joint power curves during the 100 ms following initial ground contact (IGC). Total lower extremity EA, calculated as the sum of hip, knee, and ankle EA, was normalized to the product of subject height (Ht) and body weight (BW) [%BW*Ht] and used to group subjects into tertiles. **Main Outcome Measures:** Peak vertical (vGRF) and posterior (pGRF) ground reaction

forces; internal knee extension (KEM) and knee varus (KVM) moments; and anterior tibial shear force (ATSF) were identified between IGC and the minimum vertical position of the whole body center of mass. Independent samples *t*-tests ($\alpha=0.05$) were used to compare these dependent variables between the highest (H) and lowest (L) EA tertiles. **Results:** Total EA was 15.45 ± 1.57 [% (BW*Ht)] and 9.79 ± 1.45 [% (BW*Ht)] for H (3M,10F) and L (9M,4F), respectively. No significant differences were identified between groups for vGRF (H: 3.07 ± 0.61 [xBW⁻¹] vs. L: 2.81 ± 0.66 [xBW⁻¹], $p=0.296$) or KVM (H: 0.099 ± 0.058 [x(BW*Ht)⁻¹] vs. L: 0.084 ± 0.053 [x(BW*Ht)⁻¹], $p=0.479$). However, H exhibited significantly greater pGRF (H: 0.94 ± 0.29 [xBW⁻¹] vs. L: 0.72 ± 0.16 [xBW⁻¹], $p=0.023$), KEM (H: 0.204 ± 0.053 [x(BW*Ht)⁻¹] vs. L: 0.158 ± 0.032 [x(BW*Ht)⁻¹], $p=0.015$), and ATSF (H: 1.04 ± 0.13 [xBW⁻¹] vs. L: 0.84 ± 0.16 [xBW⁻¹], $p=0.002$) than L. **Conclusions:** Individuals absorbing greater energy during the 100 ms following IGC display significantly greater peak pGRF, KEM, and ATSF. As these biomechanical factors purportedly result in greater ACL loading, we suggest that greater EA during the 100 ms following ground contact may manifest in a higher-risk movement strategy and serve as a surrogate for the multiple, discrete variables currently used to evaluate landing biomechanics. Future research should further explore these notions. Moreover, modifiable biomechanical factors that are predictive of EA should be identified in hopes that they might be targeted in intervention programs to alter landing biomechanics and minimize ACL injury risk.

Free Communications, Poster Presentations: The Ankle

Wednesday, June 22, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

Ankle Kinematics During Shod Gait In Subjects With And Without Chronic Ankle Instability

Chinn L, Dicharry J, Watt J, Hertel J: University of Virginia, Charlottesville, VA

Context: Previous research has reported that while barefoot, individuals with chronic ankle instability (CAI) demonstrate altered gait kinematics compared to healthy controls. Specifically, during the late swing phase CAI subjects tend to be less dorsiflexed and more inverted compared to healthy controls. However, no studies have previously evaluated the effect of CAI on gait kinematics while shod. **Objective:** To determine if there are sagittal and frontal plane ankle kinematic differences during shod walking and jogging between groups of individuals with and without CAI. **Design:** Descriptive laboratory study. **Setting:** Motion analysis laboratory. **Patients or Other Participants:** Nine subjects with self-reported CAI (males=6, female=3; age=28.4±7.8 yr; height=172.2±6.8 cm; mass=73.3±13.5 kg; Foot and Ankle Ability Measure (FAAM)=92.7±4.2%, Foot and Ankle Ability Measure-Sports Scale (FAAM-S)=76.0±14.4%; number of previous sprains=5.9±3.2) and 8 healthy subjects with no history of lower extremity injury (males=3, females=5; age=24±5.1 yr; height=167.0±10.9 cm; mass=65.1±18.0 kg) volunteered. **Interventions:** Subjects walked (speed=1.34 m/s) and jogged (speed=2.68 m/s) on a treadmill with embedded force plates while a 12-camera motion analysis system captured 3-D lower extremity kinematics. One 15-second period of gait (average walking strides=10; average jogging strides=20) was captured at each speed for analysis. Each stride of the gait cycle was normalized to 100 increments. Sagittal and frontal plane angles were

calculated at each increment. Means and associated 95% confidence intervals (CIs) were calculated in each plane across the entire gait cycle. To identify significant differences, increments where the CI bands for the two groups did not cross each other were identified. **Main Outcome Measures:** Sagittal plane and frontal plane angles were recorded throughout the entire gait cycle for each speed. **Results:** While walking, the CAI group was significantly less dorsiflexed compared to the healthy group from 44% to 48% of the gait cycle (mean difference=5.0±0.2°). While the CAI group was slightly more everted than the healthy group throughout the entire walking gait cycle (mean difference=0.5±2.8°), there were no increments where the CIs between the two groups did not overlap. While jogging, the CAI group was less dorsiflexed (mean difference=3.9±3.1°) and more inverted (mean difference=2.0±2.5°) than the control group across the entire gait cycle but there were no increments where the CI between the two groups did not overlap. **Conclusions:** During shod walking, the CAI group was significantly less dorsiflexed compared to the healthy group near the time of peak dorsiflexion. This kinematic difference is similar to what has previously been reported during barefoot gait. Significant differences between groups were not found in frontal plane motion during walking or in either the frontal or sagittal planes during jogging. There do not appear to be identical ankle kinematic differences between CAI and healthy groups during shod gait, as has been previously reported during barefoot gait.

Decreased Hoffmann Reflex Modulation Of The Soleus And Peroneals With Chronic Ankle Instability

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Context: Hoffmann (H) reflex modulation between different body postures has been linked to postural stability. Decreased modulation between increasingly complex postures may be a potential mechanism of postural instability related to chronic ankle instability (CAI). **Objective:** To assess H-reflex modulation of the soleus and peroneals in three body positions (prone, bipedal and unipedal stances) in subjects with and without CAI. **Design:** Case-control. **Setting:** Laboratory. **Patients or Other Participants:** Sixteen subjects with unilateral CAI (10 males, 6 females; age=21±6.9 years; height=173.9±7.4cm; mass=72.6±11.9kg) and 15 controls without any history of ankle sprains (9 males, 6 females; age=19±4.3years; height=175.8±9.7cm; mass=71.3±17.8kg) participated. **Interventions:** Independent variables were group (CAI, control) and limb (involved, uninvolved). Limbs of controls were side-matched to the involved and uninvolved limbs of CAI subjects. Maximum H-reflexes and motor (M) waves were recorded bilaterally from the soleus and peroneals while subjects lied prone and then stood in quiet bipedal and unipedal stances with eyes closed. Two-way ANOVAs with repeated measures on limb compared H-reflex modulation between groups and limbs for both muscles. Tukey's HSD tests were conducted for post-hoc comparisons. The alpha level was P<.05. **Main Outcome Measures:** H-reflexes were normalized to M

waves to obtain $H_{max}:M_{max}$ ratios for the three positions. Dependent variables, for each muscle, were the percent change scores in $H_{max}:M_{max}$ ratios between each pair of positions: prone to bipedal (P-Bi), bipedal to unipedal (Bi-Uni), and prone to unipedal (P-Uni). **Results:** For the soleus, significant group by limb interactions were found for all three modulations (P-Bi, $P=.002$; Bi-Uni, $P=.05$; P-Uni, $P=.001$). In the CAI group, soleus modulations in involved limbs (P-Bi= $14.06\pm 9.11\%$, Bi-Uni= $-19.3\pm 15.9\%$, P-Uni= $-2.3\pm 16.2\%$) were significantly lower than in uninvolved limbs (P-Bi= $26.4\pm 11.8\%$, Bi-Uni= $-9.6\pm 13.0\%$, P-Uni= $19.2\pm 17.3\%$) and both limbs in the controls. There were no significant side-to-side differences in controls (control “involved”: P-Bi= $26.4\pm 14.2\%$, Bi-Uni= $10.4\pm 11.1\%$, P-Uni= $18.5\pm 18.2\%$, control “uninvolved”: P-Bi= $27.6\pm 16.6\%$, Bi-Uni= $-10.0\pm 10.9\%$, P-Uni= $20.2\pm 19.9\%$). For the peroneals, significant group by limb interactions were found for the Bi-Uni ($P=.01$) and P-Uni ($P=.02$) modulations. In the CAI group, peroneal modulation in involved limbs (Bi-Uni= $-27.1\pm 23.4\%$, P-Uni= $-9.0\pm 25.1\%$) were significantly lower than the uninvolved limbs (Bi-Uni= $-10.4\pm 21.7\%$, P-Uni= $8.8\pm 15.6\%$) and both limbs in controls. There were no significant side-to-side differences in controls for the peroneals (control “involved”: Bi-Uni= $-15.6\pm 13.7\%$, P-Uni= $5.5\pm 14.2\%$, control “uninvolved”: Bi-Uni= $-16.4\pm 13.7\%$, P-Uni= $5.7\pm 17.1\%$). The group by limb interaction ($P=0.18$) and group main effect ($P=0.66$) were not statistically significant for the P-Bi peroneal reflex modulation (CAI involved = $14.3\pm 11.2\%$, CAI uninvolved = $20.6\pm 12.8\%$, control “involved” = $18.5\pm 7.8\%$, control “uninvolved” = $19.2\pm 9.7\%$). **Conclusions:** Decreased H-reflex modulations in the CAI involved limbs were present in the soleus during all of three postural transitions and in the peroneals for two of the three transitions. Constrained ability of the sensorimotor system to down regulate

H-reflex in more demanding postures may represent a potential mechanism of postural control deficits associated with CAI.

Effect Of Posture Control Insoles® On Static And Dynamic Balance In Healthy Young Adults

Wheeler R, Chinn, L, Hertel J, Sauer L: University of Virginia, Charlottesville, VA

Context: Postural Control Insoles® (PCI) are over the counter orthotics purported to improve function and posture and decrease pain in healthy and pathological populations by providing posting to the first ray. To date, no peer-reviewed research has been published on this intervention.

Objective: To determine if PCI insoles affect static and dynamic balance compared to sham and control interventions immediately and after a 2-week accommodation period in healthy subjects. **Design:** Single blind randomized controlled trial. **Setting:** Laboratory. **Participants:** Forty-four healthy subjects with no history of shoe insert use volunteered. Subjects were randomly assigned into one of three groups: PCI (females=10, males=5; age= 21.6 ± 2.7 yrs; height = 168.9 ± 8.2 cm; mass= 69.8 ± 10.8 kg), sham (females=10, males=5; age= 23.8 ± 5.3 yrs; height = 167.4 ± 7.3 cm; mass= 70.1 ± 12.0 kg) and control (females=10, males=4; age= 22.0 ± 3.1 yrs; height= 169.5 ± 7.4 cm; mass= 67.7 ± 6.1 kg). **Interventions:** The independent variables were group (PCI, sham, control) and time (baseline, immediate, 2-week). Subjects in the experimental group were fitted for PCI insoles according to manufacturer recommendations. The sham group was given insoles that identical PCI insoles but without any posting. The control group was not provided any insoles. All subjects were instructed to wear their assigned assigned intervention a minimum of six hours a day for two weeks. **Main Outcome Measures:** Measures were performed on subjects’ self-reported

dominant limb. Baseline testing was performed with no insoles. Immediate and 2-week testing was performed with subjects wearing their assigned insoles. Subjects performed three 15-second trials of eyes-closed single limb quiet standing on a force plate. Center of pressure velocity (COPV) was the dependent variable for static balance. Dynamic balance was evaluated using the star excursion balance test in the anterior, posteromedial, and posterolateral directions. Subjects performed three trials in each direction. Reach distances were normalized to subject limb length. Separate 3x3 analyses of variance with repeated measures examined the influence of group and time for each outcome variable. Interaction and group main effects were evaluated to determine the effects of insole intervention. **Results:** No significant results were found for COPV (PCI: baseline= 4.3 ± 2.6 cm/s, immediate = 4.3 ± 2.1 cm/s, 2-week= 7.7 ± 11.9 cm/s; Sham: baseline= 3.6 ± 1.6 cm/s, immediate= 3.5 ± 1.2 cm/s, 2-week = 5.1 ± 3.0 cm/s; Control: baseline = 4.3 ± 1.8 cm/s, immediate= 6.6 ± 6.6 cm/s, 2-week= 4.5 ± 2.0 cm/s; interaction: $p=0.30$, group main effect: $p=0.53$). There were also no significant results for dynamic balance in the anterior (PCI: baseline = $64.4\pm 5.4\%$, immediate= $64.5\pm 6.6\%$, 2-week= $64.2\pm 5.4\%$; Sham: baseline= $65.1\pm 5.7\%$, immediate= $66.7\pm 5.0\%$, 2-week= $66.4\pm 6.4\%$; Control: baseline= $63.9\pm 7.2\%$, immediate = $63.6\pm 8.1\%$, 2-week= $63.1\pm 6.5\%$; interaction: $p=0.61$, group main effect: $p=0.49$), posteromedial (PCI: baseline = $88.2\pm 7.0\%$, immediate = $86.9\pm 8.4\%$, 2-week= $86.3\pm 7.0\%$; Sham: baseline= $88.5\pm 8.5\%$, immediate= $87.2\pm 9.0\%$, 2-week= $91.5\pm 10.3\%$; Control: baseline = $85.7\pm 11.1\%$, immediate = $84.5\pm 10.1\%$, 2-week= $84.4\pm 10.0\%$; interaction: $p=0.14$, group main effect: $p=0.40$), and posterolateral (PCI: baseline= $82.9\pm 8.8\%$, immediate= $83.6\pm 11.8\%$, 2-week= $83.9\pm 10.9\%$; Sham: baseline = $83.2\pm 12.6\%$, immediate = $84.3\pm 14.0\%$, 2-week= $87.5\pm 14.7\%$;

Control: baseline= 77.8±12.3%, immediate =75.7±11.6%, 2-week =77.9±10.7%; interaction: p=0.41, group main effect: p=0.15) reach directions. **Conclusions:** In healthy subjects, PCI insoles had no effect on static or dynamic balance immediately after introduction or following two-weeks of accommodation.

Prospective Risk Factors For Exercise Related Lower Leg Pain Among ROTC Cadets

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Context: Injuries affect military readiness more than any other medical condition, both in the number of individuals affected and the annual cost to the service branches. Exercise related lower leg pain (ERLLP) is a category of lower extremity overuse injury defined as any shin, calf, ankle, or foot pain exacerbated by exercise and relieved with rest, including medial tibial stress syndrome, tibial stress fracture, and chronic exertional compartment syndrome. High incidences of ERLLP during basic training cycles have been reported, and it is cited as a major cause of failing to complete the run portion of physical fitness tests. Previous research has primarily identified risk factors retrospectively by comparing the gait characteristics of those with and without a history of ERLLP. **Objective:** To prospectively identify risk factors for developing ERLLP based on biomechanical gait characteristics. **Design:** Cohort study. **Setting:** University gait laboratory and Reserve Officer Training Corps (ROTC) Battalion facilities. **Participants:** Forty-eight male (age 26.5±7.1 years) and 25 female (age 24.2±3.6 years) cadets from the same Army ROTC Battalion participating in the same physical training program. **Interventions:** A 3D motion capture system and force

plate were used to collect time synchronized gait data as participants ran at 4.0m·s⁻¹±10% down an 18m runway. Lower extremity joint kinematics and kinetics were assessed prior to the start of the physical training program. Cadets were then tracked for the development of ERLLP by a certified athletic trainer for one academic year. **Main Outcome Measures:** At the end of the academic year, cadets were divided into two groups for analysis: those who developed ERLLP and those who did not. Multiple one-way ANOVAs were used to compare the biomechanical gait characteristics between the two groups. **Results:** Ten cadets (nine men and one woman) developed ERLLP that required a reduction in training volume and intensity. Cadets who developed ERLLP demonstrated larger maximum vertical ground reaction force (vGRF, 26.87N·kg⁻¹ vs. 24.36N·kg⁻¹, p=0.0082) and delayed timing of peak braking force (tPBF, 31.60% vs. 30.12% of stance, p=0.0223) before injury development. **Conclusion:** Incidence of ERLLP in this cohort (13.7%) is similar to that reported by previous researchers. The delay in tPBF among those who developed ERLLP indicates a delay in the shear force on the tibia as the forward momentum of the foot contact on the ground is reversed into propulsive force during stance. Because there were no significant differences in the kinematics of the knee or ankle, the change in tPBF and increase in maximum vGRF indicate a change in the shear and vertical forces absorbed by the static structures of the lower leg. Therefore, delayed tPBF and increased vGRF during running are significant risk factors for the development of ERLLP in ROTC cadets.

Elevations In Ankle-Knee Coupling Variability Correspond With Phase Transitions During Walking Gait In Healthy Adults

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Context: It has been proposed that coupling variability between two joints increases during phase transitions in gait, however little is known about this phenomenon in relation to clinically-relevant gait cycle (GC) transitions. Examining the contextual relationship between joint coupling variability and GC transitions may provide insight into sensorimotor organization. Prior to assessing if such information has clinical relevance, confirmation of the existence of joint coupling variability at the gait transitions is required.

Objective: Identify areas in the walking GC with elevated levels of coupling variability and determine if these areas are associated with specific gait transitions. **Design:** Cross-sectional. **Setting:** Laboratory. **Participants:** Ten healthy adults (6 males, 4 females; age:25.3±3.8years; height:173.2 ±4.8cm; weight: 71.7± 10.2kg) volunteered to participate. **Interventions:** Subjects walked on a treadmill instrumented with force plates at a speed of 1.5m/s. Three-dimensional kinematics of the lower extremity joints were captured for 30s using a 15-camera motion analysis system. Data were time normalized to 101 points from initial-contact (0%) to the subsequent initial-contact of the same limb (100%). **Main Outcome Measures:** Left knee flexion-extension and ankle dorsiflexion-plantar flexion angles were calculated for 5 nonconsecutive GCs. Based on ankle and foot position, the stance phase was divided into 3 rockers: heel-rocker (initial heel contact to initial forefoot-contact, e.g. load response), ankle-rocker (forefoot-contact to maximum tibial progression over the

ankle, e.g. absorption phase), and forefoot-rocker (propulsion phase noted by heel lift and toe off). The swing phase was separated into initial-swing, mid-swing, and terminal-swing (preparation for initial-contact). To assess ankle-knee coupling variability (AKCV), vector-coding coefficients (VCC) ranging from 0 (no variability) to 1 (maximum variability) with corresponding 95% confidence intervals (CI) were calculated for each of the 101 GC points. A grand mean and CI were calculated to represent the overall AKCV across the entire GC (overall VCC-CI). Points in the GC where the lower boundary of the CI exceeded upper boundary of the overall VCC-CI were considered meaningful ($p < 0.05$). The mean (\pm standard deviation), and maximum were calculated in areas with elevated VCCs. **Results:** Two areas with VCCs elevated above the overall VCC-CI upper boundary (0.20) were identified at the transition from terminal-swing to the heel-rocker (98-2% of GC; $VCC = 0.37 \pm 0.08$, maximum=0.49) and the ankle-rocker to forefoot-rocker (38-48% of GC; $VCC = 0.36 \pm 0.07$, maximum=0.47). **Conclusions:** Areas throughout the walking GC with the greatest AKCV occurred concurrently with specific rocker transitions, namely the transition from an unloaded to a loaded state and from an absorption to a propulsion state. The AKCV increases may represent areas of sensorimotor system re-organization of the ankle-knee relationship to manage perturbations encountered during these gait transitions. Further investigation within those who suffer ankle and knee injuries may provide insight into the functional role of AKCV and lower extremity injuries involving the ankle and knee.

Differences In Static Hindfoot Alignment Among Individuals With Functional Ankle Instability, Copers And Healthy Controls
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Context: Several researchers have investigated dynamic ankle motion during functional activity in individuals with and without functional ankle instability (FAI). However, few researchers have examined differences in static ankle hindfoot alignment. Additionally, to our knowledge, there is no research on static hindfoot alignment in individuals who have had a single ankle sprain but no subsequent re-injury or instability (copers). **Objective:** To determine if there are static hindfoot position differences in the sagittal (plantar-flexion and dorsiflexion) and frontal planes (inversion and eversion) among FAI individuals, copers, and healthy individuals. **Design:** A three-group cross-sectional study. **Setting:** A controlled sports medicine research laboratory. **Participants:** Sixty-five individuals volunteered to participate. The Cumberland Ankle Instability Tool (CAIT) was used to measure functional limitations. Participants included 23 healthy individuals without history of ankle sprain (age= 23.17 ± 4 years, height= 1.72 ± 0.08 m, mass= 68.78 ± 13.26 kg, CAIT= 28.78 ± 1.78), 21 copers with history of a single ankle sprain without re-injury or giving-way (age= 23.48 ± 3.80 years, height= 1.71 ± 0.07 m, mass= 69.62 ± 14.62 kg, CAIT= 27.86 ± 1.71), and 23 FAI individuals with history of ≥ 1 ankle sprain and ≥ 2 episodes of giving-way (GW) in the past year (age= 23.30 ± 3.84 years, height= 1.70 ± 0.11 m, mass= 68.66 ± 14.60 kg, GW per month= 5.81 ± 8.41 , CAIT= 20.52 ± 2.94). **Interventions:** During a single visit, each participant's standing hindfoot alignment was captured with a 12-camera motion analysis system at 100Hz (Vicon, Oxford, UK). For

motion capture, reflective markers were placed on the subjects' foot and shank consistent with the Oxford Foot Model. **Main Outcome Measures:** Hindfoot position in the frontal and sagittal planes were used for analysis. We performed separate one-way (group: healthy, coper and FAI) ANOVAs for frontal and sagittal planes. Tukey's post hoc tests were used to compare each possible pair. **Results:** Group differences were found in hindfoot sagittal plane position ($F_{2,65} = 4.70$, $p = 0.01$). Specifically, post hoc testing found that individuals without a history of ankle sprains stood with greater dorsiflexion than individuals with a history of ankle sprains, i.e. FAI and copers (Healthy: $5.08 \pm 2.81^\circ$, Coper: $3.00 \pm 2.60^\circ$, FAI: $2.89 \pm 6.07^\circ$). There was no significant sagittal plane difference between FAI and coper groups. In the frontal plane, no significant group differences were found ($F_{2,65} = 0.25$, $p = 0.78$; Healthy: $-2.28 \pm 5.62^\circ$, Coper: $-0.98 \pm 7.08^\circ$, FAI: $-1.75 \pm 6.07^\circ$). **Conclusions:** Individuals with a history of ankle sprain (both copers and individuals with FAI) show decreased dorsiflexion, regardless of whether or not they have symptoms of instability. This indicates that decreased dorsiflexion is associated with ankle sprains but not a causal mechanism for instability. Thus, it appears to be a relatively benign change post-injury.

The Relationship Between Ankle Range Of Motion And Dynamic Postural Control In Healthy Individuals And Those Reporting Chronic Ankle Instability

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Context: Structural and functional impairments have been identified as contributing factors associated with chronic ankle instability (CAI). Examining the relationship between weight-bearing ankle dorsiflexion range of motion (DFROM) and performance on the Star Excursion Balance Test (SEBT) may provide insight to sensorimotor system alterations in individuals with CAI. **Objective:** To examine the relationship between ankle DFROM and performance on the SEBT in those with and without CAI. Additionally, we explored group differences in these measures. **Design:** Case-control design. **Setting:** Laboratory. **Participants:** Twenty-four subjects with self-reported CAI (11 males, 13 females, age:23.6±5.8 years, height:174.6±7.6cm; weight: 77.9±15.1kg) were gender and side matched to twenty-four healthy subjects (11 males, 13 females, age:24.3±4.4 years, height: 172.4 ±10.4 cm; weight:71.5±13.9kg). **Interventions:** All subjects performed 3 trials of maximum reach in the anterior (ANT), posteromedial (PM) and posterolateral (PL) directions of the SEBT to assess dynamic balance. All reach distances were normalized to leg length. The weight-bearing lunge test (WBLT) was used to measure DFROM. Subjects performed 3 trials of the WBLT in which they kept their test heel firmly planted on the floor while they flexed their knee to the wall. Maximum dorsiflexion was defined as the distance from the great toe to the wall based on the furthest distance the foot was able to be placed without the heel lifting. **Main Outcome Measures:** The independent variable

was group (CAI, healthy) and dependent variables included maximal DFROM(cm) and maximal reach distance normalized to leg length on the SEBT(%). Pearson Product-Moment correlation coefficients were calculated to examine the relationship between the WBLT and each direction of the SEBT for each group. Independent t-tests were used to examine differences between groups on the WBLT and each SEBT direction. Alpha was set a priori at $p < 0.05$. **Results:** In the healthy group, the WBLT was significantly correlated to the SEBTANT ($r=0.70$, $r^2=0.49$, $p<0.001$) and SEBTPL ($r=0.47$, $r^2=0.22$, $p=0.02$), but not to the SEBTM ($r=0.38$, $r^2=0.14$, $p=0.07$). In the CAI group, the WBLT was significantly correlated to the SEBTANT ($r=0.42$, $r^2=0.18$, $p=0.04$), but not to the SEBTPL ($r=0.34$, $r^2=0.14$, $p=0.10$) or the SEBTM ($r=0.31$, $r^2=0.09$, $p=0.14$). No significant differences were detected between groups on the WBLT or any of the SEBT directions; (Healthy: WBLT=11.9±3.1cm, SEBTANT =78.4 ±5.6%, SEBTM =92.3 ±9.8%, SEBTPL= 84.8±15.2%; CAI: WBLT =11.8 ±3.0cm, SEBTANT =79.1 ±5.1%, SEBTM =90.9 ±8.9%, SEBTPL =84.5 ±11.5%; all $p > 0.34$). **Conclusions:** Although both groups exhibited similar DFROM and SEBT reach distances, up to 30% less variance in SEBT performance could be explained by DFROM in those with CAI compared to healthy subjects. These findings suggest that CAI subjects may have utilized a different movement strategy compared to healthy subjects when performing the SEBT. Examining the relationship between structural and functional contributing factors may provide more insight into the sensorimotor alterations in those with CAI beyond examining these measures in isolation.

Effects Of Chronic Ankle Instability On Excitability Of The Motor Cortex

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Context: Lower extremity neuromuscular dysfunction is common following ankle sprains and may be a contributing factor to chronic ankle instability (CAI). There is mounting evidence to suggest the central nervous system plays an important role in neuromuscular alterations following joint injury. While spinal level excitability is altered following acute and chronic ankle sprains, little is known about how excitability of the motor cortex is affected in those with CAI. **Objective:** Determine if cortical excitability of the fibularis longus (FL) differs in those with unilateral CAI and healthy controls. **Design:** Blinded, Case-control. **Setting:** Research laboratory. **Patients or Other Participants:** Ten participants with CAI (7F/3M, 20.5±1.4years, 175.9±36.7cm, 70.5 ±13.3kg) and seven healthy participants free from ankle injury (7F/0M, 19.9±0.7years, 168.9 ±8.9cm, 66.4±45.1kg) were involved in this study. Healthy subjects were assigned a matched "injured leg" prior to data analysis. **Interventions:** Cortical excitability was measured bilaterally in both groups while seated in 10° of knee flexion, ankles in 10° of plantar flexion and feet secured in a molded heel cup. Transcranial magnetic stimulation (TMS) was used to excite areas on the motor cortex corresponding to the contralateral FL. Electromyography positioned on the FL was used to collect motor evoked potentials (MEP) elicited in the muscle from the TMS. Active motor thresholds (AMT) were collected as participants plantar flexed at 5% of a maximal isometric contraction. AMT were determined as the lowest amount of TMS able to elicit a measurable MEP (> 100mV) in 5 out 10 consecutive trials at the same TMS

intensity. All MEPs were normalized to maximal FL Muscle Responses (MEP:M) elicited with an electrical stimulus over the common fibular nerve. **Main Outcome Measures:** Peak-to-peak MEP:M amplitudes were evaluated at individual AMT intensity bilaterally in both groups. A 2x2 (Leg, Group) ANOVA was used to evaluate differences in MEP:M between legs in the CAI and healthy participants, while independent and dependant t-tests were utilized post hoc to evaluate between and within groups, respectively. A priori levels of significance were set at $P \leq 0.05$. **Results:** A significant Group x Leg interaction was found ($F_{1,15}=5.21$, $P=0.04$). Injured leg MEPs (0.012 ± 0.008) in the CAI group were significantly lower than the injured leg in the control group (0.032 ± 0.023 ; $t_{16}=-2.58$, $P=0.02$), while no significant differences were found in the uninjured legs between the CAI (0.013 ± 0.007) and control groups (0.023 ± 0.029 ; $t_{16}=-.975$, $P=0.34$). Additionally, no differences were found between legs within the CAI ($t_{16}=-0.58$, $P=0.56$) or healthy groups ($t_{16}=2.0$, $P=0.09$). **Conclusions:** Lower FL MEPs in the injured legs of individuals with CAI suggests a potential motor cortex alteration that presents with diminished excitability to the FL. Decreased cortical excitability of stabilizing muscles around the ankle may have critical implications for rehabilitation strategies for those with ankle pathology.

Effects Of Injury And Tape On Dynamic Ankle Inversion Speed Using Fulcrum Methodology

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Context: The lateral ankle sprain is the most common injury in athletics. The rate at which the ankle is unexpectedly forced into inversion will influence the likelihood of a lateral ankle sprain as well as the severity of injury. **Objective:** To determine if a previous lateral ankle sprain or ankle taping effects the time to maximum inversion (TMI) during a simulated lateral ankle sprain, and to determine the reliability of this measurement. **Design:** Repeated measures design. **Setting:** Controlled laboratory setting. **Participants:** Twenty six volunteers (age= 21.46 ± 1.17 years; mass= 73.92 ± 14.55 kg; height= 1.75 ± 0.087 m), which included 13 with no previous ankle sprain (NI) and 13 with a previous lateral ankle sprain (LAS). **Interventions:** The independent variables were injury history, with two levels (no ankle injury, previous lateral ankle sprain), and ankle support, with two levels (ankle taping, no ankle taping). Statistical analysis included a 2 x 2 ANOVA with repeated measures on ankle support condition to analyze the difference in TMI between the injury groups and ankle support conditions. Reliability coefficients, using intra-class correlation coefficients, were calculated between the two testing days without ankle taping. An outer sole with fulcrum was placed on the bottom of the participants' shoe that forced them into 25° of inversion upon landing from a 27 cm single leg drop landing. The landing surface was synchronized with a multichannel electromyography amplifier/processor unit to signal the initiation and completion of the 25° of inversion. Each participant in the lateral ankle

sprain group was matched with a healthy participant of a similar height and mass. Participants reported for testing on three days; ankle taping was randomly assigned one of the first two testing days, and the third testing day (no ankle taping) was to determine the reliability of the TMI variable with the first or second testing day without ankle taping. Ten trials were performed on the previously injured leg (LAS group) or matched control leg (NI group) each testing day. **Main Outcome Measures:** The dependent variable was TMI, measured in milliseconds, defined as the time from contact of the fulcrum with the landing surface to the time when the lateral border of the outer sole made contact with the landing surface. This is a measure of the time it took the participants to complete the 25° of inversion. **Results:** Presented as Mean \pm SD and level of significance. No significant interaction ($p=.973$), or main effects for injury history (NI= 53.49 ± 18.89 ms; LAS= 48.79 ± 19.54 ms; $p=.493$) or ankle support (no support= 48.83 ± 18.49 ms; ankle taping= 53.44 ± 19.46 ms; $p=.179$) was found for either variable, but good reliability was found for TMI (ICC=.81). **Conclusions:** Neither a previous lateral ankle sprain or ankle taping affects TMI, but the TMI variable demonstrated good reliability.

Resting Muscle Spindle Activity Correlates With Ankle Stiffness

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Context: Investigations on the neuromechanical contributors to joint stability and functional performance emphasize the importance of optimal joint stiffness regulation. The maintenance of muscle tone, mediated by muscle spindle function, is often cited for its critical role in coordinated motion and musculo-skeletal protection via stiffness regulation, however, no studies have

simultaneously investigated resting muscle spindle afferent (MSA) activity and joint stiffness values. **Objective:** The purpose of this study was to determine if resting MSA activity correlates with joint stiffness during passive ankle joint loading. **Design:** Single-group post-test only. **Setting:** Human Performance Laboratory. **Patients or Other Participants:** 29 subjects (20.9 ± 2.2 yrs, 173.1 ± 8.9 cm, 74.5 ± 12.7 kg) were recruited for this study. **Interventions:** MSA recordings were obtained at the common peroneal nerve using microneurography, involving direct nerve recordings. MSA activity was identified as response to muscle stretch, with silence during muscle shortening and skin stimulation. A modified ankle arthrometer was coupled with a nerve traffic analyzer and affixed to the subjects' ankles. Three anterior translation movements to a force of 125 N of force were performed, allowing for simultaneous measurement of joint load, laxity, and MSA traffic. **Main Outcome Measures:** The MSA signal was normalized to peak values, and stiffness values (N/mm) were calculated from 0-30N, 30-60N, 60-90N, 90-125N, and 0-125N of anterior force. Pearson product-moment correlation coefficients were used to determine the relationship between resting MSA traffic (at 0N of force) and stiffness values. Alpha level was set *a priori* at 0.01. **Results:** Resting muscle spindle activity was $7.9 \pm 2.3\%$ of peak activity. Significant negative correlations ($p < .01$) were observed between resting afferent traffic and joint stiffness at 0-30N (25.5 ± 15.2 N/mm; $r = -0.61$), 30-60N (18.1 ± 7.7 N/mm; $r = -0.87$), 60-90N (17.8 ± 8.0 N/mm; $r = -0.77$), and 90-125N (15.2 ± 3.8 N/mm; $r = -0.47$), and total stiffness (17.9 ± 5.3 N/mm; $r = -0.945$). **Conclusions:** We hypothesize that the inverse relationship between MSA activity and ankle stiffness may reflect a neuro-logic optimization strategy whereby fundamental adaptations exist within the adult sensorimotor system that are contingent upon passive mechanical

properties of a joint. This synergistic relationship may permit ankles with greater inherent stiffness to passively resist loads and thus maintain lower muscle spindle activity at rest. However, relatively compliant joints may exhibit greater resting muscle spindle afferent activity for earlier detection of relatively small changes in joint biomechanics. These complementary neuromechanical properties may exist to maximize individual structure/ function relationships and preserve joint equilibrium. The inverse nature of this relationship could contribute to the divergent research outcomes attempting to link joint laxity, sensation and functional stability.

Bioelectrical Impedance Analysis Versus Clinical Hydration Measures In Minor Professional Ice Hockey Players

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Context: When choosing clinical assessment tools, clinicians must often balance accuracy and practicality. The National Athletic Trainers' Association recommends monitoring hydration status and fluid balance by assessing urine specific gravity (U_{sg}), urine color (U_{col}), and change in body mass (ΔBM). The tetrapolar bioelectrical impedance analysis (BIA) technique has been established as a valid, non-invasive measure of hydration status via total body water (TBW) in euhydrated humans. However, in the clinical setting the more cost efficient bipolar technique is often applied to both euhydrated and hypohydrated athletes.

Objective: To compare the bipolar BIA technique to common clinical measures of hydration. **Design:** We employed cross-sectional analysis of data from a larger randomized, control trial. **Participants:** We recruited 10 male minor professional ice hockey players (age = 24.33 ± 2.35 y, height = 182 ± 5.26 cm, weight = 90.51 ± 7.47 kg). **Interventions:** Hydration measures were taken before and after 10 practices of a minor professional ice hockey team. **Main Outcome Measures:** As part a larger study,

researchers obtained pre- and post measures of U_{sg} , U_{col} , BM and TBW (Tanita TBF-300A, Tanita Corporation, Tokyo, Japan). Concurrent TBW and BM measures were used to calculate percent hydration (%HY). Dependent t-tests were used to evaluate differences between pre- and post-practice BM and TBW, as well as ΔBM and TBW. Spearman's rho was

used to evaluate relationships between U_{sg} , U_{col} , and TBW, as well as ΔBM , ΔTBW , ΔU_{sg} , and ΔU_{col} . **Results:** BIA measured no significant changes in TBW and a significant increase in %HY ($1.03 \pm 1.26\%$, $P < 0.001$). We found increased U_{sg} (0.002 ± 0.005 μG , $P = 0.014$), U_{col} (0.87 ± 1.23 shades, $P < 0.001$), and decreased BM (-1.31 ± 1.02 kg, $P < 0.001$) post-practice. Body mass loss was significantly greater than TBW loss ($P < 0.001$). There were no relationships pre- or post-practice between %HY and U_{sg} , or %HY and U_{col} . We found significant relationships between U_{sg} and U_{col} both pre-practice ($\rho = 0.786$, $P < 0.001$) and post-practice ($\rho = 0.744$, $P < 0.001$). Correlations were also found between ΔBM and ΔTBW ($\rho = 0.629$, $P < 0.001$), as well as ΔU_{sg} and ΔU_{col} ($\rho = 0.528$, $P < 0.001$). **Conclusions:** U_{sg} , U_{col} , and ΔBM indicated hypohydration, while TBW and %HY indicated maintenance and increase in hydration, respectively. Previous research has indicated that resistance is decreased after exercise, which may lead to positively skewed TBW measurements and %HY calculations. U_{sg} and U_{col} provided assessments of hydration status which were comparable to each other. Bipolar BIA did not provide accurate measures of hydration status pre- or post-practice or changes in fluid balance in minor professional hockey players. Clinicians should rely on the conventional practice of monitoring hydration status and fluid balance through urinalysis and ΔBM .

Log Roll Push Or Log Roll Pull: Which Is The Favored Spine Boarding Technique For A Prone Patient With A Suspected Thoracolumbar Injury?

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Context: Previous research has found that the log roll (LR) technique produces excess motion in the spinal column during patient transfer onto the long spine board. Although alternatives to the LR have been reported for patients in the supine position with either cervical or thoracolumbar injuries, the safest method of transfer for a prone patient with a thoracolumbar injury has not been studied. **Objective:** To measure the amount of spinal motion occurring when a prone patient with a thoracolumbar injury is moved to a long spine board using LR pull or LR push techniques. **Design:** A repeated measures study design was used. **Setting:** Cadaver laboratory. **Patients or Other Participants:** Five lightly-embalmed cadavers (3 males, 2 females; mass: 135 kg \pm 31.2). None had any history of spinal injury or thoracolumbar abnormality. **Interventions:** A global instability was surgically created at the L1 level by performing a corpectomy and transection of the posterior ligamentous complex. An electromagnetic tracking device registered motion between the T12 and L2 vertebral segments as the two spine boarding protocols were tested: LR pull and LR push. Both techniques entailed performing a 180° LR rotation

of the prone patient from the ground to the supine position on the spine board while pulling (towards rescuers) or pushing (away from rescuers) the cadaver onto the spine board. **Main Outcome Measures:** Dependent variables were flexion-extension, axial rotation, lateral bending, antero-posterior displacement, axial translation, and medial-lateral translation. Techniques were repeated three times per cadaver. Repeated measures ANOVAs were completed to assess differences for each of the dependent variables. **Results:** Under all conditions motion was greater with LR pull than with LR push. Differences were statistically significant for three of the parameters. LR pull produced significantly greater motion for: flexion-extension [$10.6^\circ \pm 2.8^\circ$ for LR pull and $7.7^\circ \pm 2.8^\circ$ for LR push ($p=0.021$)]; axial displacement [$11.6 \text{ mm} \pm 4.0$ for LR pull versus $8.4 \text{ mm} \pm 4.3$ for LR push ($p=0.014$)]; and anteroposterior displacement [$17.4 \text{ mm} \pm 7.6$ for LR pull versus $15.3 \text{ mm} \pm 9.4$ for LR push ($p=0.042$)]. The amount of motion was not significantly different for: axial rotation LR pull ($16.8^\circ \pm 6.7^\circ$) and LR push ($15.1^\circ \pm 7.7^\circ$; $p=0.389$); lateral bending LR pull ($11.2^\circ \pm 2.5^\circ$) and LR push ($8.4^\circ \pm 3.4^\circ$; $p=0.185$); and medial-lateral displacement LR pull ($13.4 \text{ mm} \pm 5.5$) and LR push ($12.2 \text{ mm} \pm 6.4$; $p=0.197$). **Conclusions:** When a patient is found in the prone position and a thoracolumbar injury is suspected, use of the LR push technique is recommended, instead of the LR pull, to minimize spinal movement while transferring the patient onto the long spine board.

Athlete Assessment Of Urine Color Effectively Influences Planned Hydration Behaviors

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Context: Athletic trainers educate athletes on hydration practices and self-assessment of hydration status via urine color (UC) to help prevent heat illness and limit decrements to performance. However, athletes' ability to determine UC and their planned behaviors subsequent to this self-assessment are unknown. **Objective:** To determine the relationship between practitioner (UC_p) and athlete (UC_a) assessments of UC. To identify athletes' planned hydration behaviors after UC self-assessment. **Design:** Cross-sectional research design. **Setting:** Separate pre-participation examinations for division I and III collegiate football, cross country, volleyball, and soccer teams. **Participants:** Athletes ($n=315$) participated in a hydration station as part of the annual physical exam. Members from each team (football=169, cross country=45, volleyball=28, soccer=73; male=230, female=85) signed informed consents prior to participation. **Interventions:** Athletes provided a urine sample and completed a three-item online questionnaire. Four independent practitioners evaluated UC_p using a standard urine color chart (Inter-rater reliability $ICC=0.88$, $P<0.001$; Intra-rater reliability ICC range= $0.85-0.97$, $P<0.001$). For the UC_a assessment, the practitioners asked the athletes to compare their UC to the same urine color chart. The athletes were blind to UC_p . **Main Outcome Measures:** Dependent measures were UC_p , and the questionnaire results: UC_a , description of hydration status, and planned hydration behaviors (based on UC_a). We used Lin's concordance correlation coefficient (CCC) to examine the relationship between UC_p and UC_a . CCC is used to measure agreement between multiple raters for

continuous variables and avoids the shortcomings of other correlation statistics. We used a regression analysis to determine the predictive value of UC_a on planned hydration behavior. We also analyzed the dependent measures with univariate and bivariate statistics. **Results:** We identified a strong relationship ($\rho_c=0.772$, lower $CL_{95}=0.736$) between UC_p (4 ± 2) and UC_a (4 ± 1); however we also identified 39.7% ($n=125/315$) of athletes somewhat underestimated their UC_a (mean difference= -0.33 ± 0.97). We found that even when UC_a is moderate or high ($UC\geq 4$; 53.0%, $n=167/315$), athletes are likely to report being only "a little" (50.9%, $n=85/167$) or "somewhat" (26.9%, $n=45/167$) dehydrated. Only when $UC_a=7$ (4.4%, $n=14/315$), did these athletes state they were "very dehydrated" (50%, $n=7/14$). Using the regression, we found UC_a is a significant predictor ($R^2=0.10$, $P<0.001$) of planned hydration behavior. Specifically, those with $UC\geq 4$ (53.0%, $n=167/315$) were more likely to "Drink 4-5 cups (1L) of water/sports drink" prior to starting their practice session (62.3%, $n=104/167$). **Conclusions:** Our objective was to determine the relationship between UC_p and UC_a and to gauge athletes' planned hydration behaviors. Results indicate that athletes are capable of assessing their own UC, yet tend to underestimate their hydration status. However, athletes responded appropriately when asked about their planned hydration behaviors. We believe practitioners should continue to educate athletes about the meaning of UC and about the hydration behaviors that should follow self-assessment.

Body Size And Fitness Characteristics Of National Football League Players: An Update

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Context: The literature has described the physical characteristics of National Football Players (NFL) since 1970; however, each edition of new data has articulated level of fitness using a variety of variables. While body mass index (BMI) has been criticized for its use among athletes, the measure is still used to describe fitness. Other variables, besides body composition and BMI are available for classifying fitness among athletes. **Objective:** To update body size and physical characteristic norms of NFL players using several calculations of fitness. **Design:** We used a non-experimental, descriptive research design to observe the body size and physical characteristics of NFL players. **Setting:** Preseason physical examinations of one NFL team. **Participants:** Sixty-one players (age=25±3yrs; height=1.86±0.07m; body mass=109.2±21.5kg) participated in data collection. **Intervention:** We calculated descriptive statistics and frequencies for all dependent measures. We compared players by position using separate one-way ANOVAs. We analyzed the relationships (Pearson correlations) between BMI and the other dependent measures. **Main Outcome Measures:** Demographic data (age, position) was acquired from the medical staff. Because of the smaller sample, we classified position by the following: quarterbacks/running backs/special teams (QB/RB/ST, n=8), wide receivers/defensive backs (WR/DB, n=21), tight-ends/linebackers (TE/LB, n=12), and lineman (OL/DL, n=20). We measured body mass, height, waist and hip circumference. We calculated BMI, body surface area (BSA), BSA-to-mass ratio, and waist-

to-hip ratio. **Results:** NFL players exceed the normal values for BSA (mean=2.33±.24, norm=1.73m²) and BMI (mean= 31.35±4.70kg/m², grade 1 obesity), have a smaller than normal BSA-mass ratio (mean=0.022±0.002 m²/kg, norm=0.026m²/kg), but according to the waist-to-hip ratio (0.85±.05) are at a low health risk. We identified statistical differences between positions for BSA ($F_{3,57}=93.22$, $p<0.001$), BMI ($F_{3,57}=79.46$, $p<0.001$), BSA-mass ratio ($F_{3,57}=103.35$, $p<0.001$), and waist-to-hip ratio ($F_{3,57}=13.52$, $p<0.001$). For BSA, QB/RB/ST (2.22±0.14m²) and TE/LB (2.34±0.07m²) are statistically equal, while OL/DL (2.61±0.12m²) are larger and WR/DB (2.09±0.08m²) are smaller. For BMI, OL/DL (36.9±3.0kg/m²) are larger than all other groups, but QB/RB/ST (27.9±1.9kg/m²) and WR/DB (27.2±1.4kg/m²) are the smallest groups. BSA-mass ratio calculations reveal that QB/RB/ST (0.023±0.001m²/kg) and WR/DB (0.024±0.001m²/kg) are statistically similar, and although TE/LB (0.021±0.005m²/kg) and OL/DL (0.019±0.001m²/kg) are significantly different, they are smaller than both the other groups. Waist-to-hip ratio measurements were significantly difference between OL/DL (0.90±0.05) and all other groups were smaller (QB/RB/ST=0.83±0.04, WR/DB=0.82±0.02, TE/LB=0.85±0.04). Data suggest that BSA ($r=0.86$, $p<0.001$) and waist-to-hip ratio ($r=0.71$, $p<0.001$) are significantly correlated to BMI, while BSA-mass ratio ($r=-0.97$, $p<0.001$) and BMI are inversely correlated. **Conclusions:** Our results suggest that lineman are significantly larger than the other position players, but their smaller waist-to-hip ratio demonstrates that they may distribute adipose effectively. In addition, BMI has been criticized in the literature, but it appears that this measure is still highly correlated with other measures of morphology or level of fitness.

Lacrosse Helmet Facemask Removal Timeliness Using Cordless Screw Driver, FM Extractor, And Combined Tool Approach

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Context: In the case of a catastrophic cervical spine injury during athletic play, removal of the facemask is necessary to establish a patent airway for the helmeted athlete. Current literature stresses the importance of timely removal of the facemask from the helmet to provide appropriate care to the athlete. No data to date has evaluated face mask removal techniques on men's lacrosse helmets. **Objective:** To compare the speed of 3 methods of removing the facemask of a men's Cascade CPX lacrosse helmet. **Design:** 2 x 3 crossover trial. **Setting:** Controlled laboratory setting. **Patients or Other Participants:** We used 20 participants, 10 Certified Athletic Trainers (ATCs) and 10 Athletic Training Students (ATs). **Interventions:** Our independent variables consisted of removal method (cordless screw driver, CSD; FM Extractor, FMX; combined tool approach, CTA) and group (ATC, ATs). Each facemask removal technique was explained in detail to the participants for specific cuts of loop straps or screw(s) to unscrew. We counter-balanced the order of the removal tools throughout the study. **Main Outcomes Measures:** We measured the time to the nearest hundredth of a second from when the participants first picked up the removal tool until the time when the facemask had been completely removed from the helmet. Participants stated preference of method verbally on a 10 point scale, 0 being completely unsatisfactory and 10 being completely satisfactory. We analyzed data using a factorial ANOVA for each dependent variable. **Results:** When we analyzed the results, the interaction between removal method and group was not significant for time

($F_{2,54}=1.22$, $p=0.30$) or preference ($F_{2,54}=0.36$, $p=0.70$). We did discover a main effect for method of removal on time ($F_{2,54}=15.27$, $p<0.01$). Tukey post hoc tests indicated the use of the CSD (38.83 ± 11.49) was significantly faster than the use of the FMX (207.92 ± 143.20 , $p<0.001$) or CTA (167.83 ± 103.96 , $p=0.001$). We also found a significant main effect for method of removal on preference scores ($F_{2,54}=38.35$, $p<0.001$). Tukey post hoc tests revealed significant differences between the preference of the CSD (9.20 ± 0.52) and the FMX (4.85 ± 1.93 ; $p<0.001$), and between the CSD (9.20 ± 0.52) and the CTA (6.05 ± 1.90 ; $p<0.001$). We found no significant differences between the FMX (4.85 ± 1.93) and the CTA (6.05 ± 1.90 ; $p=0.06$). We observed no group differences for time ($F_{1,54}=1.99$, $p=0.16$) or preference ($F_{1,54}=0.057$, $p=0.81$). **Conclusions:** The CSD was the fastest and most preferred method to remove a facemask from a new men's Cascade CPX lacrosse helmet. Also, we observed no significant differences in the amount of time it took ATCs and ATSS to remove facemasks.

Free Communications, Poster Presentations: Professional Development

Wednesday, June 22, 2011, 8:00AM - 12:00PM, Outside Hall A, authors present 11:00AM - 12:00PM

What Influences Senior Undergraduate Athletic Training Students Career Decisions Post Graduation?

Gavin KE, Mazerolle SM, Pitney WA, Casa DJ: University of Connecticut, Storrs, CT, and Northern Illinois University, DeKalb, IL

Context: Career opportunities for athletic training students (ATs) have significantly increased over the past few years. However, it commonly appears that ATs are opting for a more diversified professional experience after graduation. With the diversity in available options and no current recommendation for post-professional study, an understanding of career decision is imperative.

Objective: The purpose of our study was to investigate, using the theoretical framework of socialization, the influential factors behind the post graduation decisions of the senior ATs. **Design:** Qualitative design using internet-based, structured interviews, as well as follow-up semi-structured phone interviews. **Setting:** Web-based management system, HuskyCT, which is a secure program that allows educators and researchers to engage in asynchronous communication with individuals. **Patients or**

Other Participants: 22 ATs (16 females; 6 males), who graduated in May 2010 from 13 different Commission on Accreditation of Athletic Training Education (CAATE) programs. The average age was 22 ± 2 and they represented 7 NATA districts. Six ATs agreed to participate in follow-up phone interviews. Recruitment was guided by data saturation. Criterion sampling was utilized to identify participants, while recruitment was done randomly by emailing program directors of CAATE accredited programs. **Data**

Collection and Analysis: All interviews were transcribed verbatim and

the data was analyzed inductively, borrowing from the grounded theory approach. Data analysis required independent coding by 2 athletic trainers for specific themes. Credibility of the results was confirmed via peer review, methodological and multiple analyst triangulation. **Results:** Two higher order themes emerged from the data analysis: *Persistence in Athletic Training (AT) and Decision to Leave AT*. Faculty and clinical instructor support, improved marketability, and professional growth were supporting themes describing *persistence in AT*. Additionally, the supporting theme of professional growth was categorized by obtaining more real-world professional experience and to help obtain career goals through a matched work-experience. Shift of interest away from AT, lack of respect for the AT profession, compensation, time commitment, and AT as a stepping stone were themes sustaining an ATs' *reason to leave AT*. The aforementioned reasons to leave were often discussed collectively by the participants, rather than an isolated reason for leaving; generating a collective undesirable outlook of AT profession. **Conclusions:** The results of this study corroborate previous literature on and highlight the importance of faculty support and early socialization to the AT profession. Professional growth and skill development drive the ATs to seek additional experiences at the graduate assistant level, while a myriad of factors influence the ATs to choose other career options. Socialization of pre-athletic training students could alter retention rates by providing in-depth information about the profession before students commit in their undergraduate education, as well as helping reduce attrition prior to entrance into the workforce.

Post Professional Athletic Training Education: Attractors And Career Intentions

Mazerolle SM, Dodge TM: University of Connecticut, Storrs, CT, and Springfield College, Springfield, MA

Context: Recent evidence suggests students enter the athletic training profession upon graduation due to support from faculty and clinical instructors. Students pursue graduate education in order to promote professional development. Anecdotally, we know students select graduate programs based upon location, finances, and future career goals. A recent report suggests satisfaction with post-professional athletic training (PPAT) program graduate studies, however empirically, we are lacking information on what attracts a student to these programs.

Objective: To gain an appreciation for the selection process of graduate study, focusing on the PPAT program and implications for selection. **Design:** Grounded theory study using semi-structured phone interviews. **Setting:** Post professional athletic training programs accredited by the NATA.

Patients or Other Participants: Nineteen first year PPAT students participated and represented 13 of the 16 accredited PPAT programs. The average age was 23 ± 1 . Participants rated the dynamic nature of the profession, positively (9 ± 1) and a majority of those who participated were positively influenced to attend a PPAT program because of a mentor and the existence of a PPAT program at their undergraduate institution. **Data**

Collection and Analysis: All interviews were conducted via phone and transcribed verbatim. Analysis of the interview data followed the procedures as outlined by a grounded theory approach. Trustworthiness of the data was secured by: 1) participant transcript checks, 2) participant

interpretative verification, and 3) multiple analyst triangulations. **Results:** Athletic training students select PPAT programs for 4 major reasons: 1) *career intentions*, 2) *mentorship received from undergraduate faculty/clinical instructors*, 3) *reputation of the program/faculty*, and 4) *professional socialization*. Participants discussed long term professional goals specifically working as an AT as the driving force behind wanting an advanced degree in AT. Faculty and clinical instructor recommendations along with the prestige of the program helped guide the decisions. Participants also expressed the need to gain more experience, which provided autonomy but also support while gaining real work experience. Final selection of the students' PPAT program was based upon *academic offerings*, the *assistantship* offered, including *financial support* as well as *advanced knowledge* in athletic training concepts and principles, and *mentorship opportunities*, both in application of *research* and *clinical skills*. **Conclusions:** Students who attend PPAT programs are attracted to the pursuit of advancement of their entry-level knowledge, are committed to their professional development as an AT, and view the profession of athletic training as a life-long career. These students are excited for the future and the combination of balanced academics, clinical experiences, additional professional socialization and mentorship from the PPAT program experience will help them secure their desired position. Continued research is necessary to determine the influence of mentorship both in a positive and negative direction regarding pursuit of an advanced AT degree.

College Athletic Trainers' Perceived Knowledge And Competence With Mental Health Disorders

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Context: Literature suggests that athletic populations are more prone to mental health conditions. These conditions are often clinically misinterpreted and it is common for athletes to not recognize or acknowledge the symptoms. Without appropriate pharmacological and/or psychological management, symptoms across the continuum of mental health disorders likely will persist.

Objective: The purpose of this study was to develop pilot data regarding athletic trainers' (ATs) perceived knowledge of and competence in the management of mental health conditions including depression, mood disorders and anxiety disorders.

Design and Setting: Online, electronic survey.

Patients or Other Participants: Athletic trainers (n=144) from NCAA colleges and universities were emailed a link to an online survey.

Interventions: The Athletic Trainers' Perceived Competence with Mental Health Conditions and Issues Questionnaire was validated by content experts and approved by the Office of Research Compliance Biomedical IRB prior to its distribution.

Main Outcome Measure(s): Frequencies and descriptive measures were calculated as preliminary evidence about athletic trainers' knowledge of and competence in the management of mental health conditions in collegiate student athletes. **Results:** The majority of respondents believe that ATs should have a competent level of knowledge of mental health conditions (89.5%) and mental health issues (94.7%). Respondents (80.2%)

believe that ATs are knowledgeable with regard to mental health conditions and issues affecting student athletes. Only 75% reported they are knowledgeable about and competent in the management of mental health conditions affecting student athletes. Strikingly, 54.3% report they are not knowledgeable about the medications prescribed in the management of mental health conditions. Similarly, two thirds (65.7%) of ATs state they are unaware of the adverse drug reactions (ADR) prescribed in the management of mental health conditions. **Conclusions:** These pilot data indicate a discrepancy may exist between the perceived need for establishing a knowledgeable and competent practice relative to mental health disorders and the actual perceived ability to actualize this outcome. This inconsistency is most pronounced when reflecting upon psychodynamic medications and their potential ADRs. Awareness and understanding of specific mental health disorders and issues that contribute to the mental health of the student athlete is an entry-level competence. These results demonstrate the importance of increasing the profile of the psychosocial management and referral educational domain. There is an ever increasing public awareness of mental health issues in student athletes. Athletic trainers (ATs) must be at the forefront of the recognition and management of these conditions. This must include the continuum of mental health disorders and issues, including DSM-IV criteria, appropriate referral sources, and pharmacological and psychological intervention.

Athletic Trainers' Comfort And Competence In Addressing Psychological Issues Of Athletes

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Context: The amount of time Certified Athletic Trainers (ATs) spend with their athletes is conducive to certain roles. Oftentimes, ATs are often the only health care providers managing the physical and psychological consequences of injury for athletes, yet it remains unknown how often they address non-injury related psychological issues that may predispose them to injury. **Objective:** To determine the types of psychological issues that ATs encounter, their comfort (COM) and perceived competence (PCO) in addressing those issues, and referral patterns.

Design: Descriptive survey. **Setting:** An online survey of current members of the National Athletic Trainers' Association (NATA). **Patients or Other Participants:** One-thousand ATs were randomly selected by the NATA Research and Education Foundation (REF) list service and invited for participation via e-mail. A total of 311 ATs (155 male, 156 female) responded to the invitation e-mails sent, yielding a response rate of 31.1%. The sample was mainly composed of respondents, ages 26-44 (68.7%, n=213), who were employed as ATs in Secondary Schools (38.7%, n=120), Colleges/Universities (31.9%, n=99), and Clinics (9.35%, n=29). **Interventions:** The web-based instrument was adapted from Mann et al (2007) who examined COM, PCO, and referral patterns of Physicians managing psychological issues under their care. Modified to assess ATs, the instrument was examined for content validity using a pilot study (n=21 ATs). The 32 question survey was generated and managed using Survey-Monkey.com®. The invitations, web-link, and follow-up reminders were e-

mailed to participants through the automated NATAREF service. **Main Outcome Measure(s):** Descriptive statistics including means, medians, frequencies, and modes were used to analyze the AT's demographic data. Separate logistic regression analyses were employed to determine the predictability of COM or PCO based on demographics. Differences in COM or PCO across practice settings were identified using Analysis of Variance (ANOVA) procedures, where $P < .05$ indicated significance. **Results:** ATs reported "sometimes" (54.4%, n=162) encountering psychological issues related to injury and unrelated to injury (56.4%, n=167) in their student-athletes. Respondents reported feeling slightly less competent and less comfortable in dealing with non-injury related psychological issues as compared to injury related psychological issues. Higher levels of the ATs perceived comfort and competence could not be predicted based on demographic variables such as gender, age, years of experience, highest degree achieved, additional certifications, or amount of psychological preparation. Additionally, there were no significant differences between practice settings for injury-related issues and COM ($F = .326$, $p > .05$) or PCO ($F = .522$, $P > .05$), nor for non-injury related psychological issues and COM ($F = .900$, $p > .05$) or PCO ($F = .658$, $p > .05$). **Conclusions:** Most ATs believe it is their role to address psychological issues with athletes; however it is remains unknown why some ATs have more perceived comfort or competence with psychological issues than their AT counterparts.

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